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ZOOLOGY,

OR

NATURAL HISTORY OF ANIMALS

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BY DAVID PAGE.

The subject is here presented in its two aspects of interesting and important. Interesting, inasmuch as it exhibits the progressive conditions of the earth from the remotest periods, and reveals the character of the plants and animals which have successively adorned and peopled its surface; and important, as it determines the position of those metals and minerals upon which the arts and manufactures so intimately depend.

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INTRODUCTION

BY

THE AMERICAN EDITOR.

THE present volume will be found to comprise a complete and comprehensive system of Zoology, rudimental it is true as compared with voluminous works, but not less systematic or thorough. The anatomical structure, and physiological diversities of every individual being included in the animal world, whether at present existing upon the earth, in the air, or in the waters of the globe, or found among the fossil remains which geology has developed by its researches, so far at least as the latter series admit of recognition, will all be found described, explained, and illustrated by the ingenious and learned author.

In its leading divisions, he has adopted the classification of Cuvier, modified in conformity with the present improved state of the science, and the classification approved by the latest and best authorities, the system of Professor Grant of London being that to which preference has been justly given. So full and satisfactory are the details of the work, that the task of the American Editor has been only to add explanations of such foreign technicalities as can neither be dispensed with, or substituted by synonyms in our own language; and the still further work of affixing analytical questions, to facilitate the use of the book in schools, for which it is now chiefly adapted, and which have been placed at the foot of each page. They are not intended to preclude other questions by the teacher, whose examinations may be more critical, descending to minute details when these are interesting or important, and eliciting from the pupil, as they ought to do, such reflections as the several topics may suggest. The wonders of creation, as here disclosed,

will afford ample scope not only for intellectual exercise, but for moral and religious reflections, of which no teacher should fail to avail himself while prosecuting this study.

The obvious advantages of a single book, comprehending all the departments of Zoological science, instead of numerous books, severally treating upon its numerous departments, will be appreciated by practical teachers. Instead of a distinct work upon each of the divisions into which Zoology is subdivided, there are manifest advantages in simultaneously studying the several sub-kingdoms together, and thus learning their points of analogy and their greater or less diversities more readily. Indeed, it is believed that the numerous books which have heretofore been considered necessary in learning this science, have been among the chief causes of the rare introduction of Zoology into the schools.

An example is seen in the "First books of Natural History" by Dr. Ruschenberger, the usefulness of which have been abridged, and will continue to be hindered, by the extent of the series. This single subject is cut up into no less than five volumes, the following topics being separately treated, viz., 1 Mammalogy; 2, Ornithology; 3, Herpetology and Ichthyology; 4. Conchology; 5, Entomology; so that all these books must be separately studied in attempting to learn Zoology. And no connected view of the subject can even then be realized without comparing each with the other, a labour perplexing and embarrassing to the learner.

This comparison is instituted, because the scientific character of Dr. R.'s books is unquestionable, and their diffuse method of treating the subject, alone renders the present publication necessary for schools, into which, if the science is ever extensively introduced, it must be in a condensed and simplified form. It is from this conviction that the present volume of the "Educational Course" has been republished, and is confidently submitted as having superior claims which will commend it to schools and teachers, as now adapted to their use.

D. M. R.

P R E F A C E.

THE following Treatise (which has already appeared, in an abridged form, in the "Information for the People") is designed to supply a deficiency which the Author has felt, in common with many others who are engaged in scientific instruction. The elementary works on Zoology that have hitherto been in use, are, for the most part, but abridgments of systematic treatises, executed by persons quite incompetent for the task; who, having for their object merely to produce a saleable book, have expended the chief part of their allotted space upon the most popular parts of the subject, and have given but a meagre outline of the rest. In the following volume an attempt has been made to remedy this deficiency. It is not an abridgment of any larger work; on the contrary, its materials have been brought together from a great variety of sources; and the aim of its Author has been to make it, so far as space would allow, full and complete in itself. In proportioning the amounts allotted to the several departments of the subject, regard has been had rather to their respective importance than to the degree of interest commonly felt in them; and it is hoped that the account it contains of numerous tribes, of which some fall under the notice of almost every one, and respecting which there is still much to be learned, will stimulate many, among the young especially, to contribute by their own exertions to the common stock of knowledge.

On particular departments of Zoology several good elementary treatises exist; such, for example, as Mr. Westwood's Introduction to Entomology, and the books of Animals, Birds, &c., published by the Society for promoting Christian Knowledge. But the pleasure and advantage derivable from the use

of these is so much greater, when a comprehensive survey of the *whole* Animal Kingdom has previously been taken, that it may be hoped that Instructors, availing themselves of the means afforded them in the present Treatise, will henceforth adopt such a plan, when introducing their pupils to the study of this most delightful science.

Zoology, like other branches of knowledge, is so progressive in its character, that a few years make great changes, not merely in its details, but in its leading features. Hence, the present work will not be found to have an exact correspondence, in regard to the arrangement adopted, with any of the systematic treatises which are usually considered as the standards of authority. The "*Règne Animal*" of Cuvier has been followed as to its leading divisions; but many departures from the system of that illustrious naturalist have been rendered necessary by more recent investigations. The Author has endeavoured to make his Treatise convey a fair idea of the present state of zoological science; not admitting innovations, unless they appeared to him to rest upon sufficient evidence, nor servilely following authorities already becoming antiquated. The system of Professor Grant (London University College) is the one to which that employed in the present Treatise has the closest conformity.

In conclusion, the Author has only to express the hope, that his little work will promote the introduction, into general education, of a study which is amongst the noblest that can occupy the mind of man—seeing that it brings him to a nearer acquaintance with the character and attributes of the Creator, whose almighty power, boundless wisdom, and perfect love, are displayed in his Works no less clearly than they are set forth in his Word.

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ZOOLOGY.

1. THE branch of Natural History termed ZOOLOGY, [from the Greek, *zôon*, an animal, and *logos*, a discourse,] is that which treats of the beings composing the *Animal Kingdom*. The general aspect of these, and the characters by which they may be ordinarily distinguished from plants, are under the observation of every one, and they need not here, therefore, be dwelt upon. No person is in danger of mistaking an oak for an elephant, a grass for an insect, or a sea-weed for a fish; but when we descend the scale, and pass from the highest and most complex, to the lowest and simplest of each kingdom, the characters upon which we have been accustomed to rely successively disappear, and we meet with several tribes which it is very difficult to assign with certainty to either natural division. Thus, in many shell-fish, such as the oyster, we find little evidence of *sensibility* and *voluntary power*, the two chief characteristics of animals; they are fixed to one spot, like plants, during nearly the whole of their lives, and the movements which they exhibit are not more striking than those of many plants; but their internal structure—their complex digestive apparatus, their heart, and circulating system, with the traces of nervous cords and ganglia (central knots), which they present—immediately evinces their claim to a place in the *Animal Kingdom*. On the other hand, there are many animalcules in which no structure characteristic of the *Animal Kingdom* can be discovered; and yet they exhibit an activity of motion, evidently influ-

-
1. Define Zoology.
 2. What are the two chief characteristics of animals?
 3. Why are shell-fish regarded as animals?

enced by the sensations they experience, which shows them to be far removed from plants. It is when the characteristic structure of animals, and the manifestations of sensibility and power of spontaneous movement disappear together, as is the case in the sponge, that the naturalist is the most perplexed in regard to the place he shall assign to such beings; and he can only solve the question by ascertaining whether the *general resemblance* is the greatest to beings of distinctly *animal* or of distinctly *vegetable* character. By this criterion, the sponge will hereafter be found to deserve a place in the Animal Kingdom.

2. The differences of structure which are most universally found to separate animals from plants, are those which are connected with the mode in which food is assimilated (or converted into the materials of their own fabric) by the beings of the two kingdoms respectively. Thus, it may be constantly noticed that plants imbibe their nourishment either through their external surface, or by prolongations of this into roots and leaves. On the other hand, animals nearly always possess an internal cavity, the *stomach*, into which the food is received, and where it undergoes a preparation; and the absorption of it into the system takes place by vessels distributed on the walls of this cavity. Now, this change is connected with two important differences in the nature of their food, and in the means by which they respectively obtain it. Plants require nothing but a regular supply of water, with carbonic acid, ammonia, and a small quantity of saline matter dissolved in it; and the conditions of their growth generally afford them a constant supply of these, which they can imbibe by means of their roots and leaves, without moving from the place in which they are once fixed. On the other hand, animals can only be supported by materials previously organized, all their food being derived from vegetable or animal substances; this is nearly always

4. What of sponge?

5. What difference of structure and function between plants and animals is remarkable?

in a solid state, and has to be reduced to a fluid form in order to be imbibed into the tissues; moreover, it only occasionally comes within reach of the being, and has to be stored up for the intervals; and it must be carried, during this time, in such a manner as not to interfere with the movement of the animal from place to place. All these objects are answered by the formation of the internal cavity just mentioned: in this the food is reduced, by the process of digestion, to a fluid state; in this it is kept, in contact with the absorbent vessels, during the intervals of its reception; and in this it is conveyed from place to place, partaking of all the motions of the animal, without retarding them. Thus animals may be said to carry their soil about with them; whilst the earth may be termed the common stomach of plants.

3. The life of every animal presents a number of facts for observation; and these may be separated from each other according to their character. Thus, we might consider their *structure* only—the department of science which is termed *anatomy*; or we might examine their *actions* or *functions*—in fact, the history of their lives—which is termed *physiology*. In pursuing either of these, however, we might restrict our inquiries to a single animal, though it would not be advantageous to do so. The objects of the zoologist are different. He sees that the several beings included in the Animal Kingdom may be regarded not only in their individual aspect, but in their relations to each other; that they form parts of one vast plan, as harmonious in itself as that of a beautiful building made up of a great number of subordinate parts; and that, whilst the diversities of form and aspect seem almost infinite, they are evidently subordinate to certain general principles, which produce not only the manifest conformity but the apparent departure from it. The grand aim of the scientific zoologist being to discover this plan, he employs *classification* as a means by which to facilitate his acquaintance with the vast number of beings that claim

-
6. What analogy between the stomach and the soil?
 7. Define anatomy and physiology.
 8. What agency is employed by the scientific zoologist?

his attention. The principles on which this should be founded will be presently explained.

4. But to many this pursuit would be in itself uninviting; and it may be advantageously united with another, by which important assistance may frequently be afforded, and which is usually regarded as comprehended within the province of the zoologist. This is, the study of the habits and instincts of the various beings whose form and structure are to be investigated by the systematist. This may become a source of constant interest even to the previously uninstructed mind; but it will afford pleasure of a much higher kind, when the intellect is prepared, by acquirements even of a very moderate degree, to observe facts that would otherwise pass unnoticed, to comprehend their value, to compare them with each other, to trace the wonderful analogies which everywhere connect what seemed to be most widely separated, and to rise from such observations to the conception of the vast scheme of wisdom and benevolence upon which the whole has been designed. Well has it been observed, that, "strange, indeed, must be the perversion of that mind, which is made neither wiser nor better by studying the works of Him, whose own wisdom is infinite, and all whose operations tend to good and happiness."

CLASSIFICATION.

5. On looking at the variety of animal forms around us—such as we are familiar with as inhabitants of this country, or as natives of other climates collected for our observation—the mind naturally associates together with those which have the greatest general resemblance, and separates these (although differing in some degree amongst themselves) from those with which they have greater dissimilarity. It is by pursuing this plan, from one stage or degree of resemblance and difference to another, that classifications are formed; and these will be correct according to the amount of knowledge upon which they are founded,

9. Does he nothing more than classify?

10. What moral lessons are acquired in this pursuit?

respecting not only the external form but the internal structure of the objects they include. Thus, the older naturalists placed the Bats among Birds, and the Whales with Fishes. In external form there is certainly a great correspondence; but this results only from their adaptation to a particular mode of existence. Bats produce their young alive, and suckle them afterwards, as do all other *Mammalia*; [from *Mamma*, the breast, Latin, animals which suckle their young;] whilst birds rear their young from eggs: so that these two tribes, similar as they are in form and habit, differ most widely in characters of great importance. *Whales*, again, which are truly mammiferous animals, differ yet more widely from the class with which they are still popularly associated; being air-breathing, warm-blooded, *viviparous* animals, [producing their young alive,] whilst fishes breathe through the medium of water, are cold-blooded, and *oviparous*, [rearing their young from eggs.]

6. Experience teaches that the offspring of any kind of animal is similar to its parents, though slight variations may be often traced between them; but a succession of beings having this general conformity is called a *race*. Now, the first object which the naturalist has to determine is, whether two races, such as the Negro and European races of man, or any two breeds of dogs, *might have* had a common origin. If he finds reason to believe that their differences are not greater than may be accounted for by the influence of accidental causes, and especially if he finds one race ever producing the form of another, he considers them as springing originally from a common stock, and as of one *species*; but if he cannot thus account for their differences, he regards them as of different species. This division of all the existing forms of animals into *species* is that on which the naturalist has to found all his subsequent classification; and it is necessary to take great care to avoid errors arising from variations in the forms of animals at different periods of their existence.

11. What is the basis of classification?

12. Define oviparous and viviparous, with examples.

Thus, the tadpole and the frog, the caterpillar and butterfly, would be referred not only to different species, but to different classes, were we not aware that they are only different states of the same animal; and many birds have been erroneously regarded as of different species, which belonged to the same, but presented varieties of plumage, depending upon age, sex, and period of the year. Again, in the dog and other domesticated animals, the difference between *breeds* is so great, that the naturalist would unquestionably rank them as distinct species, were he not induced to believe, by other evidence, that they had all a common origin. Thus it becomes necessary to know the whole history of an animal before deciding positively that it came from a different stock to another, to which it may bear a strong general resemblance. When several races exist in one species, obviously differing from each other, these are called *varieties*: such are the five chief races of man, the numerous breeds of the dog, of cattle, &c. And amongst the *individuals* of these are differences which we are in the habit of chiefly regarding in man, but which a practised eye, accustomed to study any particular race of animals (as the shepherd does his sheep, or the Laplander his reindeer), will detect among them.

7. A number of species, differing from each other in trivial points, but having a strong general resemblance, are said to belong to one *genus*. The genera most nearly allied are united into one *family*; several families into an *order*; and several orders into a *class*. The class, therefore, contains a very large number of species, many of them differing widely from each other, but all agreeing in some prominent and important character. And the classes composing the animal kingdom are arranged under four groups, on account of their correspondence in certain general particulars, and their difference in others; these are called *sub-kingdoms*. This is the alphabet of the

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13. How are animals of the same species distinguished?
 14. What of varieties and breeds?
 15. What does a genus include?
 16. Define the use of the terms family, order, and class?
 17. What of sub-kingdoms?

science: and when this has been acquired, the student will proceed to his grammar, which consists of such a knowledge of the principal divisions of the animal kingdom as will enable him to read the language of nature with understanding, so as to learn from the simple *name* much respecting the structure and character of the particular specimen, of which he would otherwise be ignorant.

8. These remarks may be illustrated by reference to the common dog, which would be thus described by a naturalist:—1st, It belongs to the *Animal* kingdom. It is, therefore, a being endowed with powers of sensation and of voluntary motion, and with a stomach for the reception and digestion of food. 2d, It is one of the sub-kingdom *Vertebrata*, [from the Latin, *vertere*, to turn.] By this it is known to possess a jointed back-bone, containing the spinal marrow, and expanded at one end into the skull, the cavity of which contains the brain; it is also known to possess red blood and five senses, and not more than *four* legs or members: these are but a few of the particulars involved in the idea of *Vertebrata*, as distinguishing them from the other sub-kingdoms. 3d, It is one of the class *Mammalia*, the members of which produce their young alive, and nourish them afterwards by suckling; they breathe air during the whole of their lives, and their blood maintains a fixed and elevated temperature; they are generally covered with hair, and live on land, and are altogether the most highly organized of the *Vertebrata*. To say, therefore, that an animal belongs to the class *Mammalia*, communicates the knowledge of all the foregoing particulars to a person but slightly acquainted with natural history. Further, 4th, It is one of the order *Carnivora*, [from the Latin *carnis*, flesh; and *voro*, I eat,] characterized by its possession of claws or nails, and of three kinds of teeth—*incisors*, or cutting teeth, *canine*, or dog's teeth, and *molars*, or grinders. In these respects it agrees with Man and Monkeys, forming the two first orders; but it differs from them in not having a

thumb opposable to the rest of the fingers, and in the adaptation of the teeth and general structure to preying upon animal food. In these respects, again, it agrees with the hedgehog, mole, and other species of the order *Insectivora*; but it differs from them in having the molar teeth raised into cutting edges instead of conical points, and in the great size of the canine teeth, by which it is adapted to devour the flesh of large animals rather than insects. 5th, It belongs to the family *Canidæ*, [from the Latin, *canis*, a dog,] which is distinguished from the Bear and Badger tribe by walking on the ends of the toes instead of on the sole of the foot (the former mode being termed Digitigrade, from the Latin *digitus*, finger or toe, and *gradus* a step, and the latter Plantigrade from the Latin, *planta*, the sole of the foot, and *gradus*, a step); and it is separated from the Cat tribe, which is also digitigrade, by the absence of the power of retracting the claws, which is possessed by the latter. 6th, It belongs to the genus *Canis*, distinguished from other genera of the tribe by a peculiar adaptation of the teeth to partly vegetable food. 7th, It is of the species *Canis familiaris*, for which Linnaeus could find no character distinguishing it from the wolf, but the peculiar way in which it carries its tail. Here the naturalist strictly stops; but it is interesting to him to trace the origin of the *variety* of which the specimen may be a member, whilst its possessor only is interested in the *individual history* of the animal.

PRIMARY DIVISIONS OF THE ANIMAL KINGDOM.

9. When we contrast an animal with a vegetable, we see that the former, in common with the latter, lives and grows, converts into its own substance the food which it obtains from external sources, arrives at maturity, reproduces its kind, and at last dies and decays. But the animal performs an additional set of actions, to which there is nothing analogous in the plant. It feels, and it acts spon-

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19. What in the order Carnivora? and family Canida?
 20. What of the genus and species?
 21. Define the technicals.

taneously. Sensibility (implying consciousness) and the power of voluntary movement, are then the distinguishing characteristics of animals. Hence, to the first set of changes, performed alike by both kinds of living beings, is given the name of *organic functions*, whilst the others are designated as *animal functions*. On looking at any one of the higher animals, it is very easy to distinguish the parts of the structure by which these functions are respectively performed. To the former are appropriated the stomach and intestines, for the digestion of the food: the heart and blood-vessels, for conveying the nutritious ingredients, separated from it in the form of blood, to all parts of the body; the lungs, for purifying this fluid by exposure to the air; and many others, all contained, however, in the cavities of the *trunk*. The instruments of the latter are the nervous system and organs of sensation, principally situated in the *head*; and the muscles, which constitute the bulk of the limbs, and which, by their contractions in obedience to the impulses of the will, produce the voluntary movements of the body. There will be found, in the different groups of animals, a remarkable variation in the relative development of these two systems.

10. The term *skeleton* is commonly applied to the system of *bones*, which are well known to form the internal framework of the higher classes of animals. But it is convenient to apply it to those harder parts of the fabric of *all* animals, which are destined for the support and protection of the softer tissues; as, for example, the firm envelope of the crab or lobster, the shell of the oyster, or the stony cells of the coral-polypes.

11. In considering the primary subdivisions of the Animal Kingdom, it is desirable to view them at first in their most simple aspect, and to regard merely the points of agreement amongst all the beings contained in each group, and their most striking differences from the members of other groups. The subordinate differences amongst the forms contained in any one of the primary groups,

22. Wherein do organic, differ from animal functions?

23. What organs occupy the trunk, and the head respectively?

24. Define skeleton.

will be subsequently attended to. Following the arrangement of Cuvier, which in this respect is unexceptionable, we divide the animal kingdom into four sub-kingdoms—VERTEBRATA, ARTICULATA, MOLLUSCA, and RADIATA. The principal characteristics of these will now be pointed out.

12. The VERTEBRATA derive their name from the peculiarity of their skeleton, which essentially consists of a back-bone or spinal column, formed of a number of separate pieces, so united as to combine great strength with flexibility. These are termed *vertebræ*. Each is perforated with a large aperture: and, when all are united, a continuous tube is formed, in which is lodged the *spinal marrow*, a very important part of the nervous system (this is quite different from the *marrow* of other bones, which is an oily substance, subservient to their nutrition.) At one extremity, the spinal column is extended into a large bony structure, the *skull*, which is especially designed for the protection of the *brain* (a large nervous mass, which may be regarded as an expansion of the spinal marrow) and of the organs of sense connected with it. At the other extremity it is contracted into a *tail*, the size and prolongation of which are usually greater in proportion to the small size of the skull. Connected with this spinal column are a series of *ribs*, which pass off from it on each side, and generally meet again in a breast-bone, enclosing a cavity (that of the chest), in which are contained some of the organs of nutrition. Appended to it are two pairs of *members* or *extremities*, which are usually the instruments of locomotion. Although these are very differently formed in the different classes, they are essentially the same in all. The arms and legs of man, the four legs of a quadruped, the wings and legs of a bird, and the fins of a fish, are all exactly alike in their position, and in the elements of which they are composed. The skeleton of the Vertebrata is *internal*, being clothed with muscles by which its various parts are moved; and, from what has been said, it is evident that it is particularly

25. What are Cuvier's sub-kingdoms?

26. Describe the structure of the first.

destined for the protection of the nervous system, which, from the high place of this group in the scale of animal beings, is the organ of the greatest importance in the whole structure. Vertebrated animals are endowed with all the *special* senses—sight, smell, hearing, and taste—the organs of which are situated in the head; besides the *general* sense of touch, which is common to the whole body. They have all *red* blood, which is propelled through the system by a muscular heart. The mouth is furnished with two jaws, which are placed one *above* or *before* the other; there are never more than two, and they never open sideways as in the *Articulata*. They are usually armed with teeth, which are in structure very analogous to bone.

13. The *Vertebrata* are characterized by a higher degree of *intelligence* than is possessed by any other group. The animal powers of sensibility and spontaneous motion are also greatly developed; and in accordance with these, a complete symmetry or correspondence between the two sides of the body is observable externally. But this symmetry does not extend to the organs of vegetative life, which are irregularly disposed in the cavities which they occupy.

14. In the *ARTICULATA*, the skeleton is *external*, enveloping not only the nervous system but the entire body, with the muscles which move it; these, as is well seen in the crab or lobster (which are the largest animals of this group), being attached to the interior of the firm casing. This skeleton is formed of a number of pieces or *segments*, jointed or *articulated* together—whence the name of the group. The centipede [from the Latin *centum*, a hundred, and *pedes*, feet] is a very characteristic illustration of this structure. The legs, as well as the body, are here seen to be enclosed in a firm envelope, of which the pieces are connected together by a flexible membrane; and the segments of the body are nearly alike along its entire length. But in the higher classes of this sub-kingdom,

27. What are the peculiar endowments of this group?

28. Describe the structure of the second sub-kingdom.

29. What example of this group is cited as characteristic?

where the movement is performed entirely by the legs, as in Crustacea, or by the legs and wings, as in Insects, the segments of the body to which these are attached are firmly united together, in order to give their muscles a fixed point from which to act. But, in the lower classes, such as the leech and worm, where the extreme flexibility of the body, and the change of its dimension, are the only means of locomotion (no members being present), the whole envelope of the body is so soft that the division into segments is scarcely perceptible. The nervous system of the Articulata is not by any means so highly developed as that of the Vertebrata; in general, the organs of taste and vision are all that can be detected in them; those of hearing and smell being possessed only by a few of the higher tribes. The number of legs, when these are present, is often very great; they are never less than six. More than one pair of jaws usually exist, and they open laterally. The blood is white, and only in the highest classes is propelled by a powerful heart. The Articulata have their whole structure adapted to great activity of locomotion, and to the performance of *instinctive* actions of a high character. The class in which this is most evident—that of Insects—is by far the largest in the whole animal kingdom. The body, which is usually of small size, derives its principal bulk from the organs of *animal* life, especially the muscles which move the extremities; and the *lateral symmetry* is even more remarkable in them than in the Vertebrata, extending in part to the organs of nutrition, as well as to those of sense and motion.

15. The group of MOLLUSCA, [from the Latin, *mollis*, soft,] must be described more by its negative than its positive characters. The body, as the name imports, is here soft, and destitute of any distinct skeleton. It is enveloped in a loose elastic skin, which is termed the *mantle*; and the outer surface of this has often the power of secreting a shell. But this shell is by no means adapted to the form of the animal; it has no regular series of joints

30. Name some of the varieties of structure in the articulata?

31. Which class in the animal kingdom is the most numerous?

for the purpose of facilitating the movement of the body, and it has no prolongations for giving protection and support to locomotive appendages. Moreover, of two species closely allied in general structure, it is often present in one and absent in the other, as in the snail and slug; and, when present in both, often differs much in form; so that it cannot be regarded as a part of the structure essential to our idea of a molluscous animal. That idea is principally founded upon the softness of the body, the high development of the organs of digestion, nutrition, &c.—in fact, of the system of *vegetative* life, which constitutes the bulk of the body; and, on the contrary, the low development of the powers of sensation and locomotion, and the organs of *animal* life. Many of them are entirely fixed to one spot during all but the very earliest period of life; and in the lowest species, there is a tendency to aggregation into a compound structure, like that which is seen in the zoophytes, [from the Greek *zōon*, an animal, and *phuton*, a plant, from the fancied resemblance to the nature of both.] The number of Mollusca possessing *active* powers of locomotion is comparatively small; and of those which are not entirely fixed, the general character is *sluggishness*. The blood is generally white; and is often propelled by a powerful heart, and distributed through a complex system of vessels, even where the animal seems almost inert. Where any correspondence between the two sides of the body exists, it is usually restricted to those parts which are concerned in the functions of animal life: especially the head, on which the organs of special sense (when they exist) are placed.

16. The division *RADIATA*, [from the Latin, *radius*, a spoke of a wheel,] includes the lowest members of the animal kingdom, and those, therefore, which most nearly approximate to vegetables. There is a great tendency in the animals of this group to associate into compound structures, in which each individual has a certain degree

32. How may the third group be described?

33. Is the system of vegetative or animal life well developed?

34. What is their general character?

of connection with the rest. Thus are formed those assemblages which, from their general resemblance to plants, are commonly called *Zoophytes* (animal plants). But as, in investigating the characters of a tree, we study the separate flowers and leaves, so, in studying the zoophytes, we consider the individual polypes, [from the Greek, *polus*, many, and *pous*, a foot,] which form them. These polypes, in common with the higher kinds of radiated animals, which are formed to exist separately (such as the star-fish), are distinguished by the *circular* arrangement of their organs around a centre, in which the mouth is placed; and from this arrangement the name of the group is derived. There is thus a repetition of similar parts; and, as in most other instances where this is the case, a great power of reproducing those which have been lost. In many of the Radiata there is no distinct skeleton; in others a very firm support exists, almost always partaking of the circular arrangement of the soft parts. The sea-anemone is a good example of the lower forms of this group; the star-fish, or sea-urchin, of the higher; very few species belonging to it possess much sensibility or power of locomotion. In many instances there are no distinct blood-vessels, but the nourishment is conveyed to the tissues by direct absorption from the external surface and from the walls of the stomach.

SUB-KINGDOM—VERTEBRATA.

17. Setting off with the idea of a *vertebrated* animal as one possessing an internal bony skeleton, essentially composed of a jointed spinal column, containing the spinal marrow, and expanded at one extremity into a bony case for the reception of the brain, having usually members or appendages for locomotion, which never exceed *four* in number, endowed with all the five senses, and in general with considerable activity, having red blood, and altogether a more complex organization than the lower classes pos-

35. What of the next division?

36. Describe zoophytes and polypes, with examples.

sess, as well as a higher degree of intelligence—we next proceed to consider upon what principles this extensive group may be subdivided into others, which, agreeing in all these particulars, shall yet differ in other important characteristics.

18. The ordinary observer would readily establish three subdivisions or classes, upon the three well-marked types of form which he perceives to be adapted to existence in the three different elements. He sees that one large group is entirely confined to the water; that the form of its body is peculiarly adapted for motion in that medium; that its members are constructed for most advantageous propulsion in it; and that it is incapable of existing, at least for any length of time, out of it. This group he calls by the name of *FISHES*; and he naturally associates with it some of a higher class, which resemble it in external appearance and mode of life. Another large group he observes to be formed to pass a great part of its life buoyed up only by the air; that the form of its body, the construction of its members, and the peculiar covering with which these are invested, specially adapt it for this peculiar mode of support, and for rapid motion through the element it inhabits; and that it is incapable of existing for more than a few minutes under water. This is the class of *BIRDS*; and with it, also, the ordinary observer associates a portion of a superior class, which is adapted in part to a similar mode of existence. A third group would consist of animals possessed of four feet, adapting them to a residence on the earth, and to motion on its surface; these would also be found to agree in their incapability of living beneath water like fishes, or of rising into the air like birds. But further examination of these *quadrupeds*, [from the Latin *quator*, four, and *pes*, a foot.] would disclose some important differences in structure and vital actions, which separate them into two great divisions, very widely apart from each other. It is soon observed that some are *warm-blooded*, maintaining a constant and

37. What is the natural subdivision of the Vertebrata into three classes?

elevated temperature, whilst the others are *cold-blooded*, their bodily heat varying with that of the atmosphere, and in general being but little above it; that the former are covered with hair or something analogous to it, whilst the latter are coated with scales; and that the former produce their young alive, or are *viviparous*, and nourish them afterwards by suckling, whilst the latter rear them from eggs, or are *oviparous*. Hence this group is subdivided by the naturalist into two, of which one—that of **MAMMALIA**—is superior in its general organization to birds, whilst the other—that of **REPTILES**, [from the Latin *repere*, to crawl,]—is intermediate between birds and fishes. The scientific characters of these groups will next be considered.

19. **FISHES** are oviparous vertebrata, inhabiting the water, and respiring that element by means of *branchiæ* or gills, which are filamentous prolongations of the surface, into which the blood is propelled, in order to be brought into relation with the air contained in the surrounding water. The heart only contains two cavities; one of these receives the blood which returns from the system, and the other propels it through the gills, from which it is conveyed by the blood-vessels to the body at large. They are in general cold-blooded, but few of them maintaining a temperature above that of the surrounding medium. Living habitually in an element which is nearly of the same specific gravity with their bodies, fishes have no weight to support, and have only to propel themselves through the water. Accordingly, we find their structure adapted for great freedom of motion rather than for firmness and solidity; progressive motion is chiefly accomplished by the lateral action of the spine, which is endowed with great flexibility. The vertebræ, instead of being articulated by a flat surface, as in the Mammalia, or by a ball-and-socket joint, as in serpents, have each of their surfaces concave, and these glide over a bag of fluid which is interposed between each pair of

38. How are quadrupeds distinguished into varieties?

39. Into what two classes do naturalists divide this group?

vertebræ. The tail is flattened vertically ; and it is by its movement from side to side that the fish is urged forwards, as a boat by a sculler. The *pectoral* fins, [from the Latin, *pectus*, the breast,] which answer to the hands of man, and the *ventral* fins, [from the Latin, *venter*, the belly,] which represent the feet, serve rather as *steering* than as *propelling* organs ; and they also assist in raising and depressing the animal in the water. In a large proportion of this class, the skeleton is cartilaginous [from the Latin, *cartilago*, gristle] only ; and in a few of the lowest the vertebral column is not divided into distinct portions, but forms one continuous tube of gristle or even of membrane only. The surface of the body of fishes is almost always covered with scales ; and these are sometimes quite bony, and fitted closely together, especially where the internal skeleton is soft.

20. REPTILES are also oviparous, cold-blooded vertebrata ; but, in their adult state, they breathe air, which is introduced into *lungs* or internal cavities ; and they mostly are formed to live on land—those which inhabit the water being obliged to breathe at the surface. Their heart possesses three cavities, one of which receives the blood from the lungs, and another from the system at large ; the pure and impure blood are mixed in the third cavity, and the fluid is propelled by it partly to the lungs and partly to the body. Thus, only part of the blood expelled from the heart is exposed to the influence of the air at each contraction ; and this deficiency is accompanied by a general inertness of the other functions. Their motions are chiefly confined to crawling and swimming ; for though a few at times can run and leap very quickly, their general habits are sluggish, their sensations obtuse, and their digestion slow. Hence they can exist for a long time with a very feeble exercise of these functions, under circumstances that would be fatal to animals in which they are performed with greater activity. In cold and temperate climates they pass the whole winter in a state of torpidity. There is greater diversity of form and

structure among the members of this class than in any other division of the vertebrated series. The *tortoises*, *lizards*, and *serpents*, appear so different that a common observer would separate them widely; and yet they not only agree in all the foregoing characters, but pass into each other by links of transition so gradual that it is difficult to classify them. There is one group which, in its adult condition, bears a general correspondence with reptiles, and has been commonly associated with them, but which only arrives at this condition by passing through a kind of metamorphosis, [from the Greek *meta*, after, and *morphè*, a change of form,] like that of insects: this is the *frog* tribe, which includes several animals bearing the form of lizards and serpents, but differing from them in having a soft naked skin, instead of a scaly one, and in passing the early part of their lives—that which, in the frog, is called the *tadpole* state—in a condition like that of fishes in all essential particulars. These differences have been regarded by some naturalists as establishing their title to rank as a distinct class, to which the term AMPHIBIA [from the Greek *amphi*, double, and *bios*, life] has been given.

21. BIRDS are, like fishes and reptiles, oviparous vertebrata, and, like the true reptiles, they breathe air during the whole of their existence; but they are warm-blooded, having a heart with four cavities and a complete double circulation, by which all the blood returned from the system is transmitted to the lungs, before being distributed to it again. This high amount of oxygenation of the blood is accompanied by great activity and energy of all the organic functions, acuteness of the senses, and rapid and powerful locomotion. The class is further distinguished by the position of the body upon two legs only, and by the modification of the anterior members for wings; by the covering of the body with feathers, or something analogous to them; by the deficiency of teeth, in place of which the

41. How are reptiles distinguished in their peculiarities?

42. What of their variety, with examples?

43. Why has the term Amphibia been applied to this class?

jaws are furnished with a horny covering or bill; and by various other characters of less importance. There is a peculiar conformity in the general structure and aspect of all the members of this class, with which scarcely any other animals are liable to be confounded. Birds have been not inappropriately termed the insects of the vertebrated classes.

22. The MAMMALIA agree with birds in possessing a complete double circulation and warm blood; and with reptiles in breathing air, and generally living on the surface of the earth; but they differ from all other vertebrata, not so much in producing their young alive (which is the case in a few species of reptiles and fishes), as in their subsequent nourishment of them by suckling—from which circumstance the name is derived. This class is placed at the head of the animal kingdom, not only as being the one to which man belongs, but also because it is that which enjoys the most numerous faculties, the most delicate sensations, the most varied powers of motion; and in which all the different faculties seem combined to produce a more perfect degree of intelligence; the one most fertile in resources, most susceptible of perfection, and least the slave of instinct. Although principally adapted to motion on the ground, we find one tribe possessed of the power of rising into the air like birds, and another formed to inhabit the water like fishes; but both these agree with other Mammalia in all essential characters, and differ very widely from the classes with which their habits seem to associate them. To the Mammalia is confined the protection of the body by hair or fur; the nearest approach to it being in the hair-like feathers of a few species of birds. But the presence of this covering is by no means universal in the Mammalia.

44. What are the peculiarities of birds?

CLASS I.—MAMMALIA.

23. The Mammalia are universally regarded as constituting the highest group in the animal kingdom ; not only from being the one to which man belongs (so far, at least, as his bodily structure is concerned), but also as possessing the most complex organization, adapted to perform the greatest number and variety of actions, and to execute these with the greatest intelligence. The contrast is here extremely strong between the *reasoning* and the *instinctive* powers. When we compare the sagacity of a dog, and the great variety of circumstances in which he will display an intelligent adaptation of means to ends, with the limited operations of the insect, over which the judgment and will seem to have no control, we cannot help being struck with the difference. The one is *educable* [from the Latin *e*, out ; and *duco*, to bring, capable of being educated, or brought out ; but this term is unauthorized,] in the highest degree next to man ; the other could not be made to change its habits by the most prolonged course of discipline. In ascending the animal scale, we observe the instincts gradually becoming subordinated to the reasoning powers ; and this may be particularly noticed among the members of the class under consideration, which exhibit much variety in this respect.

24. If we regard intelligence as the chief characteristic of the Mammalia, we should perhaps rest upon the principal varieties in the degree in which this is possessed by the several subordinate groups, as the groundwork of our division of the class into orders. But it would be difficult to derive from their structure any other indications of it, than those which are furnished by the conformation of the brain ; and as the connection between varieties in the structure of this organ, and the relative development of particular mental faculties, has not yet been established with sufficient clearness and universality, the naturalist seeks for other characters, and more parti-

45. What is remarkable in the Mammalia?

46. Why do these rank highest in the animal kingdom ?

47. What illustration is cited of reason and instinct ?

cularly aims to establish his classification upon such as are external and easily recognised. Such a classification will be *natural*, that is, will most nearly associate together the animals that have the greatest general resemblance, and will most widely separate those which have the least, in proportion as the characters which are selected for the purpose may be regarded as indicating the general conformation of the several animals. In this respect, the structure of the extremities, and the arrangement of the teeth, are found to be the most valuable.

25. From the general structure of the extremities, we may learn much of the habits of the animal, and the adaptation of its whole organization to a particular mode of life. These, for example, would be at once determined by an inspection of the wing of a bat or the flapper of a whale. Hence we shall not be far wrong if we throw into distinct groups all the Mammalia possessing one or the other of these modes of conformation. But among those which are adapted to walk upon land, we must seek for some slighter differences; and such we may in the first place look for in the organs of touch, since on these will depend much of the address of the animal, and a number of differences connected with the amount of its intelligence. The degree of perfection of the organs of touch is estimated by the number and mobility of the fingers, and the greater or less extent to which their extremities are enveloped by the nail or hoof. When the fingers are partly absent or consolidated together, and a hoof envelopes all that portion which touches the ground, it is obvious that the sensibility must be blunted, whilst at the same time the extremity becomes incapable of prehension or grasping. The opposite extreme is, where a thin nail covers only one side of the extremity of the finger, leaving the other possessed of all its delicacy; and where several such fingers exist, of which one can be opposed to the rest, so as to render prehension more perfect, and to perform a great variety of actions.

48. How is the most natural classification made?

49. What varieties are named as to the extremities?

50. How does structure indicate the power of touch?

26. Another important series of characters is furnished by the teeth, which are varied in structure and arrangement according to the nature of the food ; and it is obvious that, as to each kind of food, the means of obtaining it must be adapted, certain forms of the extremities and of the teeth will be found together. Not only will the correspondence extend thus far, but to the whole interior structure of the animal also. The organs of the senses, and the digestive system—the one employed in obtaining the food, and the other in assimilating it—will in particular exhibit this adaptation ; and thus we should find that the structure of the whole animal is so far connected with that of its teeth and extremities, that it might be predicted from the inspection of them. The extended application of this general fact to the determination of the characters of the animals whose fossil remains are so abundant in many parts of the crust of the earth, is the labour which will chiefly render the name of Cuvier immortal.

27. A primary division of the class Mammalia, however, may be founded on a character more important than any of the foregoing. As already mentioned, the animals of this group are distinguished from most others by producing their young alive—that is, having nearly their adult form, and being capable of executing spontaneous movements, and, to a greater or less degree, of seeking their own nutriment, from the time of birth ; and they differ from all others in affording their young a subsequent nourishment secreted from their own bodies. But there are several amongst them which produce their young in a state so immature, having so little of the form of the species, and so nearly motionless, that they can be scarcely called alive ; and it is only after having been for some time nourished by suckling, that they attain a degree of development corresponding to that at which other young mammalia are born. Now, it is a general law that, the higher the grade of development a being is ultimately to attain, the more it requires to be assisted in the early stages of that development by its parent ; and accordingly,

the animals in which the intimate connection between the parent and the offspring is separated at the earliest periods, are those which attain the lowest permanent condition. In this case, the inferiority in the general organization of the Mammalia thus produced, to that of the others, is sufficiently evident to the naturalist ; and it is manifest in their low amount of intelligence, as well as in their bodily structure, which presents many points of affinity with birds and reptiles. We may accordingly divide the class Mammalia into two sub-classes, the truly *Viviparous* and the *Ovo-viviparous** Mammalia. The first comprehends by far the largest proportion of the whole, and nearly all the best-known animals. The latter contains comparatively few.

28. The truly Viviparous Mammalia may then be subdivided, according to the structure of their extremities, into the *Ungulated* or hoofed, and the *Unguiculated*, or clawed. Hoofed animals are necessarily herbivorous, inasmuch as the conformation of their feet precludes the possibility of their seizing a living prey ; and they have flat-crowned, grinding teeth for triturating their food. These teeth have irregular ridges on their surface, occasioned by the slower wearing of their harder portions ; and by these, aided by the lateral motion of the jaws, tough vegetable substances are reduced to a pulp. Animals with unguiculated fingers are susceptible of more variety ; their food is of different kinds ; but it may at once be known from the form of the grinders, and from the degree of mobility and delicacy of the fingers. In some, the grinders are formed, like those of the hoofed animals, to triturate vegetable substances by elevated ridges ; and in these the extremity has the least power of varied movement, the habits of the animals assimilating to those of the Ungulata. In others, the grinders are very

* This term is perhaps not altogether scientifically correct, but to employ any other would involve explanations unsuited to the character of this work.

52. How else are the Mammalia divided ?

53. Define the names of each ?

54. How are the Viviparous subdivided ?

narrow, and are formed with sharp points and edges, cutting like the teeth of a saw ; these are adapted for dividing animal flesh ; and the jaws are fitted together like the blades of a pair of scissors, having no action but a vertical one. In others, again, the summits of the grinders are raised, not into cutting edges, but into conical points ; and they are thus adapted for breaking down the hard envelopes of insects, upon which such animals prey. Finally, in mammalia which are adapted to a variety of food, but which employ rather the soft and pulpy than the tough and stringy parts of plants, the summits of the grinders (which are covered entirely with enamel) are raised into flattened knobs or tubercles, adapted rather for crushing and bruising than for grinding or cutting. This is the case in man and most of the monkey tribe. Thus, by the form of the grinders, the nature of the food may be at once known.

29. In front of the grinders or *molar* teeth, we find, in all the tribes that subsist entirely or in part on animal food, and in some of the vegetable-feeders also, a single pointed projecting tooth on each side, which is termed *canine*, from its large size and prominence in the dog. It is very large in all the truly carnivorous animals, and it enables them to lay a firm hold of their prey. It is also larger, however, in some animals which are mostly herbivorous, [from *herba*, a vegetable, and *vorare*, to eat ; Latin,] as the boar ; and in these it seems chiefly intended as an organ of offence and defence. Between the canines, and occupying the front of the jaws, are the *incisors*, or cutting teeth, the purpose of which is nearly the same in all animals which possess them, namely, to divide the food that is to be introduced into the mouth. When they are altogether absent, the food is obtained by the tongue. In the truly Viviparous Mammalia there are never more than six incisors in each jaw.

30. (I.) The variations in the form and arrangement of the teeth, taken in conjunction with the differences in the

55. Describe each of these, with examples.

56. What of the molar, canine, and incisor teeth ?

structure of the extremities, enable us to subdivide the *Viviparous* Mammalia into ten orders. In the first place, they may be separated into the *Unguiculated*, containing eight orders, and the *Ungulated*, containing two only. Of the former group, some have all three kinds of teeth, whilst others are deficient in one or more of them.

31. A. The *unguiculated* animals having three sorts of teeth, may be divided into the six following orders:—

I. BIMANA.—This contains man only, who is characterized zoologically by the adaptation of his frame to an erect posture, supported upon his posterior extremities only, and by possessing *hands* (that is feet with opposable thumbs) on the superior extremities only.

II. QUADRUNANA.—This order includes the apes, monkeys, &c., which have hands on all four extremities.

III. CHEIROPTERA.—In this order, known as the bat tribe, the anterior extremities are formed into wing-like organs, which enable the animals to rise into the air like birds.

IV. INSECTIVORA.—The animals of this tribe, which includes the hedgehog, mole, &c., have the peculiar adaptation of their teeth to insect food, just now described.

V. CARNIVORA.—In this very extensive group, of which the cat tribe may be taken as an illustration, the teeth manifest, in the most remarkable manner, the adaptation to devour animal flesh.

VI. CETACEA.—This order, properly restricted to those members of the whale tribe which feed on animal substances, follows very naturally on the aquatic forms of the Carnivora; since its digestive system exhibits the same general character, although the adaptation of the extremities for swimming prevents them from showing the same form.

32. The two other orders of *Unguiculated* Mammalia are adapted partly to vegetable, and partly to animal food. They are—

VII. RODENTIA.—In these, the toes differ but little from

57. Into how many orders are the unguiculated divided?

58. Name them, and their varieties.

those of the Carnivora ; but the jaws are deficient in true incisors, their place being supplied by the canines, which are brought very much forward (so that a wide interval exists between them and the molars), and are adapted to gnawing. This order includes the beaver, rat, hare, &c.

VIII. EDENTATA.—This order is so named from the absence of front teeth, sometimes also of canines, and even of molars. The extremities of their toes are nearly included in large nails, which approach in character to hoofs. To this order belong the sloth, ant-eater, armadillo, &c.

33. B. The *Ungulated* Mammalia form two orders only—those which *ruminate* (or chew the cud), and those which do not. The latter differ much amongst each other, but are associated into one order:—

IX. PACHYDERMATA.—In some of these the toes are still partly separated, in others they are entirely united. The food is mostly vegetable ; all three kinds of teeth are sometimes present ; in some the canines, and in others the incisors, are deficient. Besides the elephant, horse, hog, &c., this order properly includes certain aquatic forms, which have been commonly associated with the Cetacea, but which are strictly herbivorous, and approach very nearly to the hippopotamus.

X. RUMINANTIA.—This order, containing the ox, sheep, deer, &c., is a very distinct one, and is characterized by its cloven feet, the absence of incisors in the upper jaw, and the complex arrangement of the stomach, by which rumination is effected.

34. (II.) The sub-class *Ovo-vivipara* is easily divided into two orders—the one having a pouch, or *marsupium*, in which the young are received and nourished for some time after their birth, and the other being destitute of it.

XI. MARSUPIATA.—The animals of this order, which includes the opossum, kangaroo, &c., differ considerably amongst each other in their food and habits ; and the arrangement of their teeth, or their *dentition*, varies ac-

59. What of the Rodentia and Edentata ?

60. What are the orders of the ungulated ?

61. What is the first order of the ovo-viviparous group ?

cordingly. They have mostly three kinds of teeth, the incisors more than six in number, and their feet are ungiculated, with an opposable thumb, in some instances, on the hind foot.

XII. MONOTREMATA.—This is unquestionably the group which approaches most nearly to oviparous animals. It contains only two genera, in one of which the teeth are altogether absent; and in the other nearly so, the jaws being covered with a horny bill. In addition to five claws on each foot, the males have a peculiar spur on the hind ones, like that of a cock.

35. The foregoing arrangement, founded entirely on external characters, does not give an altogether accurate representation of the relative intelligence of the different orders. If this be taken as the guide, we should first arrange the Viviparous Mammalia into a *Zoophagous* (or animal-feeding) and a *Phytophagous* (or vegetable feeding) series, of which the former will rank highest on the whole, although the highest of the latter may surpass its lowest forms.

36. The *Zoophagous* subdivision will include the BIMANA, QUADRUMANA, CARNIVORA, INSECTIVORA, CHEIROPTERA, and CETACEA.

37. To the *Phytophagous* belong the PACHYDERMATA, RUMINANTIA, RODENTIA, and EDENTATA.

38. These last approach most nearly of the *Vivipara* to birds in the structure of their brains; but a still lower type is exhibited by the *Ovo-vivipara*, which are unquestionably the lowest of the Mammalia in point of intelligence.

Order I.—Bimana. [From the Latin *bis*, twice, and *manus*, hand; *two-handed*.]

39. If we regard the possession of intelligence as the peculiar characteristic of the class Mammalia, we can have no hesitation in selecting the order Bimana, to which Man

62. Name some examples.

63. What of the Monotremata?

64. How are the Mammalia divided farther?

65. What of the order Bimana?

alone belongs, as the *type* of the group, being the form most unlike that of any other groups on which this class borders. It has been already pointed out, that there is an important connection between the high development of the bodily structure and of the intelligent powers of this class, and that peculiarity which distinguishes it from all others, namely, the prolongation of the period during which the young is dependent on its parent for support. And this prolongation is greater in the human species, in proportion to the whole length of life, than in any other; and it has evidently a direct connection with the ultimate high development of the mind and body of the offspring, and also (as will be presently pointed out) a most important indirect influence on the social condition of the human race. Thus man, presenting in the highest degree the characters which have been stated as distinctive of the Mammalia, is rightly placed at the head of the class, although, as will presently appear, he is surpassed by many other animals in particular portions of the bodily organization.

40. The order Bimana includes but the single genus *Homo*, [being the Latin word for *man* ;] and there is strong reason to believe, on scientific grounds alone, that all the races of men originally sprung from a common stock, although many of them present more striking differences from each other than would constitute distinct species in other races. But this is no more than is noticed in the breeds of animals domesticated by him: and it may be observed, that the capability of domestication essentially consists in the susceptibility on the part not only of the habits but also of the structure of the animal, to conform to a variety of circumstances. This susceptibility exists in a higher degree in man than in any other animal, the dog approaching most nearly to him; and we should accordingly expect to find considerable variations among the races which have been subjected for long periods to different external conditions. But these differences, even when

66. Is there more than one genus in this order ?

67. How are their differences to be regarded ?

we compare the most dissimilar forms—as the lowest Negro and the highest European—are as nothing, when we contrast man with the animals which approach most nearly to him, and from which, in the opinion of some, he has had his origin. Some of the most important of these differences will be now noticed.

41. Man is the only mammiferous animal to which the erect position is natural, and in which there is an essential difference in the organization and function of the two pairs of extremities. In those of the monkey tribe, whose form approaches most nearly to his, the erect posture is not natural but constrained; and none of these agile movements, so peculiar to the group, can be exhibited, unless the body is supported in front as well as behind. All the extremities of these animals are alike formed as organs of prehension; in the Carnivora, all are alike organs of prehension and support; in the hoofed animals, all are organs of support alone; in man, the anterior or upper extremities are entirely for prehension, and the posterior or lower entirely for support. When we examine these more particularly, we observe that each pair is adapted to its respective use in a higher degree than the extremities of the monkey or any other animal. The foot of man is broad, and its surface expanded; and the leg bears vertically upon it, the heel resting upon the ground. In the monkeys it is a sort of oblique continuation of the leg, as the hand of the arm, and supports the body chiefly by its powers of prehension. The whole structure of the body is adapted to being exclusively supported by the feet. The legs are so long, that a man could not, if he wished it, walk on all-fours; his short and nearly inflexible foot, and his long thigh, would bring his knee to the ground; whilst his widely-separated arms, and his shoulders, which are but loosely attached to the trunk, would ill support the fore part of his body.

42. But by the adaptation of his whole frame to the erect posture, his upper extremities are left at entire lib-

68. Wherein does man essentially differ from all other animals?

69. What proves that man was made for the erect position?

erty, whilst his organs of sense are most favourably situated for observation. The hand of man is adapted to a far greater variety of purposes than that of the monkeys, in which it is most perfect. Its power consists chiefly in the size and strength of the thumb, which can have its tip brought into opposition with that of any of the fingers; and all these are capable of being moved separately. In none of the monkeys can the thumb be opposed to the fingers with any degree of force, and in many their tips cannot be brought into contact; so that, though admirably adapted for clinging round bodies of a certain size, such as the small branches of trees, their hands can neither seize very minute objects nor support large ones. To the hand of man some have attributed his superiority, but it may be safely said that he owes this to his mind and its instruments conjointly. The hand would be useless without the mind to direct it; and mankind, if handless, would soon be reduced to a very subordinate kind of existence, if not speedily extinguished altogether.

43. Man, possessed of so remarkable a means of executing that which his mental ingenuity devises, is less provided, in regard both to acuteness of sensibility and to muscular power, than many other mammalia. His swiftness in running is inferior to that of other animals of his size. The smallness of his face, compared with that of the cranium, shows that the portion of the nervous system connected with the external senses is less developed in him than in most other animals. Accordingly, he is surpassed by many in the acuteness of his sensibility to light, sound, &c. But he stands alone in the power of comparing his sensations and drawing conclusions from them. Moreover, although none of his senses are very acute in his natural state, they are all moderately so, which is not the case in other animals; and they are capable (as is also his swiftness of foot) of being much improved by practice, especially when circumstances strongly call for their exercise.

70. What of the structure of the hand?

71. How else is he distinguished?

41. This improvability is one of the most remarkable characteristics of the bodily as well as the mental constitution of man. It is to a gradual advance in both, that the civilized races now enjoy so much of comfort, and of means of still further elevation. In the processes by which these are attained, we observe a remarkable difference between the character of man and that of other animals. The arts of which these are capable are limited and peculiar to each species; and there seems to be no evidence of a power of invention, or of construction for any purpose, beyond that to which the original and instinctive powers are adapted. Hence it would appear that there is no proof of any species or race among the lower animals ever making an advance towards an improvement or an alteration in its condition; and where a particular adaptation of means to ends, of actions to circumstances, is made by an individual (as is often the case where some amount of intelligence or rationality exists), the rest do not seem to profit by it.

45. Man is as much distinguished, then, from the lower animals, by his mental as by his corporeal endowments. Yet they are not of a *kind* altogether different from that which we may elsewhere see. In common with the inferior tribes, he possesses strong instinctive propensities, which are kept under control, however, in a well-balanced mind. But when the reasoning powers are undeveloped, as in early childhood and idiocy, the exclusive sway of the instincts is obvious. The more violent passions and emotions are nearly akin to these; and whilst they give great activity to the operations of the mind, it is requisite that they should be duly restrained by the intellect and will. This power of internal regulation is one of the most striking characteristics of the human mind above that of animals, which possess like it reasoning faculties, often to no mean extent, and are actuated by emotions and moral feelings. One of the most important aids to the use and development of the human mind, is the power of producing articulate sounds, or language; of which, as far as we

72. To what characteristic of man is his superiority owing?

73. Is this in his bodily or mental constitution, or both?

know, man is the only animal in possession. There is no doubt that many other species have certain powers of communication amongst individuals ; but these are probably very limited, and of a kind very different from a verbal language.

46. The more we study the physical and mental constitution of man, the more are we led to the belief, that it is in the adaptation of the whole to a great variety of circumstances that its great perfection consists. There seems scarcely any condition in which he cannot support himself. He is capable of sustaining the lowest as well as the highest extremes of temperature. His diet is naturally of a mixed kind ; but he can support himself in health and strength on either animal or vegetable food exclusively. At the same time, it is by the demands which his peculiar condition makes upon the exercise of his ingenuity, that his mental powers are first called into active operation ; and, when once aroused, their development has no assignable limit. On a cursory glance at the condition of the inhabitants of different parts of the earth, it will almost always appear that, where food and shelter is the most easily obtained, civilization is the least advanced. Frequently, as in many eastern nations, a certain progress is early made, and the race then remains stationary for centuries.

47. The slow development of those intellectual powers and corporeal faculties which are necessary for the mere maintenance of individual existence, renders the human infant long dependent upon its parent for support and guidance. The nearly equal number of individuals of the two sexes renders their association in single pairs natural ; and as the father is led by the affection implanted in his heart to participate in the support and education of his offspring, the length of time required for that education allows the birth of others, whence the natural perpetuity of the conjugal state. In many other animals which pair, the male and female separate after each brood has become independent of parental care, and before the production of

74. Describe resemblances and differences, relatively to other animals.

another. From the long period of infantile weakness result domestic subordination and the social affections, and, consequently, the order of society at large. The disposition to mutual assistance multiplies to an almost unlimited extent the advantages previously derived by man from his intelligence; and for giving effect to this, language is one of the most important instruments.

48. The striking differences in colour, in the form of the head and other parts of the body, and in degree of intelligence, amongst the different races of men, has caused some naturalists to regard them as constituting distinct species, that is, as being descended from original stocks having corresponding differences from each other. But this notion does not appear reconcilable with the fact, that in each race there not unfrequently exist subdivisions of which the characters approximate more closely to those of other races than is ever seen among distinct species. For example, although a characteristic specimen of the Negro race is extremely different from a well-formed European, a series of nations might be traced in Africa, whose common origin can scarcely be questioned, and which yet lose one Negro peculiarity after another, until a very close approach is manifest to the character of the white races.

49. Again, it is to be remarked, that the differences among the races of men are such as are observed in other animals to result from the influence of external causes, or to have a spontaneous origin; whilst in those points which most completely separate him from the species most nearly allied, there is a thorough conformity. This is especially the case in regard to his mental endowments; for similar natural prejudices and impressions, the same feelings, sympathies, and propensities, and intellectual faculties corresponding in kind if not in degree, may be traced in all of them.

50. Nevertheless, the different races peopling the earth may be associated into groups, from their greater or less

75. Whence the natural perpetuity of the conjugal state?

76. What proves that all varieties of men belong to one race?

resemblance to each other; these groups having probably been distinct from a very early period, and their members usually having affinities in language as well as in physical confirmation. Five of such groups are usually described.

51. The first occupies Europe and the south-western part of Asia, and may be geographically divided from the second by a line passing eastwards from the Euxine through the Caspian, then following the direction of the Himalaya mountain range, and descending to the Gulf of Bengal. The two great regions thus separated have been from the earliest periods the abode of two great classes of human races, differing from each other in manners and social character, as remarkably as the arid and saline plains of Mongolia and the cold desert of Gobi differ from the warm and fertile countries of Southern Asia.

52. To the western group (commonly termed Caucasian) the name of *Iranian* is applied by Dr. Prichard, the highest living authority on this subject. The nations composing it people India, Persia, and Arabia, the north of Africa, and nearly the whole of Europe. In the inhabitants of this space, a similar configuration of body may, with few exceptions, be recognised. Of this, the ancient Greeks seem to afford the most perfect model. It is principally remarkable for the roundness of the cranium and the oval form of the face; and for the small proportion which the latter bears to the former, the upper and anterior parts of the brain being chiefly developed. The muzzle does not project, the front teeth of both jaws being perpendicular; the lips are gently turned out, the chin full and rounded. Complexion does not enter into the characters of this group; since it is of all shades, from the white and florid colour of the northern Europeans, to the jet black of many tribes in Lybia. In these Indo-Atlantic nations, we find the greatest energy of the intellectual powers and moral feelings, and the greatest susceptibility of improvement by culture. They certainly, therefore, rank highest in the human family. It seems probable

that the region of Upper Asia, termed Iran, was the primitive seat of those families of nations who have most extensively spread the same type of features.

53. The nations inhabiting the northern and eastern parts of Asia, with the Finnish nations of Northern Europe, and the Esquimaux of North America, evidently belong to a different group, (commonly called the Mongolian,) to which Dr. Prichard gives the appellation *Turanian*. These are particularly characterized by the form of the skull and face, which seem as if they had been flattened in front; so that the features run together. The cheek-bones project very far sideways; the nose is small and flat; lips rather thick; the chin less projecting. The characteristic complexion of this group is olive; the eyes are usually black; and the hair black, straight, and strong, but thin. The forehead is low and flat. Their stature is generally lower than that of Europeans; and, with greater acuteness of the senses, they exhibit less intellectual power.

54. The general characters of the Negro races inhabiting the tropical parts of Africa, are sufficiently well known. Their complexion and eyes are dark, approaching more or less closely to black; the hair black and woolly. The skull looks as if it had been compressed laterally, so as to cause the face and back-head to project. The forehead is low, narrow, and slanting; the jaws narrow and projecting; the upper front teeth oblique, and the chin receding. The nose is broad and flat; the lips, especially the upper one, thick. It cannot be denied that in these characters the Negro head is intermediate between that of the European and that of the monkey; but it far more nearly resembles the former than the latter. It is a very important fact, also, that it is only in the most degraded African races that we meet with the *whole* assemblage of characters regarded as distinguishing the Negro; and that in others we find so strong a tendency towards a higher character, that it would be difficult

78. Describe the Caucasian variety, and their locality.

79. What of the Mongolian?

to distinguish many individuals among them from individuals that might be selected from the Iranian race. The influence of climate, and other external circumstances, on the physical and mental development of the human body, is nowhere more evident than when the degraded nations of the Guinea coast are contrasted with the intelligent Kaffres of the south or the civilized Ashantees to the north. There can be little doubt, then, that no decided line separates the African from the European races; and that the former may, in process of time, be brought up to the same intellectual and moral standard with the latter.

55. According to Dr. Prichard, the Hottentots and Bushmen inhabiting the south of Africa must be regarded as constituting a distinct group, in which human nature is exhibited in its most degraded form. There is a remarkable admixture in their physiognomy, of the characters of the Negro and Turanian races. The face is extremely flat; the nose has scarcely any perceptible ridge, and its extremity is greatly widened. The eyes are placed very obliquely, as in the Chinese. The chin is prominent, but very narrow. The complexion is like that of a Negro, diluted with yellow. The hair grows in separate tufts, which spontaneously twist together. In their language, the Hottentots seem to have no affinity with the other nations of South Africa which had a Negro origin; and they live in a more destitute and miserable condition than any other inhabitants of this continent.

56. The aboriginal nations of America, excluding the Esquimaux and some other tribes, form a well-marked division of the human family, bearing a strong general resemblance to each other in their most remarkable characters, both physical and moral. As in the Iranian division, the complexion varies extremely; but in general a reddish or copper hue prevails. The form of the head more resembles that of the Turanian group than any other.

57. The Indian and Polynesian archipelagoes are in-

80. How are the Negro race characterized?

81. What of the Hottentots and Bushmen?

habited by a great variety of nations, which have probably had mixed origins, and which it is difficult, therefore, to refer to any single group. Two races, however, appear to be decidedly distinct from the rest. One of these consists of the genuine Papuas, or woolly-haired inhabitants of the interior of New Guinea and the adjacent large islands. These bear a strong resemblance to the people of Madagascar. Their hair is less woolly, is longer, and thicker than that of the Negroes, but is very different from the lank hair of the Malays and other races. The other, that of the Alfours, appears to have constituted the primitive population of the eastern archipelago, but is now nearly confined to the interior of Australia. The hair is not woolly, but hard, black, and thick. The countenance is flattened, and the nose so wide that the nostrils are almost transversely placed. The lips are thick, the mouth wide, and the teeth projecting. The colour of the skin is of a smoky black, never very deep. The stature is usually below the mean; and the limbs seem of disproportioned length. Their physical and mental development seem altogether extremely low.

Order II.—Quadrumanā, [from the Latin. *quatuor*, four, and *manus*, hand; *four-handed*.]

58. The order Quadrumanā, which takes its name, as already stated, from the peculiar conformation of the extremities of the animals composing it—all four of them having one of the toes opposed to the rest, like the thumb of man to his fingers—are remarkable for their facility in climbing, which they gain by the *grasping* power conferred upon them by the possession of *four hands*. Their anatomical structure refutes the common idea, that the upright position is natural to them; and it is certain that, though they may be taught in a state of captivity to walk erect like men, they usually support themselves by their anterior as well as their posterior limbs. It may be observed, that those species which approach the nearest to

82 What of the aborigines of America. &c.

83. Where are varieties of men found, and how classified?

man rest upon the outer side of the foot only, and not upon its sole, when imitating his position; and that they are very insecure in it. And to those which are intermediate between the higher *Quadrumana* and the succeeding orders, the maintenance of the erect position without support for any length of time is impossible. It might be supposed that the possession of "four hands" is a character which raises the animals possessing it above two-handed man; but a little reflection will show that this is not the case, since the hand even of the highest *Quadrumana* is very inferior to that of man in complexity of structure and in the variety of movement to which it is adapted, whilst that of the lower shows but a slight advance upon the foot of the *Carnivora*. A corresponding series of gradations may be traced in the aspect of the face; for whilst, at one end of the series, the muzzle (at least in the young animal) is not much more prominent than it is in some races of man, at the other it nearly resembles that of other *Mammalia*. Nevertheless, throughout the order, a certain degree of resemblance to man may be perceived, in the gestures as well as in the general aspect of these animals. All of them, like man and the *Carnivora*, possess three sorts of teeth; the canines in the full-grown animal, are much more developed than in man; and there are intervals between them and the other teeth, which are not present in his jaws, but exist in all other *Mammalia*.

59. The *Quadrumana* may be divided into three families—the *SIMIADÆ*, or Monkeys of the Old World; the *CEBIDÆ*, or American Monkeys; and the *LEMURIDÆ*, or Lemur tribe, which supply the place of monkeys in Madagascar and some parts of Africa and India. This restriction of distinct types of structure to different portions of the surface of the globe, is not a little remarkable; and it may be traced even in the subordinate divisions.

60. The *Simiadæ* include all the animals of the Old World known as apes, monkeys, and baboons—names

84. What of the order *Quadrumana*?

85. How do they compare with the *Bimana*?

86. Into how many families are they divided?

which are commonly bestowed according to the development of the tail, the apes having none, the monkeys having a long one, and the baboons a short one. All these have *ten* molar teeth only in each jaw; and they have the partition between the nostrils very slender, so that the apertures are close to one another, as in man. On the other hand, all the CEBIDÆ are possessed of a tail, which is an extremely important organ to them, having great prehensile powers; they have *twelve* molar teeth in each jaw; and the partition between the nostrils is thick, so that the apertures are wide apart, as in the lower animals. The thumb of the hand, or fore foot, is not opposable; and it is entirely wanting in some of the genera. The LEMURIDÆ are distinguished from the monkeys, partly by the greater prolongation of the muzzle, the possession of a large bushy tail (which is not, however, prehensile [from the Latin, *prehendere*, to lay hold of]) of opposable thumbs on all the feet, and of a crooked and pointed claw on the first hind finger. In their teeth, they present an approach to the type of the Insectivora.

61. (1.) The SIMIADÆ must be regarded as the types of the Quadrumanous order; and amongst these the *Apes* manifest, in the most striking manner, the peculiar characters of the group. These are distinguished from the other subdivisions, in part by the absence of a tail, but also by the want of the cheek-pouches and of the callosities, or hard spots on their haunches, destitute of hair, which the monkeys and baboons possess; and further, by the predominance in length of the fore feet or arms over the hinder ones. The most remarkable species of this group are the *chimpansee* and *orang-ou-ang*; [from the Malay, *orang*, man; and *outang*, wild; wild man,] the former a native of equinoctial Africa, and the latter of the peninsulas and islands of Eastern Asia. Contrary to the general opinion, it is in the first of these that the greatest number of points of resemblance to man are to be found.

87. What variety in the Simiadæ?

88. What of the Cebidæ?

89. Describe the Lemuridæ.

Both these animals attain considerable size when full grown; probably in their native climate the former rising to five feet, and the latter to seven; but no living specimens of those sizes have ever been seen in this country. In both, there is a remarkable difference between the young and the adult form of the skull—the young bearing the greatest resemblance to that of man, whilst in the adult, the muzzle is so much prolonged, and the canine teeth are so much developed, as to give the face much more the aspect of that of the baboon. This difference, together with a change in the colour of the hair, has caused specimens of the orang, at different ages, to be accounted distinct species. The character of the animal also changes, being mild and gentle when young, but having a good deal of baboon-like ferocity when come to its full development. In the *Gibbons*, or long-armed apes, the length of the anterior members is so great that they touch the ground when the animal is in a semi-erect attitude; these present an approach to the monkeys, in the possession of callosities on the buttocks by some of the species.

62. The *Monkeys* of the Old World are distinguished (in addition to the characters which separate them from the *Cebidæ*) by the possession of cheek-pouches, callosities, and a tail, which separate them from the apes; the tail is longer than in the baboons, the muzzle less protuberant, and the aspect less ferocious. The group contains, however, some species which present an approach to the apes, and others which form a transition to the baboons. The true Monkeys are also remarkable for the shortness of the arms in proportion to the legs, which causes some species to walk on all-fours with difficulty, climbing being their usual mode of locomotion; but, by common observers, they are still more noticed for the beauty of their colouring, their activity of movement, and gentleness of demeanour. Their character is much changed, however, by confinement. They are found in almost all the tropi-

90. What is the most remarkable species of the apes?

91. Describe these, and their varieties.

cal countries of the Old World, and particular genera have a peculiar local distribution. Many of them live in societies, chiefly inhabiting the woods, but committing great devastations on any cultivated ground in the neighbourhood. In several species the aspect of the head is extremely grotesque, as are also the attitudes of the animal. The number of species is altogether considerable. Their food seems to be rather vegetable than animal; and in one genus this is distinctly indicated by the structure of the teeth and of the stomach. One genus, restricted to Africa, is destitute of thumbs on the anterior extremities, and the deficiency is partly supplied by the great development of the tail, which is not, however, prehensile, as in the American monkeys.

63. The *Baboons* have usually a short tail, or none at all; but there is much variation in this respect. They are rather distinguished from the apes and monkeys by the protuberance of the muzzle, and the ferocity of aspect which is partly dependent upon this; the canine teeth are generally large and strong. The Baboons have also a large bag connected with the organ of voice, by the resonance of which the power of their loud and discordant cries is greatly increased. The animal commonly termed the *Barbary ape* is in reality a baboon, but, in the almost total deficiency of tail, it bears a superficial resemblance to the former group. A race of these animals inhabits the Rock of Gibraltar, where they manage to obtain a scanty subsistence. This is the only instance of the existence of *Quadrumana* in a wild state within the boundaries of Europe, and it is not improbable that these were introduced at some former period from the north of Africa. The mandril is the largest of the Baboons, and of the *Quadrumana* in general, with the exception of the chimpanzee and orang. It is a ferocious-looking animal, and is distinguished from other baboons by the bright red colour of its cheeks; it is dangerous for its size, strength, and uncertain temper, so as even to become a terror to the

92. How else are monkeys distinguished?

93. Describe the Baboons.

Negroes of Guinea, of the woods of which part of Africa it is an inhabitant. The group of Baboons is almost confined to Africa and Western Asia. "Hideous as the animals contained in it appear, and disgusting to those who have only seen them in captivity, their adaptation to a peculiar mode of life is of course as exquisite as that of any other animal, and requires only to be understood to command an amount of admiration, which must lessen to a considerable extent the abhorrence with which we are apt to regard them. It has lately been discovered (by Dr. A. Smith, the traveller in Southern Africa) that they chiefly inhabit barren, stony places, where they subsist, for the most part, upon scorpions, to procure which they employ their hands to lift up the numerous loose stones, under which one or more of these creatures commonly lie concealed; their stings they extract with dexterity. Accordingly, we find that the Baboons are expressly modified for traversing the ground on all-fours, and are furnished with efficient hands; their eyes are peculiarly placed, being directed downwards along the visage." In a state of captivity, the Baboons exhibit less docility than any others of the order. They are by no means devoid of intelligence; but they do not seem capable of being steadily attached by kindness, and generally exhibit an alternation of moody sullenness and violent outbreaks of passion. Their resentment of injuries is often manifested for a long time afterwards.

64. (II.) The Monkeys of the New World, composing the family CEBIDÆ, differ from those of the Old, not only in the number of their grinders and the disposition of the nostrils, already mentioned, but in the entire absence of the cheek-pouches and callosities, and also in the conspicuous character, and the importance as a member, of the tail, which is usually prehensile in these monkeys, and capable of being twisted round branches so firmly as entirely to support the animal. In general, the thumbs of the anterior members are not opposable; and they are sometimes scarcely developed at all. The Cebidæ are

generally of smaller size than the Simiadæ, none of them attaining nearly the dimensions of the chimpansee, orang, or mandril; they are also less malicious, more easily tamed, and susceptible of a more constant attachment; but they seem to possess less intelligence. They are found in very large numbers in the woods of South America, where they chiefly subsist on vegetable food, to which their teeth show a peculiar adaptation. The largest of them are the *Myceti*, or howling-monkeys, which derive their tremendous powers of voice from a sort of hollow drum connected with the larynx, [or organ of voice found at the top of the windpipe,] (somewhat resembling that of the baboons,) which is peculiar to them

Spider-Monkey.

amongst the Cebidæ. They are shaggy animals, about the size of a fox. The *Ateles*, or spider-monkeys, are re-

95. Describe the monkeys of the New World.

96. What are the largest called, and why?

markable for the length and prehensile power of their tails, and for the absence (in some species entire, in others nearly complete) of the thumb; whence they are called four-fingered monkeys. A large number of other genera, including many species, might be enumerated; some of these are remarkable for their nocturnal habits, and others for their carnivorous propensities. A remarkable connecting link, by which this group is connected with the Simiadae, is afforded by the genus *Ouistitis*, which includes the animals known as marmosets and tamarins. Like the American monkeys in general, they have the nostrils lateral, and the haunches covered with hair, and are destitute of cheek-pouches; but they have only ten grinders in each jaw, like those of the old continent. All their nails, except those of the hinder thumbs, are compressed and pointed, so as to assume the appearance of claws; and even the thumbs, though furnished with flat nails, are yet so slightly separated from the other toes, that they can scarcely be called "four-handed" animals. The lower jaw possesses large cutting teeth, resembling those of the Rodentia [from the Latin *rodere*, to gnaw]—an order to which this group presents several points of resemblance. They are all diminutive animals, of pleasing forms, and very active movements; some of them are rather irritable in temper, and present an appearance which is really formidable, notwithstanding their size. There is another genus, *Pithecia*, which may be regarded as representing the baboons of the Old World among the Cebidae; the tail being short, the head large, and the canine teeth much developed. Many of the species are strong, stout, and fierce; having a hoarse and hollow voice, and a malicious aspect. Some of them are nocturnal in their habits, and feed upon small Mammalia and birds, which they steal with great caution and noiselessness; such are distinguished by their large and prominent eyes.

65. (III.) The third family of *Quadrupana*, that of

97. Describe the spider-monkey.

98. What other genus is named?

99. Name their peculiarities.

LEMURIDÆ, has in many respects the general aspect of the American monkeys; but the muzzle is much prolonged, resembling that of insectivorous or carnivorous animals; the teeth, also, are modified for animal food, presenting sharp tubercles, locking into each other; and the grinding motion of the lower jaw is reduced, so that its action possesses more of the scissors-like character of that of the animal-feeders. The four thumbs of these animals are well developed and opposable; the claw-like aspect of the nail of the first hind finger has been already noticed as one of the most easily recognised characters of the family. The canines in the lower jaw have the character of additional incisors; and the first molars resemble the ordinary canines. The total number of teeth in each jaw is eighteen, as in the American monkeys. The true Lemurs are distinguished by their very large and handsome tails, which are elevated when the animals are in motion, and not trailed after them. They average the size of a large cat, but have longer limbs. They are nocturnal or twilight animals, passing the day in sleep, rolled up in the form of a ball; at night they rouse themselves, and spring with the greatest activity in search of their food, which principally consists of fruits. These are entirely confined to Madagascar, where at least thirteen species are known to exist, differing from each other but little except in colour. On the other hand, the *Galagos*, which are found in the neighbourhood of the river Senegal, are pre-eminently insectivorous. With this group may be associated a very remarkable animal, which bears a strong resemblance to the sloth—the *stenops tardigradus*, or slow-paced lori, an inhabitant of India and the eastern archipelago. It has the teeth of the Lemuridæ, the short muzzle of a mastiff, a slender body, no tail, and large approximating eyes, as in the Lemurs. It subsists on insects, occasionally on small birds and quadrupeds. During the day it sleeps, clinging to a branch, with the body drawn together; at night it prowls among the forest boughs in quest of food; its sight is then excessively acute, and it steals noiselessly

on its victim. Its grasp is remarkably tenacious ; and it has been found that the trunks of the arteries of the limbs subdivide, as in the true Sloths, into a network of branches, the object of which seems to be to retard the blood in its passage amongst the muscles.

66. In this group are to be placed two remarkable animals, which, from their strong resemblance to other orders, were associated with them by Cuvier and other naturalists. The first of these is the *galæopithecus*, or flying-lemur, which, from its strong resemblance to the

Galæopithecus, or Flying-Lemur.

bats, has been arranged with the Cheiroptera. It is, however, a *lemur* in all its essential characters, but it has its limbs connected by thin skin, which they stretch out, as the framework of an umbrella supports its covering. By this singular structure the animal is supported in the air,

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101. What remarkable animal is here named ?
102. What of the flying lemur ?

as by a parachute; but it has not the power of sustaining a continued flight, though it can leap a distance of a hundred yards with a gradual descent. Like the bats, it feeds on insects, and sleeps with its head downwards, suspended by its hind legs. It is a native of the Indian archipelago. The other of these aberrant forms is the *cheiromy*, or *aye-aye*, which, from the peculiar form of its two lower front teeth, has been ranged with the Rodentia. In its general character, however, it is essentially a lemur; the thumbs of the hind feet are opposable to the other toes, which is not the case with any truly rodent animal, and approaches to a similar conformation of the teeth as seen in other lemurs. Moreover, it is a native of Madagascar, the centre of this group. It is a nocturnal animal, about the size of a hare: it is said to spend its day in holes in the ground (but these are probably not of its own excavation), and at night to climb trees, from the crevices in the bark of which it picks out worms and larvæ of insects with its long slender fingers.

Order III.—Cheiroptera, [from the Greek, *keir*, hand, and *pteron*, wing; *winged-hands*.]

67. The order Cheiroptera (formerly arranged by Cuvier as the first family of the order Carnaria) is perhaps the most distinctly circumscribed group of the whole class Mammalia; for all the animals composing it agree in the possession of a pair of wings, formed by an extension of the skin over the very elongated fingers of the fore legs, and connected also with the hind legs, by which they are adapted to raise and sustain themselves in the air, and also to propel themselves through it by regular continued movements, in precisely the same manner as birds. Now, although in other groups we may observe a tendency towards the same adaptation, it is never carried further than to give to the animal possessing it the power of partially supporting itself in the air, so as to prolong its leaps, as is the case with the flying-squirrel, the flying;

103. What other variety in this group?

104. Describe the third order

lemur, and flying-opossum. None of these animals can really *fly*, like bats and birds.

68. We see in the bats a very interesting modification of the whole character of the mammal, to enable it to lead the life of a bird, just as in the whale tribe we see a similar adaptation to the life of a fish. The insectivorous bats bear a strong analogy to the swallow, in the character of the food itself, as in the mode in which they obtain it—by the rapid pursuit of insects on the wing; the chief

Skeleton of Bat.

difference in habit being the time at which they respectively go forth in search of their prey. “No sooner does the diurnal family of swallows retire to rest, and with them those particular tribes of insects upon which they feed, and which fly only during the day, than those twilight wanderers, the goatsuckers and the bats, emerge from their dark retreats; at the same time a host of noc-

turnal insects, which have also lain dormant during the noontide hours, commence their flight, and are thus destined by nature to supply food to their natural enemies. Now, the effect, in both instances, is the same; for the insect world is kept within due limits, while life and enjoyment are given to innumerable living beings, formed and created for particular times and seasons. Bats and swallows catch their prey only upon the wing; and their evolutions are so similar, that, but for the time of day at which they respectively appear, it would be totally impossible to distinguish the one from the other during flight."

69. The whole structure of the Cheiroptera is obviously adapted to the fulfilment of the object which is the distinguishing character of the group. All the bones of the upper extremity, as well as those which give attachment to its muscles, are very largely developed. The member itself, although consisting essentially of the same parts as in man, has its aspect greatly changed by the extraordinary prolongation of the finger bones, upon which chiefly the skin of the wings is stretched. The skin is extremely thin, and is generally devoid of hair on both sides. It extends not only between the fingers, but from the last finger to the posterior extremity, and from this to the tail, where one exists. This expansion of the tail probably serves as a rudder, enabling the animal to change its course rapidly in pursuit of its insect prey—an idea which is supported by the fact, that in the bats which feed on vegetable substances, or on animals which require less activity of pursuit, this part is either wholly wanting or is much circumscribed in extent and power.

70. The four fingers of the anterior extremity being involved in the expansion of the membrane, only the thumb is left free; this is of moderate length, and is furnished with a crooked nail, which is of great use to the animal in climbing and in making its way along the ground. The toes of the hind feet are short, and furnished with claws, by which the bats suspend themselves from the trees or

walls on which they rest, hanging with the head downwards. They walk with slowness and difficulty when placed on the ground; the wings are folded up; and they rest upon the hind feet, and upon the claw of the thumb, by which they crawl forwards, pushing on first one side and then the other. But they can climb up perpendicular surfaces with considerable agility. The expanded skin of the wings appears to be endowed with a sensibility of a peculiar kind, enabling the animals to perceive their proximity to solid bodies without the assistance of sight. That they have a very acute perception of this kind, was long ago shown by the experiments of Spallanzani, who found that bats deprived of sight, and, as far as possible, of hearing also, were still capable of directing their flight with security and accuracy, finding their way through passages only just large enough to admit them without coming in contact with the sides, and even avoiding numerous small threads which were stretched across the room in various directions—the wings never, even by accident, touching them. It is probably through the vibrations of the air, which will differ according as the wing strikes it in the neighbourhood or the absence of any solid body, that the knowledge of the proximity of such is communicated to the delicate and expanded organ of touch. The use of this curious power to animals intended to execute rapid and varied movements in the dark, and amongst trees, buildings, &c., is sufficiently evident.

71. This tendency to a great extension of the skin is manifested in other parts of the body. In many bats, especially of the insectivorous kind, the external ear is enormously developed; being, in the long-eared bat of this country, nearly as long as the body. In the *frugivorous* bats, [from the Latin, *fruges*, fruit, and *vorare*, to eat,] it is of ordinary size. The organ of smell, too, in many of the insectivorous bats, is furnished with curious leaf-like appendages, formed of the integument doubled, folded, and cut into the most curious and grotesque forms.

107. What other peculiarities are named?

108. How is the absence of vision compensated for?

The group in which these are most remarkable, is one which avoids the light of day even more than others ; the animals composing it exist almost constantly in the darkest recesses of caverns ; and it is probable that, by this peculiar conformation, they gain increased power and delicacy of the sense of smell, which in part compensates for the inutility of the organs of vision.

72. The families composing this order may be arranged under two principal divisions, which are strongly contrasted with each other in regard to the nature of their food, the conformation of their teeth and digestive system, and the peculiarities of structure which are connected with the mode in which food is obtained. One of these groups, which may be regarded as typical of the order, is insectivorous ; the molar teeth are furnished with pointed tubercles, as in the order Insectivora ; and the stomach and digestive system are evidently adapted to animal food. The other group is probably omnivorous, [from *omnis*, all, and *vorare*, to eat,] like many of the monkeys—feeding chiefly on fruits, but pursuing small birds, or large insects, that may be obtained without much difficulty ; their molar teeth have flattened crowns, adapted for bruising and grinding their food ; and the complex structure of the stomach and intestinal canal shows its adaptation to a vegetable diet. The proportional length of the intestine, in specimens of these two groups, is a remarkable illustration of this difference of adaptation. In the great bat of this country, belonging to the former group, it is only twice the length of the body ; whilst in the frugivorous *peropus* of the tropics, it is seven times.

73. The Insectivorous group may be distributed into four families :—(I.) RHINOLOPHINÆ : in these, the nose-leaf is of complicated structure, and is membranaceous ; the index or forefinger has but one joint ; the wings are large and broad. (II.) PHYLLOSOTOMINÆ, which have the nasal appendage simple and fleshy, and an index-finger of two joints. (III.) VESPERTILIONIDÆ, which are destitute

109. What other singularities are cited ?

110. How are they divided primarily ?

of nasal appendages, and have a single joint in the fore-finger. (IV.) NOCTILIONINÆ, which are also destitute of nasal appendages, but have two joints in the index-finger.

74. (I.) To the first of these families, the RHINOLOPHINÆ, belong the greater and lesser *horse-shoe bats*, which are found in the darkest and most secluded retreats of our own country; their name is derived from the peculiar form of the anterior nasal appendage. The family contains many other genera and species, most of which are inhabitants of the Old World. One of the most curious is the *nycteris*, which has the power of distending the skin, which is very loosely fitted to the body, with air, blown into it through openings at the bottom of the check-pouches which these animals possess. These openings are guarded by a circular muscle which prevents the return of the air, except at the will of the animal; and large valves for the same purpose exist in the neck and back. By this curious mechanism, the *nycteris* has the power of so completely distending the skin, as to give the idea of "a little balloon furnished with wings, a head, and feet." In this manner, the specific gravity of the body is diminished; and some other purpose may be answered by the contrivance, as in the case of the analogous air-cells of birds.

75. (II.) To the second family, the PHYLLOSTOMINÆ, belongs the celebrated *vampire*, of the blood-thirsty propensities of which such marvellous stories have been told. The wound inflicted by its teeth is very small; but its tongue is endowed with a peculiar power of suction, by which a considerable amount of blood may perhaps be drawn. There are no well-authenticated accounts of the death of any animal having been occasioned by this creature; and the story of its fanning its victim with its wings to keep him cool, and render his sleep more profound, is probably a fiction of the imagination. Some of these bats have the tail very short, and in others it is altogether absent. They appear to feed in part upon succulent fruits;

111. How many and what families are insectivorous?

112. What of the first?

113. Describe the second?

but there is one genus, the extreme shortness of whose intestine indicates that it must derive its food from animal matter almost exclusively. One of these has been taken in the act of sucking blood from the neck of a horse. The vampires are confined to South America, but other members of this family inhabit the eastern hemisphere. Many of them attain considerable dimensions; the body being equal in size to that of a magpie, and the wings, when expanded, measuring between two and three feet across.

76. (III.) The third family, *VESPERTILIONIDÆ*, is by far the most numerous, and includes most of the bats of temperate climates. At least thirteen species exist in Great Britain, the largest of which is the mouse-coloured bat, the expansion of whose wings measures fifteen inches; but this is of rare occurrence. A more common one is the noctule, or great bat, which is but little smaller; this is often met with in considerable numbers, seeking its retreat sometimes in the hollows of trees, at others under the roofs and eaves of houses. Probably the most abundant is the long-eared bat, which is easily distinguished by the charac-

Long-eared Bat.

ter implied in its name. Its ears are folded downwards during hybernation [from the Latin, *hibernare*, to winter] or profound sleep. It is easily tamed when in confine-

114. What of the third family?

115. Which is the most numerous of the last family?

ment, and may be brought to considerable familiarity, so as to eat from the hand. It has an acute and shrill, but not loud cry.

77. (iv.) The bats of the fourth family, NOCTILIONINÆ, are almost exclusively confined to tropical countries. The number of species belonging to this group is very large, but few of them present any important peculiarities. One of the most interesting is the *cheiromeles*, an inhabitant of Java and Siam, which has a distinct opposable thumb on the hind feet, by which it can grasp small objects. It is, therefore, an evident connecting link between the orders Cheiroptera and Quadrumana.

78. (v.) The frugivorous or omnivorous group contains but one family, the PTEROPINÆ. This is widely diffused throughout warm climates, and contains some of the largest species of the order. It is not improbable that the fabulous harpy may have its origin in some of these. None of them have the tail much developed, and in many it is entirely absent. The *pteropus Javanicus* is a very characteristic example of this family. It is probably the largest of the bats—its expanded wings measuring five feet across. It is extremely abundant in the lower parts of Java, and uniformly lives in societies. They suspend themselves from trees during the day; and, from their motionless aspect and contracted bodies, they might be mistaken for parts of the tree, or for fruit suspended from its branches. When night comes, they begin to move, and go in search of food to the forests, villages, and plantations, in all of which they do great mischief, attacking indiscriminately almost any kind of fruit, of which they devour a large quantity. In their turn, they are eaten by the human inhabitants of some of the countries where they abound, who consider them as delicacies. The flesh of the common roussette of the Mauritius has been compared to that of the hare and partridge.

79. The Cheiroptera or bats, inhabiting temperate climates, all remain in a torpid state during the winter. Some

116. What of the fourth in this group?

117. What of the omnivorous division?

of them make their appearance, however, in mild days ; but as casual revivals during the season of repose are injurious to them, they usually betake themselves to places of which the temperature is not readily affected by external vicissitudes. The office of this group in the economy of nature, is evidently to assist birds in restraining the too rapid multiplication of insects, and to keep down the luxuriance of tropical vegetation.

Order IV.—Insectivora, [from the Latin *insectus*, an insect, and *vorare*, to eat.]

80. The order Insectivora forms a group which is intermediate between the Cheiroptera and the Carnivora. Like the greater part of the first-named of these orders, the animals composing it are formed to live upon insect food ; their molar teeth are beset with pointed conical tubercles, adapted to crush the hard envelopes of their prey : and they are, for the most part, like the bats, nocturnal animals—like them, too, passing the winter of temperate climates in a state of torpidity. But they are completely destitute of the wing-like expansions which enable those animals to rise into the air in search of their prey ; it is *their* function to seek it upon the ground, or even by burrowing beneath it. Hence, in their general organization, they more resemble the Carnivora ; but they retain the clavicle (collar-bone) of the higher orders, which in the Carnivora is reduced to a ligament, and this affords, in the burrowing species, a very important attachment to the powerful muscles by which their anterior members are put in action.

81. The teeth in this order are extremely variable, and cannot be so safely followed as guides to classification as the general structure and habits. All the animals belonging to it possess the peculiar conformation of the molars already described ; the front molar, however, is usually of a form adapted for cutting, like those of the Carnivora ; but posterior to this, there are generally three with conical tu-

118. What are the habits and office of bats ?

119 Describe the fourth order.

bercles. The disposition of the incisors and canines is very variable; in some species they are long, and in others short, and the forms of all the teeth are often so much changed that it is difficult to assign them to their respective classes.

82. This order may be divided into four families, which are characterized by their habits as well as by their external form and internal structure. (I.) TALPIDÆ or *Mole* tribe. These are pre-eminently subterranean, and are distinguished by their extraordinary habits of forming long and complicated burrows under ground, passing their whole lives in these retreats, in which they are born, feed, breed, hybernate, and die. (II.) SORICIDÆ, or *Shrews*. These are a sort of carnivorous mice, which, though they do not actually burrow, retreat during the winter, and in their ordinary repose, into holes; they feed, however, on the surface or in the water, several of them being partially aquatic, diving with facility after aquatic insects, and remaining without difficulty long under water. (III.) ERINACEADÆ, or *Hedgehogs*. Here we have still hibernating animals, but instead of burrowing or descending into deep excavations, they conceal themselves at or near the surface, where they find their food. The hair is converted into spines of considerable firmness. (IV.) TUPAIADÆ, consisting of a single genus, the *Tupaia*. These partake of the character of the Insectivorous Quadrumana, living in trees, which they climb with the agility of a monkey or a squirrel.

83. It is remarkable that, as far as yet known, no species of this order exist in South America or Australia. In the former continent their place seems to be supplied by the Edentata, of which many species are similar in their food and habits; and in New Holland they are replaced by numerous small Marsupialia, having the same general adaptation of their structure to insect food and to an underground residence.

84. (I.) Of the TALPIDÆ, the common English *mole* is a very characteristic example. The whole structure of

this animal is beautifully adapted to the subterranean life which it leads, and to the mode in which it seeks its food. A very short arm, attached to a large shoulder-blade, supported by a stout clavicle, and provided with enormous muscles, sustains an extremely large hand, the palm of which is always directed either outwards or backwards. The hand comes to a sharp edge below, and though the fingers are scarcely perceptible, the nails which terminate them are long, flat, strong, and sharp. This forms a most admirable spade, by which the earth is at the same time dug away, and thrown behind the animal. The sternum (breast-bone) possesses, in common with that of bats and birds, a ridge or keel, for the attachment of the large pectoral muscles which are necessary to endow the anterior member with the required power. To pierce and raise up the ground, the animal employs its pointed head, of which the muzzle is greatly prolonged, and terminated by a little bone which serves as a borer. This prolonged snout is also used as an organ of prehension, for by it the food is seized and conveyed to the mouth. The hinder part of the body is feeble, and the animal advances above ground so awkwardly as to convey the impression of pain; but when placed in its gallery, or in a tube of the same size, it pushes itself forwards by its hind feet with great activity. The arrangement of the hairs composing the fur is such, that they will lie smooth in any direction; by which provision, the surface is prevented from offering any impediment to the motion of the animal either forwards or backwards.

85. The mole has been supposed to be deficient in the sense of sight, the eyes being so small and so hidden behind the hair, that their existence was long denied; it has been ascertained, however, to be tolerably sharp-sighted. (There is a species inhabiting the south of Europe, very closely resembling the common mole, which is certainly blind; the eyelids of which are totally closed.) The sense of smell is extremely acute, and its organ largely developed; it is probable that to this almost entirely the

mole is ordinarily indebted for the perception of its food, of its enemies, and of its mate. At the same time it appears to be assisted by that of hearing, which is certainly acute, although aided by no external ear. The burrows of the mole are of a beautifully complicated construction, and are formed with the utmost art. Its food chiefly consists of earth-worms and the larvæ of beetles. When hungry, however, it will attack mice, lizards, frogs, or small birds, that may fall in its way; and it is said that if two moles are confined together, they will fight until one is vanquished, and that the victor will then devour his fellow. Besides these forms of animal matter, vegetable substances, especially the roots of plants, and the smaller roots of trees, are found in the stomach of the mole; but it may be doubted whether it eats these as food, or whether it does not simply tear them for the purpose of extracting the larvæ and worms which may be entwined among them.

86. Much controversy has taken place as to whether moles are on the whole injurious or beneficial to the agriculturist; some parties maintaining that they injure crops of various kinds by the destruction of their roots, and dig up and scatter the plants in ploughing their superficial furrows, besides rendering the ground dry and sterile by their subterranean roads; whilst others point to their destruction of earth-worms and grubs, and to the lightening of the soil produced by their operations, in proof of their beneficial character. The truth probably lies between the two extremes—the animal being neither prejudicial nor useful to the extent attributed to it by its enemies and friends respectively; but pretty certainly counterbalancing its mischief by the good it effects.

87. The *chrysochloris*, or Cape mole, inhabiting the south of Africa, is very similar to the common mole in structure and habits; but is remarkable as being the only known mammal which presents any appearance of those splendid metallic reflections which adorn so many birds,

122. What of the blindness of moles?

123. How are they supposed to affect agriculture?

fishes, and insects. Its fur is green, changing with the light to a copper or bronze.

88. (II.) In the *SORICIDÆ*, or *Shrews*, all the feet are formed for running. These animals are usually small, but are very numerous and widely diffused. The fur is soft, short, and silky, and the tail long; so that the common shrew bears a strong general resemblance to a mouse, except that the snout is long and slender. The general habits of this family have already been mentioned. They do not form complex burrows at a distance from the surface, but live on or near it. The *common shrew* of this country frequents dry situations, feeding on insects and worms, in pursuit of which its attenuated snout enables it to grub amongst the closest herbage or under the surface of the soil. On the other hand, the *water shrew* frequents the margins of streams; and the under surfaces of its feet and tail are extended by a set of bristle-like hairs fixed in their margins, by which these organs are enabled to act as oars and rudder. It chiefly feeds upon aquatic insects; but it burrows in the side of the bank, and probably obtains additional food from the land. There are in other countries larger animals of the shrew kind, some of which resemble the mole in general structure and habits. They all form an odorous secretion, which exudes from the midst of a band of stiff closely-set bristles on each flank.

89. (III.) The *ERINACEADÆ*, *Urchins* or *Hedgehogs*, are remarkable not only for their covering of spines, but for the great development of the muscular envelope of the body immediately beneath the skin (especially on the back), which in most other animals is scarcely perceptible. By this they are enabled to roll themselves into a ball, presenting a panoply of sharp spines to their enemies. These are not only strong enough to resist attacks, but are sufficiently elastic to enable the animal to throw itself down upon them from considerable heights. So that, although destitute of all means of attacking its enemies or of defending itself by force, and not able to seek safety in

flight, the hedgehog is endowed with a safeguard more secure and effectual than the teeth and claws of the wild-cat or the fleetness of the hare. In its natural state the hedgehog is nocturnal, remaining coiled up in its retreat by day, and moving about all night in search of food. Its run is quick and shuffling, and, as it were, by starts. Insects, worms, slugs, and snails, form the usual food of the hedgehog; but it will also devour frogs, toads, mice, and even snakes; and has been known to feed on eggs and vegetable substances. It is easily rendered familiar with man and with other animals. Other species of this family connect it with the previous

Fig. A.

and succeeding groups, the spines not differing so much in size and strength from hares, and the powers of rolling up the body being absent. Fig. A gives a view of the common hedgehog with the skin removed; fig. B represents the same animal extended.

Fig. B.

90. (iv.) The last family, that of *TUPAIADÆ*, or *Banx-rings*, is a very remarkable one. It is confined to the Indian archipelago, and has not been long known to exist.

125. What of the third?

126. Explain the diagrams?

Their teeth chiefly resemble those of the urchins, with a slight tendency towards the lemurs; and, like this last group, their eyes are large and prominent. They are covered with hair, which is soft and glistening, but not fine in texture, and have a long bushy tail. Contrary to the habits of other Insectivora, they ascend trees with the agility of a squirrel; from which animal, however, their pointed muzzle renders them easily distinguishable, even at a distance. They are readily tamed, running freely through the house, and coming of themselves at every meal for fruit or milk.

Order V.—Carnivora, or flesh-eaters.

91. The animals composing the order Carnivora are, like the four previous orders, separated from the other Mammalia possessing distinct fingers by the presence of three kinds of teeth, and from these orders they are distinguished by characters which point them out as especially formed for the pursuit and destruction of large animals. They possess in the upper and lower jaw six incisor teeth; a large, strong, and pointed canine tooth on each side; and molar teeth, which are evidently formed for cutting and tearing rather than for bruising or grinding. The form of these teeth varies, however, in the different genera, in accordance with their several habits. These molars consist of three kinds: the anterior, immediately following the canines, which are always more or less pointed, and are termed false molars; the next class, formed especially for cutting the flesh upon which the animals feed, are termed *carnivorous teeth*; and the posterior are tuberculated, with flattened summits.

92. The proportion which these different classes bear to each other in number and development, accords with the degree of the carnivorous propensity of the animal, and furnishes important characters in the subdivision of the order. The more the surface of the molar teeth is raised into points and edges, and the more the action of the jaws is restricted to the scissors-like movement by

127. What of the last family?

128. Describe the fifth order.

which these edges are made to meet and pass each other, the more purely carnivorous is the regimen of the animal: this is well seen in the Cat tribe. On the other hand, the more the molar surfaces are flattened, and the greater the lateral grinding motion of which the jaws are susceptible, the greater is the probable admixture of vegetable food: this is seen in the Bears. The general structure of the body, and especially that of the extremities, is modified in a corresponding manner, in accordance with the habits and propensities of the animal. In all, the toes are furnished with claws, which are peculiarly sharp in the cats, and are in them kept ready for use within a sheath, from which they can be projected at the will of the animal. The stomach of the Carnivora is very simple in its form, and the intestines are short, in accordance with the easily digested character of their food.

93. The whole bony and muscular system exhibits a similar modification. Thus, whilst the powerful yet active and flexible movements of the purely carnivorous animals are adapted only to the pursuit and destruction of living prey, the more sluggish habits of most of the Bear tribe, their peculiar mode of progression, and the modified structure of the skull, the teeth, and the limbs, are all equally applicable to the mixed nature of their food. The difference in the conformation of the extremities, and in the mode of using them, is very striking in these two antagonized groups. In the former, the ends of the toes only touch the ground, the heel being considerably raised into the air; in this way, the limbs can be used to much greater advantage in running and springing: the animals possessing this conformation are termed *digitigrade* [toe-stepping] Carnivora. In the latter the whole foot rests on the ground—a structure more favourable to the maintenance of a firm position, but preventing great activity of progression: these are called *plantigrade* [sole-stepping] Carnivora. There is a third very remarkable variety of conformation in the extremities of this order; and this is exhibited in the Seals. Here the anterior as well as the

posterior feet are formed for swimming, being spread into fin-like paddles; and the whole arrangement of their organs is admirably adapted to the pursuit and capture of their scaly prey.

94. The Carnivori may be subdivided into five families, each containing a well-known form. (I.) FELIDÆ, or *Cat* tribe. In these the destructive power is most highly developed. They are characterized by their short powerful jaws, their retractile claws, and the peculiar adaptation of their teeth for cutting. They have but one small flattened molar tooth above, and no corresponding one below. (II.) CANIDÆ, or *Dog* tribe. These, like the cats, are digitigrade; but their claws are not retractile; and they have two flat tuberculated molars behind the great flesh-cutter. (III.) MUSTILIDÆ, or *Weasel* tribe. These are mostly semi-plantigrade, a portion of the sole touching the ground. They are distinguished by their long narrow bodies, and by the presence of only one tuberculated molar. (IV.) URSIDÆ, or *Bear* tribe. These are the only true plantigrade Carnivora. Most of them possess several tuberculous teeth. (V.) PHOCIDÆ, or *Seal* tribe. These are at once distinguished by the adaptation of their form and structure to a residence in the water; and of their teeth for holding the slippery surface of fish, and crushing them before they are swallowed.

95. (I.) The *Cat* tribe includes a large number of animals very closely resembling each other in structure and aspect—so closely, indeed, that many of the species can only be distinguished by their size, and by the markings of their skin. They all agree, too, in the mode of catching their prey, which is to steal upon it unawares, and seize it with a sudden spring, in which they expend their energy, often slinking off when once baffled. It is very difficult to subdivide the family, on account of the strong general resemblance of its members. Most of them are sufficiently well known to render any peculiar description of them unnecessary. It may, however, be remarked,

130. How are their extremities diversified?

131. Name the several families of the Carnivora.

that some species are found in almost all tropical and temperate countries, and that those of different parts of the globe *represent* each other in a remarkable manner. Thus, the *lion* and *tiger* are inhabitants of Africa and tropical Asia; in America they are replaced by the *puma* and *jaguar*, which are confined to that continent. In the

Puma.

same manner, we find the *panther* and *leopard* spread over tropical Asia and Africa; the *ounce* inhabiting the Asiatic mountains; the *caracal* in Turkey and Persia; and the *lynx* of Northern Europe. These are represented by the *ocelot* in South America, the *lynx* of Canada (differing from the European species), and other less known species. The Felidæ, [from the Latin, *felis*, a cat,] like

the noble falcons, will only eat the flesh of animals they have themselves killed, except when in a state of domestication or confinement, or when compelled by hunger.

96. (II.) The family of CANIDÆ [from the Latin *Canis*, a dog] includes a much larger number of different forms, some of which approximate to the Cat tribe, and others to the weasels and bears. This tendency to variation from a typical form is most remarkably shown in the races of the common dog, which are believed to have all had the same origin, although the commencement of most of them is entirely unknown. The animals of this family agree in their greater or less adaptation to a mixed diet. Although animal flesh naturally constitutes the principal food of all, they do not attack living animals with a degree of boldness proportional to their strength, and many of them feed upon carrion, sometimes even when it is much putrefied. The *wolves*, *foxes*, and *jackals*, are the animals which most nearly approach the dog; and with the first of these it is regarded by many naturalists as being really identical. A very curious connecting link between this division of the family and the hyænas, is the wild dog of the Cape (*Lycaon picta*). This resembles the dog rather than the hyæna in its teeth, but in its tall gaunt form and general aspect it is more analogous to the latter, which it is also believed to resemble in internal conformation. It lives in numerous packs, which often approach Cape Town and devastate the environs.

97. The *Hyænas* constitute a group remarkably distinct from the true Canidæ, and yet bearing enough of their characters to require to be associated with them. They are more purely carnivorous than the dog tribe, and, in the deficiency of tuberculated molars, approach to the cats. But they differ from these, not only in general aspect, which is much more nearly allied to that of the dog, but also in the absence of the retractile power of the claws, and in their propensity to feed on carrion. The teeth are peculiarly adapted for crushing bones, and their jaws are

133. What peculiarity is mentioned respecting food?

134. What characterizes the Dog tribe?

shorter than those of the dog, but longer than those of the Felidæ. In many other points of structure the hyænas are intermediate between the two groups. They are peculiarly ferocious animals, combining the persevering *doggedness* of the one tribe with the furious blood-thirstiness of the other. Their habits are nocturnal—more so than those of most other Carnivora. Hyænas are now chiefly confined to Africa and the south of Asia; but there is no doubt, from the abundant remains of them which are preserved to us, that they must have formerly lived in large numbers in England, and in other parts of Europe.

98. Another curious South African animal conducts us from the hyænas towards the *Civet* tribe, which consists of small animals, some resembling the cat in form, but having two or more tuberculous grinders, and in many instances a plantigrade walk. In the true *civets* there

African Civet.

is a pouch situated near the tail, containing a secretion of a musky odour, which is valued as a perfume. They are beautiful spotted animals, natives of Africa and India; they are of an indolent disposition, easily tamed, and

feed partly on fruits. Allied to these is the celebrated *ichneumon* of Egypt, which is an animal larger than our cat, and as slender as a marten, sharing in the highly carnivorous propensities of the next family. It chiefly hunts for the eggs of crocodiles, by destroying which it prevents the excessive multiplication of those reptiles; it is easily domesticated, and exhibits much intelligence; and it is brought up in houses, to keep them free from mice and other small animals. The ancient allegation of its entering the throat of the crocodile to destroy it, is quite fabulous. The common Indian species is celebrated for its combats with the most venomous serpents.

99. The *MUSTELIDÆ* are the most *bloodthirsty* of all the Carnivora; but they are not so much adapted for devouring *flesh* as are the *Felidæ*. These animals, on account of the length of the body and the shortness of the limbs, which permit them to pass through very small openings, are called *vermiform* [or worm-shaped]. All the members of this family are semi-plantigrade; and they thus conduct us to the truly plantigrade Carnivora. The *weasel* of this country is a very characteristic example of the family; it is one of the most sanguinary of any, but confines itself chiefly to small animals, destroying large numbers of mice, rats, moles, &c. The *ferret*, which is an allied species, is bolder, having been known to attack man; and the *polecat* is a great enemy to the farm-yard, game-preserve, and warren. All these animals have a strongly and disagreeably odorous exudation from a pouch under the tail; but it is most disgusting in the last. The *skunks* are an American tribe, intermediate between the weasels and badgers, and are remarkable for the intensity of their nauseous, suffocating stench.

100. The *Otters* constitute an aquatic form of this family, having the same general aspect and dentition with the weasels, but being readily distinguished from all other genera of the family by their webbed toes and horizontally flattened tail. They subsist on fish. Several species

136. What of the *Civet* tribe?

137. Describe the weasel group.

exist, which are diffused pretty universally over the globe, with the exception of Australia, where they are replaced by the extraordinary *ornithorhyncus*. The Indian species is employed for fishing, as the dog for hunting. A large species frequents the waters of the North Pacific Ocean, along the shores of Kamtschatka and Siberia, where it is hunted for its blackish velvet-looking fur. This species is said to feed partly on sea-weed. The British otter, also, occasionally visits the sea, swimming to some distance from the mouths of the rivers which it has descended. It is said to burrow in their banks; but this is not correct, as it lives only in natural excavations. When the supply of fish is scanty, it has been known to resort far inland, and to attack lambs, sucking-pigs, and poultry.

101. (iv.) The true plantigrade Carnivora, constituting the family of *URSIDÆ*, [from the Latin *ursa*, a bear,] participate in the comparative slow motion and nocturnal life of the Insectivora; and like them, too, the species which inhabit cold countries pass the winter in a dormant state. In the *Bears*, the cartilage of the nose is elongated and movable, somewhat resembling that of the Shrews. These animals possess a great facility, from the structure of the sole, of rearing themselves up on their hind feet; and this may be especially noticed in such as are, like the bears, fruit-eaters, becoming carnivorous only from necessity; they are thus enabled to climb trees in search of food. The bears are the largest of the family; and some species of them are pretty widely diffused over the globe. The *racoons*, which resemble bears in miniature, with the exception of the greater length of the tail, are confined to America; but a very handsome animal, differing but little from them, the *pan-ta* (*Ailurus*), is an inhabitant of the mountains of the north of India. It frequents trees, where it feeds on birds and small quadrupeds. The *coulimondi* resembles a racoon, with a larger tail, and a singularly elongated movable snout. It climbs trees, and also digs the ground in search of earth-worms.

138. What of the family of Otters?

139. How are the Bear tribe characterized?

on which it feeds, with slugs, snails, small mammalia, and birds, eggs, and vegetables.

102. The *Badgers*, *Taxels* or Badgers of America, and the *Wolverines*, form a tribe connecting the Bears with the Mustelidæ. The *badger*, for example, is only semi-plantigrade, and has a dentition very like that of the weasels and otters; but adapted for a less carnivorous regimen. But it has the tardy gait and nocturnal habits of the other plantigrades; it does not, however, become torpid in winter. All these animals, like the Weasel tribe, have the power of emitting a fetid odour at will. The European and American badgers burrow with great facility by means of the long claws of their fore feet. They go forth in search of food only by night; and devour small animals which fall in their way, and such vegetable substances as roots, earth-nuts, and beech-mast, almost indifferently. They are endowed with astonishing strength of jaws, and great muscular force, so as to confer upon them considerable powers of resistance. Of the Wolverines, the most celebrated species is the *glutton* of the north, which is about the size of a badger; it is reputed to be very sanguinary and ferocious, subduing the largest animals by leaping on them from a tree. Some species of this tribe approach very closely to the Mustelidæ.

103. (v.) The last family, that of PHOCIDÆ, [from the Latin, *phoca*, a seal,] (the Amphibia of Cuvier), is sufficiently distinguished from all the rest by the peculiar adaptation of the animals composing it to a marine residence. Their feet are so short, and so enveloped in the skin, that they are of little use in progression on land. In fact, the seal employs them only when clambering, wriggling itself forwards along a plane surface by the action of the abdominal muscles. The intervals between the toes are occupied by membranes, so as to convert the feet into oars. The body is lengthened, and the spine very flexible, as in the Cētacea and Fishes; and the animals are covered with a short close fur, sitting flat upon the skin. All these adaptations combine to render them able swim-

mers ; and they pass the greatest part of their time in the water, which they only quit to bask in the sunshine and to suckle their young.

104. Of the two genera, the *Seals* and the *Morses*, which this family contains, the former presents the least departure from the general type of the order. It possesses all three kinds of teeth ; but the canines are not particularly large, and the molars are neither adapted for shearing nor for grinding the food, but are furnished with angular points adapted to keep hold of and crush the slippery prey. The head of the seal resembles that of a dog,

Greenland Seal.

presenting the same mild and expressive physiognomy. These animals seem to possess considerable intelligence ; they are easily tamed, and become much attached to their feeder. They subsist on fish, which they always devour in the water, closing the nostrils by a kind of valve. Seals of various kinds are extensively diffused though the polar regions of both hemispheres, becoming scarcer in the temperate zone. They are occasionally seen on the coast

141. Describe the Seal family.

142. How is it divided ?

143. What of the value of the seal ?

of South Britain, but are more abundant on the north of Scotland. The fur-seal of the South Seas is extremely abundant in some localities; for a period of fifty years not less than 1,200,000 skins were annually obtained from a single island.

105. The *walrus* (also called morse, sea-cow, sea-horse) resembles the seal in the general form of the body and limbs, but differs considerably in the head and teeth. The lower jaw has neither incisors nor canines, and is compressed laterally, to pass between two enormous canines or tusks, which issue from the upper one, and are directed downwards, sometimes attaining a length of two feet. These seem to be used by the animal in hooking up the sea-weeds on which it partly feeds. The morse is a very bulky creature, exceeding the largest bull in size, and attaining the length of twenty feet. It is an inhabitant of all parts of the Arctic seas, usually assembling in large numbers; and individuals have occasionally visited the British shores.

Order VI.—Cetacea.

106. In the order Cetacea, or *Whale* tribe, the adaptation of the mammiferous structure to the life of a fish is most remarkably displayed. The whole body is formed for an exclusive residence in the water. The posterior extremities are no longer present as in the seal, to assist in progression on land; nor are the toes of the anterior furnished with claws. The trunk is prolonged into a thick tail, which terminates in a horizontal cartilaginous fin, by the vertical movement of which the propulsion of the body is effected. The head is very large, and is connected to the body (as in fishes) by so short and thick a neck, that no diminution of its circumference is perceptible; and the cervical [from the Latin, *cervix*, neck] vertebræ, which are still (as in all Mammalia) seven in number, are very thin, and partly united together. The bones of the arm and fore-arm are very short; and those of the hand are flattened, and enveloped in a tendinous membrane,

which reduces them to the condition of fins. Hence their whole aspect is that of fishes, except that they are not covered with scales, and that they have the tail-fin expanded in the contrary direction. The object of this last provision is to enable them more readily to come to the surface to breathe, which they are obliged frequently to do. The largest species can remain, however, for an hour under water. Their blood, like that of other Mammalia, is warm; and to prevent the animal temperature from being rapidly lowered by the conducting power of the water, they are furnished with a thick coating of fat over the whole body. There are never any external ears, nor hairs upon the body. In these general characters, some other whale-like animals, now separated from the true Cetacea, agree; but they differ in being adapted for vegetable food, whilst the true whales are all animal-feeders, and are, therefore, properly associated with the Carnivora, to which they make a near approach through the seal. It is evident that the want of claws should not exclude them from this division of the Mammalia, since these are rendered useless by the adaptation of the animal to an exclusively aquatic residence. Some of them, which feed upon large marine animals, seize their prey with their jaws, whilst others, which derive their support from the smaller kinds, engulf them, with a large quantity of water, in their capacious mouths.

107. The true Cetacea are further distinguished from these herbivorous forms which are now associated with the Pachydermata, by the remarkable conformation from which they receive the name of *Blowers*. As with their prey they necessarily take in a great volume of water, a means of getting rid of this is required, and it is accordingly transmitted through the nostrils, and expelled, by a strong muscular action, through a narrow aperture pierced at the summit of the head. It is thus that these animals produce the jets by which they are observed at a great distance. Their nostrils, being continually bathed in water,

145. Describe the structure of the Whale tribe.

146. What peculiarities are cited?

are not adapted to a delicate perception of odours; and their organs of hearing, being deficient in the external ear, and otherwise formed on a lower type, are also probably incapable of very acute perception of sound. But what is deficient in these respects seems to be compensated by a very high degree of sensibility of the general surface; and there is reason to believe that, by this diffused sense, whales are enabled to take cognisance of what passes in the water at a considerable distance, through the medium of the vibrations excited in the fluid.

108. In subdividing this order, the *dentition* does not afford much assistance, for the teeth are frequently absent altogether; and among the species which possess them, they often exhibit great differences, when the animals are closely allied. Where they exist, they are mostly small, numerous, and of a conical form, similar to each other. These animals do not chew their food, but swallow it whole. The stomach is usually of a rather complex form. The order may be divided into two families, according to the relative size of the head and body. In the first, DELPHINIDÆ, or the *Dolphin* tribe, the head is not out of the usual proportion; in the second, the BALÆNIDÆ, or *Whale* tribe, it is immoderately large.

109. (1.) The DELPHINIDÆ have teeth throughout both jaws, all simple, and nearly always conical. They are the most carnivorous, and, in proportion to their size, the most cruel of their order. The common *dolphin* has its snout prolonged into a kind of beak. It is extremely agile in its movements; and a number are often seen sporting together on the surface of the water. It is doubtful how far there is any foundation for the tradition of the domesticability of these animals, the fabulous and the true being strangely mixed up in the early accounts of them. Nearly allied to the dolphin is the *porpoise*, which has a short muzzle. This is one of the smallest of the Cetacea, not exceeding four or five feet in length, and is very common in various parts of the Atlantic, assembling in vast herds.

147. How is the blowing of whales performed?

148. Into what families is this order divided?

Allied to the porpoise is the *grampus*, which has large conical teeth, and is the most powerful of this family, attaining the length of from twenty to twenty-five feet. It is a cruel enemy to the whale, which it attacks in troops. Other species of this family are known on our coasts by the names of *white whale*, *bottle-nose*, *narwhal* or *sea-unicorn*, &c. This last animal is remarkable for the enormous development of a single tooth or tusk, commonly reputed to be a horn, whence the name usually given to the species. In the general form of the head and body it agrees closely with the porpoises; but it possesses no other teeth than this tusk, which projects forwards, apparently from the centre of the upper jaw, to the length of ten feet. The animal really possesses, however, the germs of two tusks, of which only one is generally developed. That on the left side usually attains its full growth, whilst the other remains permanently concealed within its socket. Another genus of Delphinidæ, the *inia*, is remarkable as inhabiting the remote tributaries of the Amazons and the elevated lakes of Peru; it has bristly hairs on the snout when young.

110. (II.) The remaining Cetacea, constituting the family BALÆNIDÆ, have the head so very large as to constitute one-third, or even one-half, of the entire length; but neither the cranium nor the brain participate in this disproportion, which is entirely due to an enormous development of the bones of the face. This family contains several remarkable and important animals, amongst which the following may be noticed:—The *catodon*, or spermaceti whale, receives its technical name from possessing teeth in the lower jaw only; these are of considerable size, and lock into cavities in the upper jaw when the mouth is closed. The superior portion of the enormous head consists almost entirely of large cavities, separated and covered by cartilages, and filled with an oil that concretes in cooling, and is known by the name of spermaceti. This is commonly, but erroneously, reputed to be

149. Describe the structure of the dolphin.

150. What of the sea-unicorn?

the brain of the animal; the cavities which contain it, however, are very distinct from the true cranial cavity, which is rather small, and lies at the posterior portion of the head. Cavities containing spermaceti are found in various parts of the body, even ramifying through the external fat or blubber, and these communicate with those in the head. This whale is extensively distributed through various seas, but chiefly abounds towards the antarctic region. It sometimes attains the length of seventy feet.

111. The *balæna*, or Greenland whale, equals the catodon in size and in the proportional length of the head, which is not, however, so much enlarged in front. Instead of teeth, the mouth is provided with a number of vertical plates, terminating in fringes, which are composed of a sort of fibrous horn, and may be regarded as a kind of prolongation of the gum. These fringed plates, commonly known as whalebone, serve to retain, by straining from the water, the minute animals on which these enormous beings subsist. Their food consists partly of fishes, but chiefly of soft molluscs, acephalæ, &c. The blubber is of immense thickness, and furnishes a large quantity of oil—a hundred and twenty tons being sometimes obtained from a single individual. The whalebone also is an important object of pursuit. This animal was formerly not very uncommon in British seas, but has now retired to the far north, where its numbers, in consequence of the attacks of man, is constantly diminishing. The *rorqual*, an allied species, attains to still greater size, having been seen of the length of a hundred feet. Like many of the *Delphinidæ*, it has a dorsal fin, supported by cartilage only, and not by the prolonged spinous processes of the vertebræ, as in fishes.

112. When whales are struck by a harpoon, they usually dive head-foremost with great velocity, and often to a considerable depth. The muscular power

151. What is remarkable in the whale?

152. What variety is described?

by which this is effected must be enormous, especially when the animal is under the pressure of a lofty column of water. The animal sometimes descends so rapidly as seriously to injure itself by striking the bottom at great depths; one has been known to fracture its skull in this manner eight hundred fathoms below the surface. After the lapse of twenty minutes or more, the whale is obliged to come again to the surface to breathe, and his pursuers then make another attack; and this system is continued until the animal is exhausted by its efforts and by loss of blood. The tail is a very powerful weapon of

The Plunging Whale.

offence and defence—a blow from it not unfrequently shattering boats, and doing great injury even to ships.

Order VII.—Rodentia, [or gnawing tribe.]

113. The order Rodentia bears a striking contrast to the last, in the size as well as habits of the animals composing it, which are, for the most part, very diminutive; but they are very widely diffused, and are often extremely numerous. One species or another is found in almost

153. What is said of their diving?

154. What of their weapon of defence?

every part of the world except New Holland, and sometimes their numbers are so great as to render them very destructive to vegetation. Some of the order are the most gentle of the Mammalia, whilst others are so ferocious that, if their size and strength were proportional, they would be extremely formidable. This order contains also some of the species most remarkable for their instincts, as the beaver. Generally speaking, the Rodentia are the most prolific of the Mammalia, the period during which they go with young being shorter, and their litters more numerous.

114. But though the animals differ much from one another in size and external appearance, the order is a very natural one ; all the species contained in it being remarkable for the peculiar adaptation of their teeth to gnawing hard vegetable substances, and of the stomach and intestinal canal to the digestion of them. The mouth of a rodent animal is at once recognised by the two long teeth which project forwards from each jaw, working against one another, and separated from the molars by a wide interval. These are usually regarded as incisors ; but they are really the canines, the direction of which has changed in consequence of the absence of the incisors. In the hare, the small true incisor teeth may be seen behind them. These gnawing teeth have enamel in front only ; so that, their posterior edges being worn away faster than the anterior, they constantly retain a sloping or chisel-like edge. They continue to grow at the root as fast as they wear away at their points ; so that, if either be lost or broken, its antagonist in the other jaw, having nothing to wear it down, becomes developed to an enormous extent. The mode in which the lower jaw is articulated to the skull, allows of no horizontal motion except backwards and forwards ; and the flat-crowned molar teeth have enamelled ridges arranged transversely, so as to be in opposition to the horizontal movement of the jaw, and the better to assist in trituration. In a few of

155. What is peculiar in the gnawing tribe ?

156. What of the structure of their teeth ?

the genera, the structure of the molars more approaches that of the Carnivora.

115. The form of the body of the Rodentia is generally such that the hinder parts exceed those of the front, so that they leap rather than run. In some of them this disproportion is as excessive as in the kangaroos. The inferiority of these animals to those of the orders already considered, is perceptible in many details of their organization; the brain is less complex in structure; the fore-arm loses the power of rotation, its two bones being often united; and the eyes are directed sideways, showing their tendency to retreat from their enemies rather than to pursue them. In some, the clavicles (collar-bones) are nearly or entirely absent, the anterior extremity being then usually deficient in strength.

116. The Rodentia may be divided into seven families, the technical distinctions between which are founded upon minute particulars in the structure of the cranium and of the lower jaw. (I.) SCIURIDÆ, or *Squirrel* tribe, comprehending a large number of light and agile animals, chiefly distinguished by their long bushy tails, and by their adaptation to a residence in trees, and to live upon their produce. (II.) MURIDÆ, or *Rat* tribe. (III.) CASTORIDÆ, or *Beaver* tribe, including the voles, lemmings, &c. (IV.) HYSTRICIDÆ, or *Porcupine* tribe. (V.) CAVIDÆ, or *Guinea-pig* tribe. (VI.) CHINCHILLIDÆ, the *Chinchilla* tribe. (VII.) LEPORIDÆ, the *Hare* tribe. The rodents of the fourth, fifth, and seventh families are destitute of the clavicle, which those of the three first and the sixth possess.

117. (I.) Of the family SCIURIDÆ, the common *squirrel* of this country may be taken as a characteristic illustration; and its form and habits are sufficiently well-known to render a particular description unnecessary. It lives entirely upon vegetable food, in search of which it leaps with great agility from branch to branch. In taking these leaps, when it is once thrown off by an effort of its long and powerful hind legs, it is in a measure sustained by the horizontal

157. Name the several families?

158. Describe the squirrel group.

spreading of its limbs and bushy tail, the hairs of which are directed laterally, so as to resemble a feather. In the *pteromys*, or flying-squirrel, this sustaining power is much increased by an extension of the skin of the flank between

Flying-Squirrel.

the fore and hind legs, which serves as a parachute. The *marmots* are allied to the squirrels in the number and structure of their teeth, which are partly adapted, however, to insect food. In other respects they are almost the reverse of squirrels, being heavy, with short limbs and a moderate-sized tail, and living on the ground, or even in burrows beneath it. They are connected with the former tribe, however, by an elegant little animal termed the *ground-squirrel*, partaking of the habits of both ; this is a native of Eastern Europe. A very remarkable kind of marmot is one known in North America by the name of the *prairie-dog* or *barking-squirrel*, on account of its voice, which resembles the bark of a small dog. It lives in great troops, in immense burrows. More allied to the squirrels in the size of their tail and active habits, but differing in their dentition, are the *Dormice*, the structure of whose teeth shows them to approximate with the next family. They chiefly subsist on vegetable food ; but some species of them attack small birds. All the members of this family pass the winter in cold climates in a state of lethargy, which is most profound in the marmots and dormice.

118. (II.) The family of MURIDÆ contains the smallest, and at the same time the most numerous, of the Mammalia. No undomesticated animals are better known than mice and rats. Of the common *mouse*, Cuvier thus concisely speaks—"known in all times and in all places." The house *rats*, abundant in this country, are almost as universally diffused; but the time of their introduction into many parts of the globe can be distinctly traced. The *brown* (commonly, but erroneously, called the Norway) *rat* made its first appearance in Paris about the middle of the eighteenth century, and in England not many years earlier. It is believed to have originally come from Persia, where it lives in immense burrows, and is said to have arrived in Astracan by swimming across the Volga, after an earthquake in 1727. Its astonishing fecundity, its omnivorous habits, the secrecy of its retreats, and the ingenious devices to which it has recourse, either to retain its existing place of abode or to migrate to a more favourable situation, all conduce to keep up its almost overwhelming numbers. Where a plentiful supply of animal food is afforded them, rats will feed exclusively upon it. The brown rat is now speedily replacing the *black* or *old English rat*, which is becoming rather a rare animal in that country, and which, from its smaller size, is an unequal match for the usurper. There is reason to believe, however, that even this is not a native of England, and that it was introduced from France about the middle of the sixteenth century. From Europe these two rats (which infest vessels equally with houses) have been sent to America, the islands of the Pacific, and many other places, in some of which they have now become a serious inconvenience. The only strictly indigenous British species of Muridæ are the *harvest-mouse* and *long-tailed field-mouse*, both of them very beautiful little animals, and very interesting to the naturalist, although highly injurious to the agriculturist. A great number of species exist in various parts of the world, which do not differ widely from each other.

119. The *Hamsters* have teeth nearly similar to those of

the rats, but their tails, instead of being long and scaly, are short and hairy, and their cheeks are hollowed into pouches in which they can stow away a large quantity of grain for transport to their nests. They abound in the sandy plains of the north-east of Europe, from Germany to Siberia, and are very injurious, from the quantity of grain they hoard up in their extensive and intricate burrows. They have more ferocity than most of the order, and will attack any animal that comes in their way. They are believed to feed upon birds as well as upon vegetables. Allied to the rats in its dentition, and having also some points of resemblance to dormice, is the curious genus *dipus*, or jerboa, the general form of whose body, as well as its mode of progression, is very similar to that of the kangaroo. The enormous length of the hind feet occasioned them to be designated *two-footed rats* by the ancients; whence their present generic name is derived.

120. (III.) Of the CASTORIDÆ, the *beaver* is probably the type; but this family contains many genera having a close resemblance to the rats. The beaver is distinguished from all other rodents by its horizontally flattened tail, which is of a nearly oval form, and covered with scales. The hind feet are webbed, by means of which and the tail these animals obtain considerable swimming powers. They chiefly subsist on bark and other hard substances, and can fell trees of considerable size, of which they use the bark and twigs as food, employing the stems in the construction of their remarkable habitations. The flattened tail is employed by them as a kind of trowel, with which they plaster the walls of their houses. The beavers are connected with the previous family by the *Arvicolæ* or *Voies*, many of which bear a strong general resemblance to rats, but differ in their dentition. Most of them are partly aquatic in their habits; such is the common *water-rat* of this country, the food of which, like that of the beaver, is (contrary to the general opinion) almost exclusively herbivorous. To this group also belong the *lemmings* or Scandinavian rats, which are remarkable for their occasional migra-

tions in immense bodies. They are stated to advance in a straight line, regardless of rivers and mountains; and while no insurmountable obstacle impedes their progress, they devastate the country through which they pass. Most of this family lay up a winter store of food, upon which they subsist in the intervals of sleep, and do not go abroad during that season.

121. (iv.) The animals which are characteristic forms of the family HYSTRICIDÆ, are recognised at the first glance by the stiff and pointed quills with which they are armed, somewhat similar to those of the hedgehogs, but usually much larger. Besides the *Porcupines* and their allies, however, to which this description more particularly applies, this family contains several forms which connect it with the two preceding. The name porcupine is corrupted from the French *porc-épin*, a term expressive of the pig-like aspect and grunting voice of these animals, as well as of their spiny covering. They live in burrows, and have very much the habits of rabbits. The best known species inhabits the south of Italy, Sicily, and Spain. It is nearly the largest of the Rodentia, measuring almost three feet in length. There is an American genus nearly allied to the true porcupine, which has a long prehensile tail, like that of the opossums, and lives in trees.

122. (v.) The next family, that of CAVIDÆ, contains the largest-sized animals of this order, although, when compared with ordinary quadrupeds, they would be termed small. They are naturally restricted to tropical America, where they replace the hares and rabbits of cold climates. But the *guinea-pig* is now extremely common in Europe, and is quite domesticated. The *capybara* is an inhabitant of the sides of nearly all the great rivers of South America, and is the largest known animal of the order, being about three feet in length, and of the size of the Siamese pig. It has a large, thick, and blunt muzzle, is destitute even of the rudiments of a tail, and is scantily covered with bristly hairs. Its semi-aquatic habits are shown by the webbing of

162. How is the Beaver tribe described?

163. What of the Porcupines?

the feet. By this structure it can both swim and dive with much activity. Upon land it makes but little progress,

The Capybara.

running badly, and generally diving in the water to avoid danger. It lives in small societies, and seems to be a nocturnal feeder. Another of the Cavidæ is the *agouti*, which is an inhabitant of the Antilles and tropical America. It is about the same size as the European hare, and like it possesses great length of the hind legs, by which it runs, or rather leaps, with considerable swiftness. In regard to its food, however, and its manner of feeding, it rather resembles the squirrel; preferring nuts to herbage, and sitting upon its haunches whilst eating. When angry, it stamps with the fore feet, grunts like a young pig, and erects the bristly hair of the crupper in the manner of a porcupine.

123. (VI.) The animals of the small family CHINCHIL-LIDÆ were until recently known only by their skins, which constitute an important article of commerce. In their general organization they seem intermediate between the cavies and rabbits, but differ from both of them in possessing clavicles. They are all natives of South

164. Describe the Guinea-pig family.

165. What variety is named?

America, chiefly inhabiting the range of the Andes, and they live socially, in extensive burrows.

124. (VII.) The LEPORIDÆ constitute the last family of the Rodentia, and are distinguished from the rest by the presence of two small incisors behind the rodent teeth. The form and habits of the typical genus, *Lepus*, are sufficiently well known in the *hare* and *rabbit* of this country. A large number of species exist in the different parts of the northern hemisphere, and some are inhabitants of the arctic regions. There is one species of this country, in which the brown fur, that forms its summer coat, changes to white at the approach of winter. The hare is a ruminating animal, though without the peculiarly complex stomach of the Ruminantia. The *lagomys* or rat-hare is a very interesting genus, allied to the hare, but having nearly perfect clavicles, and the fore legs almost as long as the hind. It is chiefly remarkable for the mode in which it lays up its store of winter provisions. It lives in solitude or in small societies in the mountainous parts of Siberia, and hollows out its burrow amongst stones and in the clefts of rocks, and sometimes in the holes of trees. About the middle of August these animals collect their store of winter provender, which is formed of select herbs, and these they bring near their habitation, and spread them out to dry like hay. In September, they build up the fodder they have collected into heaps or stacks, which they place under the rocks, or in other places sheltered from the rain or snow. Where many of them have laboured together, their stacks are sometimes as high as a man, and more than eight feet in diameter. These stacks, which consist of the choicest and most succulent herbs, are often pilfered by the natives of that part of Siberia for the subsistence of their cattle and horses. A subterranean gallery leads from the burrow of the lagomys, beneath the mass of hay, so that neither frost nor snow can interrupt the animal's communication with it.

166. Describe the Chinchilla group.

167. What of the Hare family?

Order VIII.—Edentata, [or toothless tribe.]

125. The animals composing the order Edentata cannot be described by any general positive characters which separate them from other groups; for there is a considerable dissimilarity in the entire structure and habits of the different species. The chief point of agreement amongst them is a negative one—the absence of incisor teeth, and the termination of the extremities in long claws. These claws are usually few in number, and partially embrace the extremities of the bones from which they are prolonged, so that each forms a kind of pointed hoof; and we have thus an approximation towards the unguiculated division of the Mammalia. The order may be separated into two distinct groups; one consisting of the EDENTATA-PROPER, and containing the Ant-eaters, Armadillos, &c., all of which are insectivorous; the other, denominated TARDIGRADA, from the slowness of movement of the animals composing it, and containing the Sloths.

126. (1.) The true EDENTATA are distinguished, like other insectivorous Mammalia, by their pointed muzzle. This is particularly remarkable in the *Ant-eaters*, which are peculiar to the warm and temperate regions of South America. They are destitute of any teeth; but possess a very long thread-like tongue, which they insinuate into ant-hills and the nests of the termites (or white ants), whence these insects are withdrawn by being entangled in the viscid saliva that covers it. Their fore-nails, strong and trenchant, enable them to tear open these nests, and also furnish them with an effective means of defence. These animals are well covered with hair; but the *Pangolins*, which resemble them in being destitute of teeth, and in the mode in which they obtain their food, are covered with large scales, which they elevate, as the hedgehog does its spines, when they wish to defend themselves against an enemy. These occur only on the old continent, where they represent the Ant-eaters of the new.

168. How is the toothless order divided?

169. What of the Ant-eater family?

127. Most of the other true Edentata are burrowing animals, and are covered with a dense armour, composed of hard scales arranged in a *tesselated* manner, or fitted together like stones in a pavement. Between the different bands of these, there are narrow rings of membrane, which allow the body to bend. They have claws adapted for digging, seven or eight cylindrical molars on each side, and a tongue but little extensible. Of these animals the *Armadillos* are the chief, and are the forms best

Poyou or Six-banded Armadillo.

known. They subsist partly on vegetables and partly on insects and carcasses. Some of them appear to prefer putrefying animal matter; and many are nocturnal feeders. They are all confined to South America, where also is found another extraordinary animal, the *chlamyphorus*, which presents a remarkable mixture of the characters of different tribes. It has a firm tessellated shield, like the armadillo; but this only protects the upper surface of the body, to which it is rather loosely attached. The sides and under surface of the body are covered with fine silky hair, like that of the mole. In the form of its skeleton it has points of analogy with the beaver, the mole, the sloth, the ant-eaters, the Monotremata, the Ruminantia, besides the armadillos, to which its relationship is nearest. The hinder part of the body has a remarkable squareness, as if it had been suddenly terminated; whence its specific name, *truncatus*. The

170. Describe the variety here cited.

orycteropus, termed the Cape ant-eater or ground-hog by the Dutch colonists, is a genus of this division, connecting the ant-eaters and armadillos; having the extensible tongue of the former, and subsisting on the same food, with the molar teeth and burrowing habits of the latter.

128. (II.) The animals belonging to the family TARDIGRADA [from the Latin, *tardus*, slow, and *gradus*, step] are at once known from the true Edentata by the peculiar shortness of the muzzle. The name of the family is derived from that commonly applied to the animals composing it. In the *Sloths*, according to Cuvier, "nature seems to have amused herself with producing something imperfect and grotesque." And if we consider the peculiarities of their organization in reference to the ordinary habits of mammiferous animals, this appears to be true. Both the fore and hind legs, by their form and proportions, and the manner in which they are joined to the body, are quite incapacitated from acting in a perpendicular direction, and of supporting the body from below; so that,

Two-toed Sloth.

when the animal is placed on the floor, his belly touches the ground. Moreover, he has no soles to his feet, and his claws are very sharp, long, and curved backwards; so that he has no firm support, and can only move forwards by laying hold of some fixed object, and dragging himself on by his hooked claws. But when placed on a

branch, his aspect is altogether different. In the wild state, the sloth passes his whole life on trees, and never leaves them but through force or accident, or to pass from one to the other, which in the densely tangled forests of South America, where alone it exists, is not frequently necessary. But, though appointed to spend its whole life in trees, it is not adapted to live *on* the branches, like the squirrel or monkey, but *under* them. It moves suspended from them; it eats suspended from them; it sleeps suspended from them. And, when its structure is considered in its adaptation to this extraordinary position, it is seen to be most admirably devised to meet the wants of the animal. The muscular system seems capable of prolonged action without effort; and this may perhaps be aided by the peculiar disposition of the arteries already noticed as possessed by the lori. The sloth remains upon a tree until it has stripped it of every leaf, and then it proceeds to another. It has been observed that, in the more open places, where the trees are less contiguous, the sloths take advantage of windy weather to effect their transits, when the boughs are blown together and commingled. The peculiar conformation of these animals ought, therefore, no more to excite our pity and compassion than the circumstance of fishes being destitute of legs. Their elevated habitation removes them out of the reach of the carnivorous animals, by which the race might otherwise be extirpated.

129. There have been found in South America—the country to which the existing Edentata are almost confined—remains of some enormous extinct animals, belonging evidently to the same group. Of one of these, the *megatherium*, nearly the whole skeleton has now been studied by comparing different imperfect specimens; and there can be little doubt that it belonged to a gigantic animal intermediate between the sloths and ant-eaters. Its haunches must have been more than five feet wide; and its body fourteen feet long and eight high. Its feet were

171. How are the Sloth family described?

172. Name some of their remarkable traits.

a yard long, and terminated by gigantic claws. Its whole structure seems to have been adapted to digging the earth in search of the succulent roots which probably constituted great part of its food. Another extinct animal of the same description is known by little else than its claws, and fragments of bones and teeth. From the form of the claw, the *melonyx* (as it has been named) was at first supposed to be a carnivorous animal; but Cuvier satisfactorily proved it to belong to the Edentata. It seems nearly allied to the megatherium. Remains of tessellated bony armour have also been found, which indicate the former existence of a large animal allied to the Armadillos, to which the name *glyptodon* has been given; and other remains of gigantic ant-eaters have lately been discovered in the same locality.

130. The Edentata terminate the series of the *unguicula'te* or *clawed* true Mammalia; and, as has been just seen, there are some among them with the claws so large, and so enveloping the ends of the toes, and these reduced to so small a number, as to approximate to the nature of hoofs. Nevertheless, they have still the faculty of bending their toes round various objects, and of grasping with greater or less force. The entire absence of this faculty characterizes the *hoofed* animals. They use their feet only as supports, and the forearm has not the power of rotation, its two bones being frequently consolidated into one, or one of them greatly enlarged at the expense of the other, like those of the leg of man and of most Vertebrata. The hoofed animals in no instance possess clavicles, and they are entirely vegetable feeders. Their forms and mode of life present, therefore, much less variety than is found in the unguiculated animals, and they can hardly be divided into more than two orders—those which ruminate, and those which do not. The former constitute a very natural and easily circumscribed group, the animals which compose it bearing a strong general resemblance to each other, and being easily distinguished from other groups. The latter contains a number of different forms,

173. What extinct animals of this group?

174. Describe their structure.

the connection of which with one another by any very important peculiarities common to all is not very obvious. On account of the general thickness of their skins, they are called **PACHYDERMATA**.

Order IX.—Pachydermata, [or thick-skinned tribe.]

131. The order Pachydermata, [from the Greek, *pachus*, thick, and *derma*, skin,] consisting of hoofed animals which do not ruminates, may be divided into three groups, each of which show a tendency towards some other order. The first of these, **PROBOSCIDEA**, containing only the *elephant* and its extinct congeners, [from the Latin, *con*, with, and *genus*, kind, of the same genus,] approaches in several particulars to the Rodentia. In both we find two large front teeth developed at the expense of the rest, and the grinders are formed of parallel plates of enamel and bony matter. There are also many points of resemblance in the form of the bones, and more particularly in those of the extremities. For the elephant has not a complete hoof, but five toes to each foot, which are very distinct in the skeleton; but being enveloped in a callous skin, which surrounds them all, the only external indication of their separate condition is in the nails at their extremities. The second group, that of **TRUE PACHYDERMATA**, contains those which have four, three, or two toes to their feet. Those in which the toes make even numbers, as the **SUIDÆ**, or *Pig* kind, have feet somewhat cleft, and approximate to the Ruminantia in various parts of the skeleton, and even in the complication of the stomach. Of the others, which have not cloven feet, some approach the Proboscidea, with which they are connected by forms now extinct, but of which the bony remains are sufficient to determine their character. The third group of Pachydermata, the **SOLIDUNGULA**, consists of quadrupeds with only one apparent toe, and a single hoof to each foot, as in the *horse*. These, also, in their general form and manner of life, approach

175. Into what groups is the thick-skinned order divided?

176. What species belongs to the first division?

177. Give an example of the 2d and 3d.

th Ruminantia, with which they are particularly connected by the camel and an animal now extinct. Another group should also probably be associated with this order, holding the same rank in it as the Amphibia or Seal tribe among the Carnivora. This is the small family of aquatic herbivorous animals, termed *MANATIDÆ*, which were placed by Cuvier among the Cetacea, but which differ from the true whales in several important particulars, and are found to be closely connected with the hippopotamus [or river horse] by links now extinct.

132. (1.) The first group, *PROBOSCIDEA*, [from the Greek *proboskis*, a trunk or proboscis,] contains only one living genus, the *elephant*, of which the *mammoth*, which has become extinct within a comparatively recent period, is an allied species. Another extinct animal of this group is the *mastodon*, which, in the conformation of its teeth appears to have some affinity with the hippopotamus. All these animals agreed in possessing a pair of enormous tusks or front teeth, and a very elongated nose or proboscis; and it is probable that this last organ was formed, as in the elephant, to answer the purposes of a hand, laying hold of large objects by coiling itself round them, and of small by means of the finger-like organ at its extremity. The magnitude of the sockets necessary to hold the tusks renders the upper jaw so high that the nostrils, which are prolonged through the trunk, are placed in the skeleton near the top of the face. By means of its trunk, the elephant not only lays hold of its food, but sucks up its drink, which it causes to fill its capacious nostrils, and then discharges, by bending its trunk, into its mouth. By this admirable organ, the shortness of the neck, rendered necessary by the weight of the head, is fully compensated. The cavity for the

Elephant.

178. What animals are included in the first group?

179. Describe the proboscis and its use.

brain by no means corresponds with the external form of the skull; for, in order, as it would seem, to give a larger surface for the attachment of the muscles of the trunk, the outer layer of bone is widely separated from the inner, and between the two are a number of large bony cells.

133. In none of the Proboscidea has the lower jaw of the adult any front teeth. The arrangement of the grinders differs in the various species; but in all they are composed of alternating plates of hard *enamel* and softer *bony* matter, cemented together by a third substance, which is termed the *cortical*, [from the Latin *cortex*, bark.] These grinders are in constant progress of renewal; but they succeed each other, not by rising from below upwards, as in man, but by being pushed forwards from behind, in proportion as the tooth before each is worn away. There is never more than one *perfect* molar on each side; but in proportion to the age of the animal there may be two, three, four, or more, the front ones being the worn-down remains of those at first formed. It is stated that the molars are thus renewed eight times. The tusks, however, are only changed once; but, like the cutting-teeth of the Rodents, they are constantly being renewed at the roots. Two species of elephants exist at the present day, both of which inhabit tropical climates, one in Asia, the other in Africa. Remains of the mammoth are chiefly found in the north of America and of Siberia; and, from a nearly perfect specimen, which was discovered frozen in the ice near the mouth of the river Lena, it appears that this species was adapted to live in cold climates—the skin being densely covered with hair of two kinds. The habits of the elephant are sufficiently well known to render it unnecessary here to dwell on them. Its food is entirely vegetable; and in its undomesticated state, it consists chiefly of the leaves and young branches of trees, and of the long herbage of the ground, both of which it gathers with its trunk. The tusks serve not only as weapons of offence and defence, but to root up small trees and tear down cross

branches, either to obtain their leaves or to make a passage for the bulky body of the animal through the tangled forest.

134. (II.) Of the true Pachydermata, the first family is that of *Suidæ*, [from the Latin *sus*, a hog,] the *Pig* kind. It is characterized by the peculiar thickness of the skin, and by the presence of four toes on each foot. They have three sorts of teeth in each jaw; the canines are usually long, and project forward as tusks; the anterior molars are more or less narrow and conical, whilst the posterior are tuberculated. The food is principally vegetable, but admits of considerable variation. The domesticated pig is well known to be quite an omnivorous animal. In the true pigs, the foot has two toes furnished with large hoofs, and two much shorter ones that scarcely touch the ground. The *wild-bear*, which abounds in some parts of the continent of Europe, is well known to be a very ferocious animal; and the domesticated race which is derived from it often exhibits indications of the same character. One of the most curious animals of this tribe is the *babyroussa*, a native of the Indian archipelago;

Babyroussa.

the upper canines of which are very long, and grow spirally upwards and backwards. These serve as defensive weapons of a very powerful description, inflicting severe lacerations by an upward stroke of the head. The *pec-*

181. Describe the Pig tribe.

182. How are they diversified?

caries of South America want the external toe, and the central ones are partly joined together, as in the Ruminants; to which the complex structure of their stomachs also exhibits their affinity.

135. With the family of Suidæ is probably to be placed the *hippopotamus*, [from the Greek *ippos*, a horse, and *potamos*, a river,] or river-horse, which seems in many respects intermediate between the pig and the elephant; whilst its aquatic habits, and the conformation by which it is adapted to these, approximate it to the Dugongs. Only one species is known, which is now confined to the rivers of middle and south Africa. But for its short, thick, and very blunt muzzle, it might be compared to a gigantic pig; the body is extremely massive, and the legs so short that the belly almost touches the ground; and it is destitute of any covering but a few weak and scattered bristles. The canine teeth are long; the upper ones straight, and the lower curved backwards, so that they rub against each other. Although ferocious, or rather courageous, when attacked, these unwieldy inhabitants of the waters are in their nature shy, and feed entirely on roots and other vegetables, seeming to prefer those which are partially decomposed by the action of the water.

136. (III.) The second family of true Pachydermata, to which the name of TAPIRIDÆ, or the *Tapir* tribe, may be given, resembles the first in the thickness of its skin, but differs in the arrangement of the toes, of which there are only three on each hind foot, and sometimes also in front, without any central cleft. There is considerable variation in regard to the teeth; but the whole family is exclusively herbivorous. No members of it exist in Europe at the present time; but fossil remains of very large species are abundant in some localities. The *tapir* of America is about the size of a small ass, with a brown and almost naked skin, a short tail, and fleshy neck that forms a crest at the nape. It is common in humid places and along the rivers, and its flesh is eaten. The nose

183. What of the river-horse?

184. Describe the Tapir tribe.

assumes the form of a short fleshy trunk—the rudiment, as it were, of that of the elephant. Other species have been recently discovered of a larger size; one of which has the bones of the nose still more elongated, approaching a very remarkable fossil genus, the *palæotherium*, [from the Greek *palæos*, ancient, and *therion*, a wild beast.] This seems to have been an animal nearly allied to the Tapirs; remains of several species, varying in size from a rhinoceros to a small sheep, have been found in the gypsum quarries of Paris, the fresh-water deposits of the Isle of Wight, and other places.

Form of Palæotherium.

137. To this family belongs the *rhinoceros*, [from the Greek *rin*, a nose, and *keros*, a horn,] which is remark-

African Rhinoceros.

able for its large size, and for the kind of horn, composed of a solid fibrous substance, resembling agglutinated hairs, which is supported on an arch formed by the nasal bones. Several species exist in different parts of the tropical por-

tion of the Old World. They are naturally stupid and ferocious, frequenting marshy places, and subsisting on herbage and the branches of trees. In some species a second horn exists behind the first. The upper lip is generally elongated, and has some power of prehension. Rhinoceros' bones have been disinterred in many parts of Europe. There is a curious little animal, the *hyrax*, which is about the size of a rabbit, and was formerly placed among the Rodentia; it is, however, little else than a rhinoceros in miniature, without the horn. It is not uncommon in rocky places in Africa and Syria, and one species ascends trees. It is probably the animal spoken of in Proverbs xxx. 26, as the *cony*.

138. (iv.) The third group of Pachydermata, the SOLIDUNGULA, contains only one family, that of the EQUIDÆ, or *Horse* tribe. Though there is only one apparent toe and single hoof to each foot, there are appendages beneath the skin which represent two lateral toes. The well-known animals of this tribe, the *horse*, *ass*, *zebra*, *quagga*, *onagga*, and *dzigguetai*, are commonly regarded as belonging to but one genus; but the first of these is probably to be separated from the rest, from the circumstance of its tail being wholly clothed with long hair, while that of the rest has long hair only towards the tip. On this point, however, there is much uncertainty, arising from our ignorance as to the original stock of the horse. In all the instances in which we at present know horses to exist in a wild state, the race appears to have been originally derived from a domesticated stock. This is certainly the case with regard to the wild horses which now spread over the plains of South America, all of which are descended from those first introduced there by the Spaniards.

139. All the animals just named agree in their dentition. There are six incisors to each jaw, which, during youth, have their crowns furrowed by a groove, and six molars on each side, above and below, with square crowns, marked, by plates of enamel which penetrate them, with

186. What of the rhinoceros?

187. How is the Horse tribe diversified?

four crescents. The males have, in addition, two small canines in their upper jaw, and sometimes in both; these are always wanting in the females. Between the canines and the first molar there is a wide space, which corresponds with the angle of the lips, where the *bit* is placed, by which alone man has been enabled to subdue these powerful quadrupeds. None of the species of this family are indigenous to America.

140. (v.) The animals associated in the family *Manatidæ*, may be considered as Pachydermata still more adapted than the hippopotamus to an aquatic residence. In their teeth and general organization they bear a close correspondence to this order; and the fish-like form which they exhibit is scarcely a greater variation than is seen in the order Carnivora. The posterior extremities of these animals are entirely wanting, as in the true Cetacea. The trunk is continued by a thick tail, which terminates in a horizontal cartilaginous fin; and the bones of the anterior extremities are arranged in a flattened form, so that the skin which includes them all has a fin-like surface. They act rather as *steerers* (like the lateral fins of fishes) than to propel the animals through the water, which is chiefly done by the tail. They not unfrequently leave the water to seek their food on shore. Although the nostrils in the skeleton open near the summit of the head, as in the elephant, the orifices of the skin are pierced at the extremities of the muzzle. They have usually no hair on the general surface, but possess mustaches like the seals and morses. One species, however, the *stellerine*, is entirely covered with a thick rugged cuirass, formed of agglutinated hairs, like the hoofs of some ungulated quadrupeds. The type of this family is the *manati*, which grows to the length of fifteen feet, and frequents the mouths of the African and American rivers. It is called sea-cow, and its flesh is eaten. Vestiges of nails are visible on the edges of the swimming paws, which it employs with some address in carrying its young. The

188. What of their teeth?

189. What other family of this group?

dugong, inhabiting the Indian Ocean, differs a little from the manati in its dentition.

141. This group is connected with the true Pachydermata by several fossil genera, but particularly by a very remarkable one recently discovered, the *dinotherium*, [from the Greek *dienos*, terrible, and *theiron*, wild beast.] This must have been the largest of the Mammalia not strictly aquatic, its total length being probably eighteen feet. It blends the characters of the tapir and elephant with that of the Cetacea, having probably possessed a trunk and an enormous pair of tusks, directed downwards, though fixed in the lower jaw, and having been deficient in posterior extremities. The tusks, like those of the morse, were probably employed in raking up vegetable matter from the bottoms of the rivers and lakes it seems to have inhabited.

Order X.—Ruminantia, [or cud-chewing animals.]

142. The order Ruminantia is perhaps the most natural and best determined of the whole class, for all the species which compose it seem constructed, as it were, upon the same model, the camels alone presenting any considerable exceptions to the general characters of the group. The first of these characters is the entire absence of incisor teeth from the upper jaw; whilst the lower appears to possess eight: of these, however, the two outer ones are really canines which have taken the form of incisors, so that the number of the true incisors is six, as in the other viviparous Mammalia. The molars are almost always six in number, both above and below, and have their crowns marked with two double crescentic ridges of enamel, which aid in triturating the food. The feet are each terminated by two toes and two hoofs, which present a flat surface to each other, appearing as though a single hoof had been cleft; hence the names that have been applied to these animals, of cloven-footed, &c. Behind the hoof there are

190. What recent fossil genus is named?

191. Describe the cud-chewing order.

always two small spurs, which are the vestiges of lateral toes.

143. The name of the order intimates the singular faculty possessed by these animals, of masticating their food a second time, or "chewing the cud." This faculty depends on the structure of their stomachs, which are four in number. The food which is cropped by the incisor teeth is swallowed almost without mastication, and is moistened in the stomach; and after being compressed into little pellets or *cuds*, is returned to the mouth to be rechewed while the animal is at rest. When this operation has been performed, the food is transmitted to the true digestive stomach. This remarkable provision has a very interesting adaptation to the general structure and characters of these animals. The Ruminantia, taken as a group, are timid, and destitute of powerful means of defence against their foes. They rather seek their safety in flight when attacked. Their food, consisting chiefly of the grasses of various kinds, requires to be thoroughly masticated before it can be properly digested. When feeding on the pastures they frequent they are liable to many alarms; and if they were compelled to spend a considerable time in masticating their food before swallowing it, they would often be in danger of starvation, by being obliged to leave their pasture before their wants were supplied. But by their power of subsequent rumination, they are enabled to dispense almost entirely with the first mastication, and to feed with comparative quickness. They convey a store of food into the first stomach or paunch, as the monkey into its cheek-pouches; and then, retiring to a secure place, they prepare it for digestion at their leisure.

144. The whole structure of these animals corresponds with the account just given of their habits. Their legs are long in proportion to their body, and the spinal column is very flexible; both which conditions are favourable to great activity of motion. They are endowed with a very acute sense of smell, which seems to be their guide in the

192. How is their peculiarity explained?

193. What peculiarity in their structure?

selection of their food. Their ears are placed far back, and are very movable; and these are well adapted to catch sounds from behind, so as to warn the animals of danger whilst feeding. The eyes are placed at the sides of the head, and the pupil is in the form of a horizontal oblong; so that the range of vision along the surface of the earth is very great, and the animals can easily look behind them when pursued. Their means of defence consists in the use of their horns to gore their enemy, and of their hind feet to kick it; but it is only when peculiarly courageous that single animals of this species will act on the offensive, or stand on the defensive, against others of proportional size and strength.

145. The Ruminants, of all animals, are those which are most useful to man. They supply him with a large proportion of his animal food. Some serve him as beasts of burden; others furnish him with their milk, their tallow, leather, horns, and other useful products.

146. The great resemblance which exists among the very numerous members of this order, renders the distribution of them into families, each characterized by some important peculiarity, a matter of some difficulty. These subdivisions are, probably, best erected upon the character of the horns, which are possessed by the males of all the species in their natural state, excepting such as (like the camel) connect this order with other groups. The horns are essentially bony prominences from the fore part of the skull. In some Ruminants, commonly termed *cattle*, such as oxen, sheep, goats, and antelopes, these prominences are covered with an elastic sheath, formed as it were of agglutinated hair, which continues to increase by layers during life. It is to the substance of this sheath that the name of *horn* is commonly applied, whilst the bony support is termed the *core*; this grows during life, and never falls. In the *giraffe*, again, the bony prominences are covered with a hairy skin, which is continuous with that of the head; and here, too, the bony part of the horn is perma-

194. Of what uses are these to man?

195. What variety is the basis of sub-division?

ment. But in the *deer*, these prominences, which are covered for a while with a hairy skin (commonly termed *the velvet*), like the other parts of the head, have at their base a ring of bony tubercles, which periodically enlarge, and compress the nutritive vessels of the horns. These accordingly die, and fall from the skull, and the animal remains defenceless. Others, however, are reproduced, generally larger than before, which are destined to undergo the same fate. These horns, periodically renewed, are usually styled *antlers*.

147. The Ruminants with horny sheaths to the bony prominences, may be divided into three families. ANTELOPIDÆ, or *Antelope* tribe, characterized by the lightness of their forms and the activity of their movements, and by the solidity of the bony core. CAPRIDÆ, or *Goat* tribe; in these the bony core is partly occupied with cells, and the general form approaches that of the Ox tribe; but the horns are directed upwards and backwards. BOVIDÆ, or *Ox* tribe: these have the horns directed upwards and forwards; the form is robust, and the movements heavy. The division of the Ruminants in which the horns are periodically cast off, constitutes only one family, that of CERVIDÆ, the *Stag* tribe. Another family, including only the giraffes, and named CAMELOPARDÆ, is characterized by the shortness and permanence of the horns, which are covered with a skin. Of the Ruminants without horns there are two distinct families—the MOSCHIDÆ, or *Musk Deer*, which are remarkable for their elegance and lightness, and differ but little from the rest of the order save in the absence of horns; and the CAMELIDÆ, or *Camel* tribe, which in their dentition and in the structure of the extremities, exhibit a transition to the Pachydermata.

148. (1.) The family ANTELOPIDÆ, remarkable for the slenderness of form and swiftness of foot of the animals composing it, contains above seventy well-ascertained species bearing a strong general resemblance to each other. Most of these are natives of Africa; a few species, however, inhabit Asia; a still smaller number exist in Ame-

rica ; and one only, the *chamois*, now remains in Europe. Among these numerous species we meet with forms that remind us of the other families of the Ruminantia—the ox, goat, stag, &c. They generally associate in large herds, which migrate together in search of pastures. A species well known to the colonists of South Africa is the *spring-bok* ; which occasionally visits their cultivated lands, during seasons of drought, in innumerable herds, causing devastation wherever they pass. The antelopes may probably be regarded as the types of the Ruminantia, exhibiting the peculiar characters of the order in the most remarkable degree. They are extremely vigilant and timid : and the speed of the swiftest species surpasses

Spring-bok Antelope.

that of every other mammiferous animal. Those which are adapted to live on rocks and mountains exhibit the most remarkable agility, and fearlessness of those dangers which their habits would seem to involve ; they walk with perfect composure along the giddy brinks of the most awful precipices, climb and descend with wonderful care and precision, and leap up or down to the smallest surface that will contain their collected feet, with perfect firmness ; and yet they are so fearful of any supposed enemy, that it is difficult to get within gunshot of them. Allied to the antelopes is a very curious genus, the *gnu*, which at first

sight seems to be a monstrous being, compounded of parts of different animals. It has the body and crupper of a small horse, covered with long hair; the tail furnished with long white hairs like that of a horse; and on the neck a beautiful flowing mane. Its horns resemble those of the Cape buffalo; and its legs are as slender and light as those of a stag. It inhabits Southern Africa.

149. (II.) The family of *CAPRIDÆ* [from the Latin, *capra*, a goat] is connected with the last by many antelopes, which, like the chamois, approach the goats in form. It includes only the *goats* and *sheep*. The original stock of the domestic breeds of the former appears to be indigenous to Persia, where it inhabits the mountains in large troops. The goats of Angora, Thibet, &c., celebrated for the fine quality of their hair, are no more than varieties of the common species. The *ibex*, which inhabits the mountains of the Old World, and especially the Caucasian chain, is distinguished by the size and strength of its horns. It is said that this animal fearlessly precipitates itself down precipices, always falling on its horns, the elasticity of which secures it from injury. The *sheep* appear to have extremely little real difference from the goats: a large number of races exist, the relation of which to each other is uncertain; and there is doubt as to the original stock of the whole. Of the domestication of this animal we have an earlier record than of any other.

150. (III.) The species of the family *BOVIDÆ*, [from the Latin *bos*, *bovis*, an ox,] or *Ox* tribe, are comparatively few. They are all large animals, with a broad muzzle, heavy and massive body, and stout limbs. Of the original stock of the domestic ox we have no certainty, since, as in the case of horses, the existing races of wild cattle are probably all descended from those which have been at some period subservient to man. Of all the animals

198. What species are named?

199. What of the Gnu genus?

200. How are the Goat family divided?

which have been reduced to his service, the ox is, without exception, that to which he is most indebted, for the extent and variety of his means of usefulness. The universal utility of the animal appears to have been very soon detected; and we find, consequently, that its domestication soon followed that of sheep, and that it is mentioned in the most ancient records as a servant of man, long before either the horse or dog are noticed. The ancient accounts of the *urus* or *wild-ox* declare it to have

Brahmin Ox.

been an animal of great size and fierceness, with large spreading horns; and bones are found in the most recent deposits, both in this country and on the continent, which correspond with that description. Many races or breeds of oxen exist in different parts of the world, which were probably all descendants from one stock, and yet differ considerably from one another. Most of those inhabiting the torrid zone have a lump of fat upon the shoulders, which increases in size and proportion to the abundance of their food. This is especially remarkable in the *Indian* or *Brahmin-bull*, which, being held sacred

by the Hindoos, is supplied with food in great profusion, and leads an indolent life. When left to themselves, their form changes; they become less bulky and more active, and the hump, in particular, greatly diminishes. Some of the tropical races of oxen are no larger than a hog.

151. Amongst the undomesticated species of this family, which have all a strong general resemblance to each other, and are the most powerful and savage animals of the whole order, may be noticed the European *bison*, which was formerly spread over Europe, but is now restricted to Lithuania and the Caucasian region; the American bison, commonly called *buffalo*, which inhabits all the temperate parts of North America; the *Indian buffalo*,

Cape Buffalo.

of which there are several different races (in one, the horns include a space of ten feet from tip to tip), of which some have been domesticated; the *Cape buffalo*, an extremely

202. Describe the varieties of this family.

203. What of the bison and buffaloes?

ferocious animal with large horns, first directed downwards so as nearly to cover the forehead, inhabiting the woods of Caffraria; and the *musk-ox*, a species inhabiting the coldest regions of North America, with short legs, and long hair reaching the ground, which diffuses more strongly than the rest the musky odour common to the whole genus, and which is particularly noticeable in the European bison.

152. (IV.) The family CERVIDÆ, [from the Latin *cervus* a stag,] or *Stag* tribe, includes, like that of antelopes, a large number of species differing but little amongst each other, very widely diffused over the earth's surface, and easily separated from others by the character of the horns. With the exception of the reindeer, however, the female is destitute of horns, save in a few rare individual cases, analogous to those in which the hen assumes the plumage of the cock bird. The substance of the horns, when completely developed, is that of a dense bone, without pores or internal cavity; the figure varies greatly according to the species and even in the same individual at different ages. These animals are extremely fleet, and live mostly in forests, where they feed on grass, the leaves and buds of trees, &c.

153. This very extensive genus may be subdivided into sections, according to the form of the antlers. In some species they are wholly or partially flattened. This is the case, for example, with the *elk*, one of the largest existing species, which lives in troops in the marshy forests of the north of both continents. It is as large as a horse, and sometimes larger. The antlers of the male, at first dagger-shaped, and then divided into narrow slips, assume, at the age of five years, the form of a triangular blade, with tooth-like projections on its outer edge. These increase with age; so that the horns have at last fourteen branches proceeding from each expanded portion, and weigh fifty or sixty pounds. To this group also belongs the *reindeer*, so serviceable to the Laplanders, which is the only species properly domesticated, though others

204. Describe the Stag tribe.

205. How are these divided?

are doubtless susceptible of being so. The *fallow-deer*, now naturalized in this country, but probably introduced from the south of Europe, or even originally a native of Barbary or Western Asia, is another species of this group. The remains of a gigantic species of deer, belonging to the same section, are frequently found in peat bogs, and other recent deposits in this country, and more especially in Ireland, whence the name *Irish elk* has been given it. Judging from specimens of which the greater part of the bones have been discovered, it must have stood more than six feet high, and have been nine feet long; but there is no doubt, from the dimensions of many of the horns which are preserved (one pair measuring thirteen feet between the tips), that this is under the average size of the race.

154. The species with round antlers are more numerous; those of temperate climates change colour, more or less, with the seasons. The common stag, or *red deer*, is the best known of these, being indigenous to the forests of all Europe and of the temperate parts of Asia. The Canadian stag, or *wapiti*, the elk of the Anglo-Americans, is a fourth larger. There is also another species, inhabiting Virginia and the central parts of North America, which is smaller than the European stag, and is known as the deer. A large number of species are indigenous in central and southern Asia, of which some have been naturalized elsewhere.

155. (v.) Of the family CAMELOPARDÆ [from the Greek *kamelos*, a camel, and *pardalis*, a leopard] only one species was for a long time known to exist; but there are probably two or even three kinds of giraffe, all of which are natives of Africa, mostly frequenting the borders of the deserts. Its remarkable form, depending chiefly on the great length of its neck and forelegs, is familiar to every one. In its general structure, however, it closely resembles the deer, differing from them in the permanence of the horns. It has also some points of affinity to the camels, especially

206. What variety in the antlers?

207. How are they diversified?

in the length of its neck, the existence of callosities, or hard surfaces, on the breast and knees, and the absence of the small spurious hoofs. It is the tallest of all animals, its head being frequently raised eighteen feet from the ground. Its disposition is gentle, and it feeds on leaves; browsing upon the young branches at a height much above that which any other animal can reach, and drawing them towards its mouth by its prehensile tongue. It lives in small troops of five or six individuals, and is very timid, although capable of powerfully defending itself by kicking. Notwithstanding the length of its neck, the number of vertebræ which this part contains is no greater than in other Mammalia.

156. (vi.) The MOSCHIDÆ, or *Musk-deer*, are completely intermediate between the true *Deer* and the *Camel* tribe, which last connects the Ruminantia with the Pachydermata. They resemble the ordinary Ruminants in the lightness and elegance of their forms, and in the nimbleness of their movements; and differ chiefly in the absence of horns, and in the projection of the canine tooth on each side of the upper jaw, as in the camels. The name of this group has been derived from the common musk, the males of which secrete the odoriferous substance so called. This species is almost without tail; and the hairs, which completely cover it, are so coarse and brittle that they might almost be called spines. It is confined to the mountainous region between Siberia, China, and Thibet, from which most of the Asiatic rivers descend. Its habits are nocturnal and solitary, and its timidity extreme. The other musk-deer inhabit the warmer parts of Asia and the eastern archipelago; they have no musk-pouch. They are the smallest and most elegant of the Ruminantia, and are active and gentle in their habits.

157. (vii.) The CAMELIDÆ, or *Camel* tribe, approximate to the preceding order, and especially to the whole-hoofed division of it constituting the Horse tribe, more than do any other Ruminants—to such a degree, indeed, that some

208. What of the giraffes?

209. Describe the musk-deer.

naturalists prefer associating them with that group. They have always canines in both jaws, and two of the incisors have also the same pointed shape. The animals of this family are much less elegant in form and graceful in action than the other Ruminants; but their organization is, equally with theirs, most perfectly adapted to the circumstances in which they exist. The family contains two groups, the *Camels* and *Llamas*; the former are restricted to the Old World, and the latter correspond to them in the New.

158. In the true *Camels* the two toes are united below by a kind of horny sole, almost to their points, which terminate in small hoofs; and there is a soft cushion beneath the foot, by which it bears upon the sandy surface over which it is formed to move. Two species are known, one called the *Bactrian*, or *two-humped camel*, and the other the *Arabian*, or *one-humped*. Both are completely domesticated. The first is employed chiefly in Central Asia, the latter in Arabia, North Africa, Syria, Persia, &c. The two-humped camel is the larger and stronger, being capable

Dromedary.

of sustaining above one thousand pounds' weight, and is best adapted for rugged ground; the other is the most abstemious, and the best fitted for the sandy desert. The

210. What is remarkable in the Camel tribe?

211. What variety is cited?

dromedary is merely a lighter variety of it, possessed of greater fleetness and power of endurance. The flesh and milk of the camel serve as food, and the hair for the manufacture of cloth, to the people who possess it. Their humps, principally composed of fat, are provisions of super-abundant nutriment, which are gradually absorbed and disappear on the occasion of a scarcity of other food, as is observed at the end of a long journey. By resting on their callosities, they are enabled to repose on a scorching surface, and their stomachs are adapted to contain a supply of water sufficient for several days.

159. The *Llamas* of South America are much smaller than the preceding; they have the two toes quite separate, and are without humps. They were the only beasts of burden possessed by the Peruvians at the time of the conquest. They can only make short journeys, and the largest of the four species known cannot sustain more than one hundred and fifty pounds. Remains of a fossil species have been lately found, which must have equalled the camel in stature.

Order XI.—Marsupialia, [from the Latin *marsupium*, a purse, pouch, or bag.]

160. The two remaining orders of Mammalia, the Marsupialia and Monotremata, are now usually regarded as constituting a distinct sub-class, termed *Ovo-vivipara*, intermediate between the truly viviparous Mammalia and the oviparous Birds and Reptiles. Their most obvious peculiarity is the production of their young at a very early period of development, in a state incapable of motion, and barely exhibiting the rudiments of limbs; so that it is not until a long time after their birth that they acquire a condition parallel to that of a new-born animal of one of the higher orders, and they much more resemble the half-formed chick in an egg which has been but a few days incubated. In accordance with the lower grade of this important function, we find a general inferiority of the

212. Describe the dromedary.

213. How are the Llamas characterized?

214. What is the next order and its peculiarity?

whole organization to that of the truly viviparous Mammalia, and approaches, in many points of structure, to birds and reptiles. The skeleton, the nervous system, the arrangement of the large blood-vessels, and the larger number of the incisor teeth (which in the higher sub-class never exceed six), all show indications of this approximation; and this is also indicated in the deficiency of intelligence, which is manifest in their physiognomy as well as in their actions.

161. Of these two orders, that of Marsupialia is the one which exhibits the least departure from the general type of the Mammalia, and it is that, too, in which the provision for the continued nourishment of the young by its parent is the most remarkable. The new-born imperfect offspring attaches itself to the teats of the parent, and remains fixed there until it has acquired a degree of development comparable to that with which other animals are born. The skin of the abdomen of the parent is so disposed as to form a pouch, in which these imperfect young are protected, and into which, long after they can walk, they retire for shelter on the apprehension of danger. It is from the pouch (*marsupium*) that the order takes its name, this being its distinguishing peculiarity. It is remarkable that, notwithstanding the general and usually very striking resemblance of the species to each other, they differ so much in the teeth, the digestive organs, and the feet, that, if we rigidly adhere to these characters, we should find it necessary to separate them into distinct orders.

162. The geographic range of this order is extremely peculiar. With the exception of the Opossum group, which inhabits America, its species are at present almost confined to Australia and the neighbouring countries, where they constitute, with the Monotremata, almost the only mammiferous animals. It is remarkable, also, that from the remains found in secondary rocks, they appear to have existed at a much earlier geological period than

215. What is said of their structure?

216. Describe the pouch and its use.

217. What of their geographic range?

the true Mammalia, and to have been more extensively diffused over the earth's surface than at present.

163. The Marsupialia may be divided into the following families, which have been named according to their predominating food. These terms must not, however, be regarded as strictly indicating the food of the several species contained in each group, but only their general tendency to select for their support the substances implied by those designations. (I.) SARCOPHAGA, or flesh-eaters, such as the *dasyurus*. These have three kinds of teeth, long canines, and a simple stomach like that of the Carnivora. (II.) ENTOMOPHAGA, or insect-eaters, such as the *opossum*. These have also three kinds of teeth and a simple stomach, but a more complex intestinal canal: they are parallel with the Insectivora. (III.) CARPOPHAGA, or fruit-eaters, as the *phalangers* or flying opossums. These have large and long incisors in both jaws, the canines sometimes absent, and a more complicated intestinal canal. They may perhaps be regarded as representing the frugivorous bats. (IV.) POEPHAGA, or grass-eaters, as the *kangaroos*. These have long anterior incisors, the canines only present in the upper jaw, or altogether wanting, and a complex intestinal canal like that of other herbivorous Mammalia. (V.) RHIZOPHAGA, or root-eaters, as the *wombat*. These, in the structure of the teeth and alimentary canal, are true Rodentia. Thus it is seen that most of the principal groups of the superior sub-class of Mammalia are represented in this one.

164. (I.) All the existing species of the first family, SARCOPHAGA, are confined to New Holland and Van Diemen's Land; but it is to this that the remains belong which have been found in the Stonesfield slate and the gypsum quarries of Paris. These animals vary in size from that of a small wolf to that of a mouse. The larger ones possess considerable ferocity, destroying sheep, and even penetrating into houses. Others attack poultry, of which they suck the blood. And the smallest are partly insectivorous, and live on trees, thus showing an approach

to the next family. The names *hyæna*, *devil*, *wild-cat*, &c., applied by the colonists to these animals, sufficiently indicate their general correspondence in habit with those of the order Carnivora.

165. (II.) Of the second family, ENTOMOPHAGA, some are adapted to live on the ground, and even to burrow beneath the surface, whilst others ascend trees in search of their food. To this latter group belongs the *Opossum* tribe, which is extensively diffused through America. These

Virginian Opossum.

have a long prehensile tail; and the hinder thumbs are long, and effectively opposable to the other digits. They are fœtid and nocturnal animals, of slow gait, nestling upon trees, where they pursue birds, insects, &c., without rejecting fruit. The *Virginian opossum* is nearly the

size of a cat. It enters the villages at night, and attacks poultry, devouring also their eggs. One species frequents the marshes of the sea-coast, where it feeds chiefly on crabs. In a part of this tribe no pouch exists, but only a vestige of it, in the form of a fold of skin on each side of the abdomen. In these, the mother supports her young by entwining her tail with theirs.

166. (III.) The animals of the third family, CARPOPHAGA, are peculiarly adapted to live among the trees on which they seek their food. Some species, in their general form and in the prehensile character of their tails, approach the *Opossums*. Such are the *couscous* of the Molucca Islands. These feed on insects and fruit: at the sight of a man they are said to suspend themselves by the tail; and if he gazes at them steadily for some time, they fall through lassitude. The most remarkable species, however, is the *petaurus* of New Holland, which much resembles the flying-squirrels. Like these, it possesses an extension of the skin on each side of the body, between the anterior and posterior legs; and a flattened bushy tail, by the help of which it can take leaps of considerable length. Like the bats, or the flying-lemur, to which it may be compared, it is a nocturnal animal, remaining during the day nestled in the hollows of trees; but it becomes animated as night advances, skimming through the air, supported by its lateral expansions, half-leaping, half-flying from branch to branch, and feeding upon leaves and insects. It would seem that, whilst in motion, it has some power of altering and directing its course. Another animal belonging to this group, the *phlascolarctos*, or *koala*, a native of New Holland, is as large as a moderate-sized dog. It has the gait and carriage of a young bear, is arboreal in its habits, and passes its life upon trees, and in dens or holes which it hollows at their feet. The female carries her young for a long time on her back.

167. (IV.) The family of POEPHAGA consists chiefly of

220. Which are the fruit-eaters?

221. What variety is named?

the *Kangaroos* and the *kangaroo-rat*, all of which are inhabitants of New Holland and the neighbouring countries. The Kangaroos are remarkable for the enormous length of their hinder feet, whence their generic name, *Macropus* (long-footed), is derived. The hind legs and tail are also very largely developed ; whilst the fore legs and feet

Great Kangaroo.

are very small. From this great inequality in the size of the limbs, they advance on all-fours very slowly ; but they can make immense leaps with the hind legs, the tail probably assisting them. These are furnished with one large nail, almost like a hoof, which is a powerful weapon of offence and defence ; for supporting itself upon one leg and its tail, the animal can inflict a very severe blow with the leg which is at liberty. It will sometimes grasp its enemy with its fore paws, whilst it kicks it with its hind foot ; but this it will only do when attacked, for it is naturally a very gentle animal. The largest species is sometimes six feet in height, having the bulk of a sheep, and weighing 140 lbs. Its flesh is used as food by the New Hollanders, and is described as being somewhat

like venison. The kangaroo grazes, like ruminant animals, and is the only inhabitant of New Holland that at all represents that tribe. The young ones reside in the maternal pouch until they are able to graze for themselves, which they effect by stretching out the neck from their domicile, while the mother herself is feeding. Several species exist, diminishing in size to less than that of a hare. The *kangaroo-rat* connects this family with the preceding one; it is about the size of a small rabbit.

168. (v.) The last family, RHIZOPHAGA, contains only one species at present known, the *phascolomys wombat*. This animal is about the size of a badger, by which name it is known to the colonists; and is a native of Van Diemen's Land. It is a sluggish animal, with a flattened head and body. It burrows in the forests and low grounds; hiding itself in natural crevices at higher elevations. When attacked, it grunts like a pig; it bites hard, and is furious when much provoked. Its pace is hobbling or shuffling, something like the awkward gait of the bear; but, from the structure of its feet and claws, it is probable that its burrowing powers are considerable. As already mentioned, the organization of its digestive system corresponds closely with that of the Rodentia; and from what is known of its food, it seems to find its support, like the animals of that order, in the tougher kind of vegetable substances.

Order XII.—Monotremata, [from the Greek, *monos*, one, and *trema*, perforation.]

169. The order Monotremata is a very extraordinary one. It contains but two species, the *echidna* or spiny anteater, and the *ornithorhyncus* or duck-billed platypus; and these are found nowhere else than in New Holland and Van Diemen's Land. These were included by Cuvier (who regarded the absence of teeth as the chief character) amongst his Edentata; but zoologists have now generally agreed that the peculiarities of their structure

223. Describe the root eaters.

224. What is peculiar in the next order?

and physiology fully entitle them to rank as a distinct order, even more dissimilar to the other Mammalia than are the marsupial quadrupeds just considered. Until recently, indeed, it was much doubted by many, whether they could be included in the class Mammalia at all, since their organization did not appear at all adapted for the nourishment of the young by suckling, which is the essential character of the group. The lips of both animals, in adult age, are of horny consistence, resembling the bills of birds; in the echidna they are prolonged into a narrow beak, and in the ornithorhyncus they form a wide flat bill like that of a duck. Moreover, the presence of glands for the secretion of milk appeared doubtful. But the late researches of Mr. Owen have shown that the lips, in the young state of these animals, are much softer and more flexible, and that mammary glands certainly exist; so that the question may now be regarded as decided.

170. The name and character of the order are derived from the fact of the excretory openings at the posterior part of the body being united into one, as in birds; and this is a point of very remarkable affinity with that class, which is borne out by their general organization. There is a sort of clavicle (collar-bone) common to both shoulders, placed before the ordinary clavicle, and analogous to the *furcula* (merry-thought) of birds. Each foot possesses five claws; and, besides these, the males have a peculiar spur on the hinder one, like that of a cock. The skeleton possesses the additional bones described in the Marsupialia, though there is no vestige of the pouch which they there support. The young ornithorhynchi are produced in an extremely imperfect state; the fur being totally wanting, and the place of the eyes scarcely discernible. The tongue, which in the adult is lodged far back in the mouth advances in the young close to the lower mandible; and this disproportionate development, viewed in connection with the flexibility of the bill, is evidently designed to enable it to derive its nourishment by suction. The young echidna has not yet been discovered.

225. How many species are cited?

226. Describe their structure.

171. The echidna is characterized by the slenderness of the prolonged muzzle or bill, which contains an extensible tongue, like that of the ant-eater. The jaws are not furnished with any teeth; but the palate is armed with many rows of small spines directed backwards. The feet are short, very robust, and adapted for digging. The whole upper part of the body is covered with spines, bearing some resemblance to those of the hedgehog; and, when apprehensive of danger, and unable to escape from it by burrowing, the echidna can erect its spines, and roll itself into a ball. Besides the spines, the skin is furnished with a quantity of soft silky hair, so abundant at certain seasons as to half cover the spines, whilst at others it entirely disappears. From the difference in the aspect of the animal at these periods, two species have been described by some naturalists; but these are in reality the same.

172. The habits of the *Echidna* in a state of nature are but little known, for they do not exist in any large number; and they burrow so rapidly in the ground, that, even when one is discovered, it is not easily got hold of. To lift it from the ground requires more force than would be supposed; for it firmly fixes itself to the earth in an instant, and but a few moments elapse before it is so far down that its back is level with the surface. Lieutenant Beton, who kept one of them alive for some time in captivity, considers the strength of the echidna as exceeding, for its size, that of any other quadruped in existence. It feeds upon insects, principally ants, which it captures by its long extensile tongue; and this appears to be furnished with a glutinous secretion which causes them to adhere to it.

173. The *ornithorhyncus* (so named from its *bird-like bill*) is an animal of such extraordinary aspect, that the specimen first brought to this country, at the end of the last century, was supposed to have been *made up*, by the attachment of the beak and feet of a bird to the body of an otter-like quadruped. It was not until other specimens

had arrived, and had been submitted to most careful examination, that naturalists were satisfied of the real exist-

Ornithorhynchus [from the Greek, *ornithos*, a bird, and *rugchos*, a beak.]

ence of such an animal. Since that period, its true place in the scale, depending upon the mode in which it produces and nourishes its young, has been a most fertile source of controversy; but the question may now be regarded as set at rest by the inquiries of Mr. Owen, already alluded to.

174. The muzzle of the ornithorhynchus, as already stated, bears a close resemblance in form to the bill of a duck. The jaws contain no true teeth; but there are two pairs of horny ridges on each side, which may be considered as representing them. The fore feet are furnished with a membranous web, which not only connects the toes, but extends beyond the claws. The under surface or palm of this is concave, so that it can strike the water with great effect; but when the animal burrows, it falls back behind the claws. The hind feet are directed backwards when the animal is swimming, and somewhat resemble a fin; the membranous web does not extend on them, however, beyond the roots of the claws. The tail is broad and flat. The body is covered with two kinds of hair, like those found in the seal and the otter; the one fine,

long, and thick ; the other, a still finer, short, and very soft fur.

175. The whole organization of this singular animal is evidently designed to adapt it for seeking its food in the water, and for chiefly inhabiting that element ; and what is known of its habits fully confirms this view. It burrows in the banks of rivers, choosing generally a spot where the water is deep and sluggish, and the bank precipitous, or overhung with trees. Considerably below the surface of the stream is the main entrance to a narrow passage, which leads directly into the bank, receding from the water, and gradually rising above its level. Besides this entrance, there seems to be usually another above the water. The passage is of about the usual breadth of the animal when uncontracted ; and it seems to run for about twenty or thirty feet before it terminates in the nest. This is a roomy excavation, lined with leaves and moss ; and seldom less than two feet beneath the surface. Some have been found as much as fifty feet from the stream. The mode in which these excavations are effected is very obscure, for the animal never throws up any heaps on the surface, or leaves any excavated earth at the entrance. The situation of these burrows can thus be only found accidentally.

176. The *ornithorhynchus* seeks its food in precisely the same manner as the duck ; plunging its bill into the mud, and withdrawing it again to swallow what it has obtained. A sort of masticating movement of the jaws may be observed, by which the food appears to be partly ground between the horny ridges previously mentioned ; but, as gravel is almost always found in the stomach, the mechanical reduction of the food is probably in part effected there, as in many birds. River insects, small shell-fish, and water-plants, appear to constitute its nourishment. The animal is very timorous ; and, if alarmed whilst at the surface of the water, dives down head-foremost, and does not ascend at the same spot. In captivity they are

229. What is remarkable in their habits ?

230. Describe their method of seeking food.

very harmless and playful; but they move with difficulty over the surface of the ground.

CLASS II. —BIRDS.

177. Birds have been denominated, and not inappropriately, the Insects of the vertebrated series. As in the animals of that class, we find the whole structure peculiarly adapted to motion, not in water, nor supported by solid ground, but in the elastic and yielding air. It is true that there are some birds whose wings are so slightly developed, as not to be able to lift them off the ground; and there are others whose natural element seems to be the water, through which they are more adapted to move than through the element above. But in looking at the general character of a group, the naturalist has to put out of view these exceptional cases, and to consider the structure and habits of the mass.

178. It is impossible to conceive of any more beautiful adaptation of structure to conditions of existence, than that which is exhibited in the conformation of the bird with reference to its intended mode of life. To make a vertebrated animal capable of soaring through the air, sometimes moving with a swiftness which, in proportion to its size, far surpasses that of any other beings but insects, and at others sustaining itself on the wing almost without motion for a considerable period, is a problem which human ingenuity, even with an unlimited command of materials and of power of construction, would almost certainly fail of solving—so many are the conditions necessary to be fulfilled, the slightest failure in any one of which would have marred the result. It is only after attentively studying the structure of these animals, as presented to our view by an all-wise Creator, that we become aware of the complex nature of these conditions, and of the variety of adaptations necessary to fulfil them.

231. What are the characteristics of birds?

232. What wonders are seen in their structure?

179. In regard to the place of the class in the vertebrated series, this is easily determined to be between the Reptiles and Mammalia. Like the former, its members are oviparous, and like the latter, they possess a complete double circulation and warm blood. In conformity with the general rule of *progress*, however, we find that, even in regard to their reproduction, they hold an intermediate place between Reptiles and Mammalia. The former, when they have once deposited their eggs, leave them to be hatched by the warmth of the sun alone, and take no further care of them than in some instances to defend them. In fact, they have not, from the coldness of their own temperature, the power of affording them any superfluous heat. Birds, on the contrary, with but few exceptions (and these among species which inhabit the neighbourhood of the equator, where the sun has its maximum of power), *incubate*, or sit upon their eggs, for the purpose of hastening their development by the high and steady temperature of their own bodies. Without this aid, the requisite changes are not performed; but it may be afforded by artificial means, as has long been done on a large scale in Egypt, and more recently in this country. It has already been seen that the lowest Mammalia produce their young in a state but little advanced beyond that of the chick within the egg at an early period of incubation; but whilst the latter advances in its development under the influence only of the high temperature to which it is exposed, and the assistance of the nourishment previously laid up around it, the former is more directly nourished and sustained by its parent. In this manner the transition from the oviparous to the truly viviparous modes of reproduction, appears much less abrupt than when the extreme forms of each are alone compared.

180. In order to adapt the vertebrated animal to its aerial residence, it is obviously necessary that the body should be of as low specific gravity as possible, that is, should be as nearly as can be of the same weight with an equal bulk of air. It is further necessary that the surface

should be capable of being greatly extended, and this by some kind of appendage that should be extremely light, and at the same time possessed of considerable resistance. The great degree of muscular power required for support and propulsion in the air, involves the necessity of a very high amount of respiration, for which an express provision also exists in insects; and as the general activity of the vital processes depends greatly upon the high temperature which this energetic respiration keeps up, a provision is required for keeping in this heat, and not allowing it to be carried away by the atmosphere through which the bird is rapidly flying.

181. The first and third of these objects—the lightening of the body and the extension of the respiratory surface—are beautifully fulfilled in a mode which will be found to correspond with the plan adopted for the same purpose in insects. The air which enters the body is not restricted to a single pair of air-sacs or lungs, placed near the throat, but is transmitted from the true lungs to a series of large air-cells disposed in the abdomen and in various other parts of the body. Even the interior of the bones is made subservient to the same purpose, being hollow, and lined with a delicate membrane, on which the blood-vessels are minutely distributed. In this manner, the respiratory surface is immensely extended, and, by the large quantity of air introduced into the mass, its specific gravity is greatly diminished. There is another provision in the conformation of birds, having reference to the same objects. The ribs are connected to the breast-bone by bony instead of cartilaginous arches, and are fixed in such a manner, that a state of fullness is that which is natural to the chest and its contents, whilst that of emptiness is forced. And thus the body almost always contains as much air as its cavities can hold.

182. The other two objects—the extension of the surface and the retention of the heat within the body—are also accomplished in combination, by a most beautiful and

234. How is their physiology remarkable?

235. Describe their peculiarities.

refined contrivance, to which there is nothing parallel in the whole animal kingdom, namely, the covering of feathers. Like hair or scales, feathers are to be regarded as appendages of the cuticle or outer skin; and the apparatus by which they are formed does not differ in nature, although more complicated, from that which secretes hair. The feather consists chiefly of the *quill* and *vane*; by the former it is attached to the body, and the latter gives the expanded surface. The vane consists of a number of small *laminæ*, or separate plates, which are formed between folds of membrane that serve as a kind of mould to them; and they are afterwards connected to the stem of the feather. When perfectly formed, they are connected by minute barbs at their edges, which hook into one another, and thus give the necessary means of resistance to the air. The substance of which feathers are formed is a very bad conductor of heat; and when they are lying one over the other, small quantities of air are included, which still further obstruct, by their non-conducting power, its transmission. Thus the two chief objects are fulfilled—power of resistance and slow conducting properties being combined with lightness and elasticity; so that a covering is formed, so beautiful in itself, and so appropriate to the life which the animal is to lead, that, as Paley justly remarked, “I think we should have had no conception of any thing equally perfect, if we had never seen it, or could now imagine any thing more so.”

183. Besides the proper vane of the feather, most quills have a downy tuft, more or less developed, which is called the *accessory plume*, in which the *laminæ* are not connected, and are much more flexible. This varies in its degree of development, and is frequently larger than the true feather. This is often the case with the feathers next the body of birds, which have the retention of the animal heat as their chief object. In those species which are much exposed to the influence of cold and wet, the downy feathers of the body often form a distinct layer,

236. What of their feathers, and the use?

237. What other appendage is cited?

which, from its looseness and thickness of texture, and the quantity of air which it includes among the disconnected laminae, is admirably adapted for this purpose. The plumage is rendered completely waterproof by the application of an oily secretion, formed near the rump, with which the bird dresses its feathers.

184. The true feathers may be divided into those which are merely for the covering of the body, and those of the wings and tail, which serve for its support and motion in the air. On the texture of the latter, the powers of flight greatly depend. When it is very loose, as in the owl, the rapidity of movement is much diminished; but the motion is at the same time almost noiseless, so that the animal is enabled to steal unheard upon its prey. The wing of the partridge, on the other hand, from the peculiar rigidity and compactness of its feathers, may be said to *cut* the air: and as the owls are the most silent flyers of all birds, the partridges are the most noisy; the sudden *whirring* produced by their wings on first arising, being entirely due to the sharpness and equality with which the air is beaten in successive impulses.

185. The change of plumage termed *moulting* takes place in all birds at least once a year, and frequently oftener. It commonly occurs several times before the plumage attains that state which is regarded as characteristic of the adult bird; and the advance to perfection seems to be retarded by change of climate, confinement, deficiency of natural food, &c. The regular changes are subject to certain laws, of which the following have been ascertained:—1. When the plumage of the male, as is usually the case, is the most brilliant, and the female has a different dress, the young birds of both sexes resemble the latter in their early plumage. 2. When the adult male and female are of the same colour, the young have a plumage peculiar to themselves. 3. In some birds, the plumage during the breeding season differs from that which they bear during the winter; and the young bird then has a

238. What variety in feathers is named?

239. What of moulting, and its laws?

plumage intermediate in colour between that of the two periodical states of its parent, and bearing indications of the colours afterwards to be assumed by it at each period.

186. Besides the alteration in plumage effected by moulting, the feathers are liable to undergo a certain degree of change in their colours, whilst still attached, as is sometimes seen in human hair. From the combined action of these two causes, it often happens that migrating birds present such different aspects in the two regions they frequent that they are mistaken for distinct species. The general colour is observed to vary principally according to that of the usual habitation of the race. Thus, the birds of the arctic circle are white; those of temperate climates dark, and generally of a dull colour; whilst those of tropical climates usually possess a brilliant lustre, corresponding with that of the flowers and foliage amongst which they dwell. This adaptation serves the purpose of concealment, which is necessary alike to the bird of prey, to prevent his victim from being alarmed, and to the timid vegetable-feeder, for escaping the notice of his enemies.

187. The general adaptation of the bony framework to give effect to the purposes for which this remarkable covering is constructed, will next be considered. In the accompanying wood cut, I. represents the elbow-joint; II. wrist-joint; III. finger-joint; *a*, humerus or arm-bone; *b*, bones of forearm; *c*, bones of hand; 1, 2, 3, 4, rudiments of fingers; *o*, rudiment of thumb, or winglet. The

Jer Falcon's Wing.

feathers which form the wings are fixed into the skin covering the anterior extremities, which correspond to the arms of man. In the bones of these may be recognised the chief parts which are elsewhere found; but those which form the hand, being only intended for support, and having no prehensile powers, are much consolidated together, but at the same time elongated. The quills adhering to the hand are called *primaries*; from their greater distance from the centre of motion, they have the most powerful effect, and they are therefore constructed in the strongest manner; those attached to the fore-arm are called *secondaries*; and weaker feathers attached to the humerus are called *tertiaries*; whilst those that cover the shoulder are termed *scapulars*. These distinctions are very important in dividing the principal groups into subordinate sections.

188. The anterior extremities of birds being thus solely adapted to sustain them in flight, the posterior are necessarily modified for their support on the ground. These are usually placed rather far back, and the spine has a position more inclined than horizontal, so as to be balanced upon them. The trunk is supported on the thighs by very powerful muscles; and there is another series which pass from the lower part of the spine to the toes, turning over the knee and heel, in such a manner that the flexion of these joints shall shorten them: by this contrivance, the simple weight of the body flexes the toes, and birds are thus enabled to sleep perched on one foot. Most commonly the feet possess four toes, of which one is directed behind and three in front. This posterior toe opposed to the rest is not, however, analogous to the thumb of *Quadrumanus*, which is only represented in birds by the spurs of the Fowl tribe. In some birds two of the toes are disposed behind, and two in front; in others the posterior toe is deficient; in others, again, it is brought forwards. The number of joints in the posterior toe is but two; in the external it is five.

240. How are the colours diversified?

241. Describe their bony frame-work.

189. The upper part of the skeleton of the trunk is peculiarly adapted to give power to the wings. The *sternum*, or breast-bone, is made to project forwards with an elevated ridge or keel, to which the strong muscles which depress the wings are attached ; and from the depth of this, the powers of flight may be in some degree judged

Sternal apparatus of the Common Harrier.
a, furcula ; b, keel of sternum.

of: in the ostrich tribe, where the wings are not sufficiently developed to raise the bird off the ground, it is quite flat. The shoulder-bones are connected with the sternum and with each other in a much stronger manner than in other Vertebrata. The two *clavicles*, or collar-bones, are united together on the central line, forming the *furcula*, or merry-thought ; and the use of this is to keep the shoulders apart, notwithstanding the opposing force exerted by the action of flying. It is generally firm, and its angle open, in proportion to the power of flight. Besides this, we find the sternum connected with the shoulder by two bones termed *coracoid*, which in man and the other Mammalia are scarcely developed, being merely short processes from the shoulder-blade, which do not reach the sternum.

190. In order to give as great firmness as possible to the centres of motion of the wings, the trunk of birds has

but little flexibility ; the vertebræ being firmly jointed to one another, and the ribs united to the sternum by bony prolongations of the latter, instead of by cartilages. But this want of flexibility of the trunk is counterbalanced by the length and flexibility of the neck. The number of cervical vertebræ (which in the longest necked Mammalia is never more than seven) is very considerable, varying from twelve to twenty-three, the highest number being present in the Swan tribe. These are so jointed together that the head can be turned completely round (the position assumed when at rest) or moved in any direction. The jaws or mandibles of birds are not furnished with teeth ; but are covered, like those of the Chelonia, with a horny envelope, which sometimes projects considerably beyond them, and forms the *bill*. This is occasionally furnished with little projections, which in some degree supply the place of teeth ; but it is only in the birds of prey that these are supported by any corresponding projections of the bone beneath.

191. The reduction of the food is entirely performed in the stomach. The digestive process is extremely powerful in birds, and the demand for food very frequent. The gullet, before entering the stomach, is dilated into a large cavity, termed the *craw*, in which the food is stored up as in the cheek-pouches of monkeys, and from which it is transferred by little and little to the true stomach. This is composed of two parts, the *proventriculus*, or membranous stomach, the walls of which are beset with glands ; and from these a secretion is formed, by which the food is moistened. It is then transferred to the second division, termed the *gizzard*, which is furnished with thick fleshy walls ; and by the muscular action of these it is ground down to a pulp. Gravel is swallowed by some birds, for the purpose of augmenting the triturating power of this organ. The gizzard is most powerful in birds which feed on grains, as the common fowl. In those which subsist on animal food, or on soft herbage, its muscles are reduced to extreme tenuity, so that it is

scarcely distinguishable from the proventriculus. The dilatation of the craw is sometimes wanting. In parrots and pigeons it is an important organ in the nutrition of the young. It is furnished with numerous glands, which become developed in both sexes during the period that they alternately perform the duty of incubation; the function of these is to secrete a milky substance, with which a part of the food swallowed by the parent is impregnated, and this is then disgorged for the supply of the young.

192. The development of the senses of birds varies in different tribes according to the mode in which they are adapted to obtain their prey. The sight is almost always extremely acute, and is the chief means of seeking food. The powers of vision in the rapacious birds are probably the greatest. A hawk has been known to distinguish a lark, coloured like the clod of earth upon which it is sitting, at twenty times the distance at which it would be perceived either by a dog or man. The rapacious birds seem more remarkable, however, for their *length* of sight; those which, like the swallow, capture insect prey on the wing, must have a *quickness* of sight of which we can scarcely form a conception, since, while flying at the rate of three miles in a minute, they are constantly on the watch for their victims. The sense of smell does not seem to be in general highly developed in birds; even the vultures would seem to become cognisant of their food at least as much by sight as by scent. The sense of hearing seems to be in general tolerably acute, especially in the nocturnal birds of prey, some of which possess—what the rest want—an external cartilaginous ear. The tongue of birds does not appear to serve as an organ of taste, except in a few species. It is employed in various ways as a means of obtaining food. The sense of touch appears to be generally very obtuse; but in such as the duck, which search for their food in mud, where neither sight nor smell can be of much avail, the bill is covered with a

244. Describe their apparatus for digestion.

245. What of the senses in birds?

skin abundantly supplied with nerves of sensation, in order that the animal may feel about for its hidden sustenance.

193. Of all the endowments of this interesting class, none is more striking, or ministers more to the pleasure and delight of man, than their varied powers of *song*. It may safely be affirmed that one, at least, of the reasons for which so much strength of voice has been given to the feathered creation is, that it may serve for mutual recognition and companionship, which would otherwise be difficult between individuals of so small a size, when separated by distance or intervening foliage; for this power has been bestowed upon the birds which make their habitation amongst trees, much more universally, and to a much greater extent, than upon any other part of the class. To this order of *INSESSORES*, or perching-birds, indeed, the *musical intonation* of the voice seems almost exclusively confined. The assertion that the song of birds is peculiarly an expression of love at the breeding season, is certainly erroneous; the use of the faculty is by no means confined to that season, and probably indicates general pleasure and contentment; the voice will consequently be most exercised at the time of courtship, as well as during the period of incubation, when the male solaces the partner of his cares with his melody. For a combination of power, sweetness, variety, richness, and compass, the nightingale is generally regarded as entitled to the first place among singing-birds; but the vocal achievements of the mocking-bird, which can imitate "to the life" the song of every other bird, and the voice of almost every animal which it hears, while at the same time it possesses a rich and peculiar song of its own, are yet more extraordinary. Many birds which have no song, possess a remarkably expressive voice, obviously adapted to communicate their wants or desires: the common crow is an instance of this.

194. Not only do birds resemble insects in their general

246. What of their organs of voice?

247. How is their singing diversified?

structure and mode of life, but also in the peculiar development of the instinctive powers. Under the direction of these, the place for their nests appears to be selected, their materials collected, the nests themselves built, and the young reared in them, the migrations are performed, and many curious stratagems are employed to obtain food. These it is sufficient thus to indicate in general terms, since it is well known that the habits of birds have something peculiar to each species, yet that in all the individuals of each species they are as precisely alike as their circumstances will admit. Nevertheless, there is observed in birds a degree and kind of adaptation to varying conditions, which insects do not possess, and which display an amount of *intelligence* superior to what is found in that class. And in the domesticability of many tribes of birds, we see an obvious approach towards that higher form of attachment to man, which is exhibited by many species among Mammalia.

195. There is a more striking conformity in the entire class of birds to one general type, than is probably seen in any other group of equal extent in the whole animal kingdom. The instances of any remarkable departure from it are very few; the chief is that exhibited in the Ostrich tribe, in which the development of the wings is very small. In no other instance are either of the extremities wanting; and thus birds never exhibit the irregularity occasionally presented by fishes, reptiles, and even Mammalia.

196. Owing to this general conformity of type, the subdivision of the class is a matter of some difficulty, since it is not easy to say what characters should be regarded as of most importance, and what are but secondary. And this difficulty extends also to the smaller subdivisions; in separating which, characters that appear very trivial are often necessarily employed from the want of others. The following orders may probably be regarded as constituting

248. What of the intelligence of birds?

249. How are they subdivided?

groups of species having a positive resemblance to each other, and a well-marked dissimilarity from the rest.

197. The NATATORES, or Swimming-Birds, are known by the union of the toes with a web, so that the surface by which the foot acts upon the water is greatly extended. The legs are short, and placed behind the point of equilibrium. The body is closely covered with feathers, and coated with a thick down next the skin. It is in this order that we find the nearest approach to reptiles which birds present.

198. The GRALLATORES, or Waders, are known by the length and slenderness of their legs, which are bare of feathers to a considerable height, by the elongation and straightness of the toes, the length of the neck and beak, the slenderness of the body, and the considerable development of the wings.

199. The CURSORES, or Runners, were included in the last order by Cuvier, chiefly, it would seem, on account of the length of the legs. But these members, instead of being slender, are very strong, being the only locomotive organs; and the wings are very slightly developed, and not capable of raising the bird into the air. This last character is quite sufficient to separate the group from all others.

200. The RASORES, or Scratchers, receive their name from an action common to many of them, and particularly observable in our ordinary poultry. The character of the order is chiefly derived from the structure of the feet, which are furnished with three toes, united at the base by a short membrane, and with one behind, higher than the rest; and these are armed with short, blunt, and robust nails, for the purpose of scratching up their food.

201. In the first of these orders, the habitation is, more or less exclusively, aquatic; in the second, marshy places are chiefly frequented; and the third and fourth contain birds essentially adapted to live on the ground, and to seek their food without rising into the air. In the remaining orders, the habitation is more or less aërial.

202. The **SCANSORES**, or Climbers, pass most of their time in trees, clinging to the branches by means of their feet, which are specially adapted to that purpose. The external toe is turned backwards, as well as that which was posterior in the **Rasores**, so that they have two toes in front and two behind. This conformation prevents them from walking readily on the ground; and their powers of flight not being usually great, they are not so active as the **Insessores**.

203. The **RAPTORES**, or Birds of Prey, constitute a group sufficiently well marked by the robustness and muscularity of the whole body, the strength of the legs, and of the bill and talons. The former is strong, curved, sharp-edged, and sharp-pointed; and all of the toes—three before and one behind—are armed with long, strong and crooked claws.

204. There now remains a very extensive group of birds, presenting no very marked differences amongst its members, and not readily defined by any striking characters which separate it from the rest. Accordingly, it is usually made to constitute but one order, that of **INSESSORES**, or Perching-Birds. The principal character in which all these agree, is the slenderness and shortness of the legs; the feet have three toes in front and one behind, and the two outer ones are united by a very short membrane; they are all slender, flexible, and moderately long, with long and slightly curved claws. These feet are readily distinguishable from those of the other orders; they are destitute of the webbed expansion possessed by the **Natatores**; they have not the robust strength and destructive talons which characterize the Birds of Prey; nor do they present the very extended toes which enable the **Waders** to walk safely over marshy soils, and tread lightly on the floating leaves of aquatic plants. They are adapted to enable the bird to *rest* on the branches of trees, but not to *cling* to them; and, accordingly, the birds of this order pass a large proportion of their time on the wing.

205. Of all these orders, the Cursores present the nearest approach to the Mammalia in their conformation and mode of life ; but it is among the Incessores that we find most developed those characters which have been mentioned as distinguishing the class—power of flight, beauty of plumage, and melody of voice. These, therefore, as the types of the class, will be first considered.

Order I.—Incessores, [or perching-birds.]

206. This order is the most numerous and varied of the whole class. Its character seems principally negative ; for it embraces those birds which are neither swimmers, waders, climbers, rapacious, nor gallinaceous. Nevertheless, by comparing the different tribes it includes, a great general resemblance of structure becomes apparent ; and such insensible gradations are perceived between those that at first appeared most unlike, that it is difficult to establish the subdivisions of the group. The foot, as the name denotes, is especially formed for grasping or perching—a peculiarity evinced by the situation of the hinder toe, which is invariably placed on the same level or plane as those in front. The length of the tarsus or shank (that which appears the lowest division of the leg, but is really the higher part of the foot) is moderate, and often very short in comparison to what is seen in other orders ; and, as these birds never seize their prey by their claws, these weapons are never retractile. The perchers are thus distinguished from the birds of prey properly so called ; from the climbers they are separated by having three toes directed forwards ; whilst the situation of the hind toe enables them to be readily known as neither gallinaceous, wading, nor swimming-birds. Their food is various, but in general mixed, consisting of insects, fruit, and grain ; those in which the beak is stout and strong feed more upon grain, some of them, how-

252. What of their relative numbers ?

253. How is their structure remarkable ?

ever, even pursuing other birds; and those which have a very slender bill feed on insects, or on the juices of flowers. The proportional length of the wings, and their powers of flight, are as various as their habits. In general the females are smaller and less brilliant in their plumage than the male; they always live in pairs, build in trees, and display the greatest art in the construction of their nests. The young come forth from the egg in a blind and naked state, and are wholly dependent for subsistence, during a certain period, upon parental care.

207. The *larynx*, or organ of voice, is always of complex structure in the members of this order, which contains all that are commonly known as singing-birds. There are few that do not either sing, or utter some peculiar note or chatter analogous to song, during the season of courtship; and even of those which in general utter only monotonous cries, or of which the notes are harsh, some are frequently capable of being taught to speak, to whistle airs, or to imitate other sounds.

208. The families composing this order may be distributed under four large groups or assemblages, characterized by the respective forms of their bills. The CONIROSTRES have a stout beak, more or less conical, and with regular edges. The DENTIROSTRES have the upper mandible notched, as in the Raptores, towards the point; but this notch only exists in the horny covering, and not in the bone. The FISSIROSTRES have a short, broad, horizontally-depressed beak, so formed that the gape of the mouth is extremely wide; it is slightly hooked, but without any tooth at the edge. The TENUIROSTRES have the bill very slender and elongated; it is sometimes straight, and sometimes curved.

209. (I.) CONIROSTRES, [from the Latin, *conus*, a cone, and *rostrum*, a beak.] The Conirostres are to be regarded as containing the types of the order, the species belonging to it having the most varied faculties. They feed indis-

254. Which organ is complicated and various?

255. How are they distinguished into groups?

criminally upon insects and vegetables, and are therefore termed omnivorous. Their feet are so constructed that they can walk upon the ground with nearly the same facility as they perch upon branches. The families included in this tribe are the CORVIDÆ, or Crows; STURNIDÆ, or Starlings; FRINGILLIDÆ, Finches; BUCERIDÆ, Hornbills; and LOXIADÆ, Crossbills.

210. Of the family CORVIDÆ, [from *corvus*, a crow,] the common *Crows* are the most characteristic examples, and may be regarded as combining the general characters of the class in a greater degree than any other birds. In every climate habitable by man these birds are found; they are constructed for powerful and continued flight, as well as for walking firmly upon the earth; they feed indiscriminately on animals or vegetables, and when pressed by hunger, they do not refuse carrion; their smell is remarkably acute. They are bold but wary, live in common societies, and possess great courage; when domesticated, they possess a power of imitating the human voice nearly equal to that of the parrot; and, like it, show signs of greater intelligence than is found in the rest of the class. Under the general term *Crow* are included the raven, which is the largest of European perching-birds, and which is bold enough occasionally to carry off poultry; the corby crow, which is very destructive to eggs and young game; the rook, which chiefly feeds on insects, and especially devours the grubs of the Coleoptera, though it occasionally eats grain if its proper food be scarce; the hooded crow, which feeds upon molluscs, &c., on the sea-shore; and the jackdaw, which is a very vigilant enemy of predatory birds. The *magpies* are nearly allied to the crows; as are also the *jays*, which live principally, however, in woods, and feed on acorns, &c. The *nutcrackers* also belong to this family; their habits in many respects resemble those of the woodpeckers; they climb trees, and perforate their bark, and devour all sorts of fruits and insects, as well as small birds.

256. What families are included in the first tribe?

257. Describe the variety of crows.

211. The STURNIDÆ, [from *sturnus*, a starling,] are best known by the European *starling*; the family seems like a smaller race of crows, which they nearly resemble in manners and structure, but are much weaker. They seek their food generally upon the ground, are social in their habits, and seem to prefer plains frequented by cattle. They are easily tamed, and may be taught to speak, or to imitate the song of other birds. A great number of species, in different parts of the world, are referred to this family; amongst them may be specially noticed the *Icterinæ*, or Hang-nests of South America, which build long purse-shaped nests, suspended from the slender branches of lofty trees; they feed on fruits and beetles, and are never seen upon the ground. The African *Buphaga*, or ox-pecker, is also remarkable for its habit of perching upon the backs of cattle, to which it clings by its sharp claws, and then, compressing the skin, to force out the larvæ of gad-flies, &c., on which it feeds.

212. The FRINGILLIDÆ, [from the Latin *fringilla*, a chaffinch,] or *Finches*, are the smallest of this group of perching-birds, and are readily known by the shortness and strength of their conical bills. They subsist generally on grain. The number of species is very great; and some among them are everywhere diffused. The sparrows, chaffinches, linnets, goldfinches, bullfinches, and larks, are the kinds best known in this country. To the same genus with the linnet belongs the canary-bird, originally brought from the Canary Islands, but now so abundantly bred in captivity, that it is difficult to assign the original colour from the numerous varieties that present themselves. The chaffinch is a bird of cold climates; one species, known as the brambling, visits Britain only in the winter; and another nestles in the high Alps, and descends only in the depth of winter to the secondary ranges. To this family belong the weaver-birds of tropical climates, which are celebrated for the remarkable construction of their nests, composed of blades of grass interwoven together; in one species, a number of indi-

viduals unite their nests into a large single mass, divided into numerous compartments. The *whidas*, or widow-birds, resemble the linnets, but have a remarkable development of feathers in the tail at the breeding-season, being destitute of it at other times. The *grosbeaks*, of which one British species is known as the greenfinch, are remarkable for the thickness of their beaks, which are exactly conical, and with which they pick out the kernels on which they feed. The Virginian nightingale is nearly allied to the grosbeak. To this family also belong the *buntings*, granivorous birds, of which several species have been seen in Britain; and the *larks*, so well known for their habit of continuing their song whilst ascending to great heights in the air. With the exception of one species, these last are peculiar to the eastern hemisphere. The hind toe, and the claw which terminates it, are greatly prolonged; the feet are altogether formed for walking on the ground, where, indeed, these birds construct their nests.

213. The BUCERIDÆ, or *Hornbills*, are readily distinguished at first sight by the enormous size of their bills, which are swollen or enlarged at the base into protube-

Bill of Hornbill.

rances resembling horns or knobs, which are sometimes as large as the beak itself. The form of this excrescence varies much with age; and in very young individuals

259. In the tribe of Finches, what species are comprised?

260. What is peculiar in their structure and habits?

there is no trace of it perceptible. It is not solid, except in one species, but composed of a fragile network of bony fibres. The use of this curious appendage is unknown. The Hornbills are gregarious, noisy birds, of large size, and are peculiar to the Old World. Their flight is sailing, and resembles that of a crow; and on the ground they advance by a leaping kind of movement, assisted by the wings. The larger species are extremely shy and difficult of approach, and they perch on the decayed branches of lofty trees, where their vision can command a wide range. They subsist on all sorts of food, devouring tender fruits, chasing mice, small birds, and reptiles, without disdaining carrion; and they breed in the hollows of lofty trees.

214. The family of LOXIADÆ, [from the Greek *loxia*, oblique,] or *Crossbill* tribe, contains a large number of genera, of which the common crossbill can scarcely be regarded as a characteristic illustration, the peculiarity from which it takes its name not being possessed by more than a few other species. This peculiarity consists in the strong curvature of the mandibles, so that their tips pass each other, and

Bill of Crossbill: *a* and *b*, muscles which move it.

not always on the same side. By this extraordinary bill the bird is enabled to extract the seeds from pine-cones with astonishing facility, and it is confined to localities in which these are to be obtained. The species common in Western Europe has of late years become more abundant than formerly in the British Isles, where it was previously chiefly known as an occasional straggler. Amongst the other tribes associated in this family may be mentioned the *colies*, in which the upper mandible somewhat passes the other. They are birds of Africa and India, which climb somewhat in the manner of parrots, live in troops,

and even breed in society, constructing numerous nests on the same bushes. They feed on fruits, the buds of trees, and the tender sprouts of vegetables, and sail from bush to bush in a long row, one after the other, alighting always near the ground, and clambering to the topmost twig with the assistance of the beak and long stiff tail; having picked off all the buds or berries, they sail to the next, but not until the whole flock is ready. They are very mischievous in gardens in the Cape colony, devouring young plants as soon as they spring up; but they are themselves the ordinary food of several birds of prey. They have remarkably heavy, massive bodies for their apparent size, the plumage lying flat and close. This family is connected with the FRINGILLIDÆ by the *Tanagers*, which are birds peculiar to America, resembling the Sparrow tribe in their habits, feeding on grain as well as on insects and berries, and for the most part brilliantly coloured.

215. (II.) DENTIROSTRES, [from the Latin *dens*, a tooth, and *rostrum* a beak.]—This group is the most allied of all the Insessores to the Birds of Prey. As its name imports, the species it includes are distinguished by a distinctly notched bill, and they are the greatest destroyers of insects among the Perchers. With very few exceptions, they either live entirely on insects, or resort to fruit only when insufficiently supplied with their favourite nourishment. The mouth is protected on each side by bristles, which defend the soft parts during the struggles of the prey; and the feet are generally adapted more for perching than for walking. The form of the beak varies in different species; in the shrikes, for example, it is stout and compressed, whilst it is flattened or depressed in the fly-catchers, which lead towards the Swallow tribe. This group includes the following families:—LANIADÆ, or Shrikes, which most prominently manifest the peculiarities of the group. MERULIDÆ, or Thrushes, in which there is less restriction to peculiar kinds of food. SYLVIADÆ, or Warblers, chiefly peculiar for the small size, delicate structure, and vocal powers, of the species it con-

tains. **AMPELIDÆ**, or Chatterers, distinguished by the enormous width of their gape. **MUSCICAPIDÆ**, or Fly-Catchers, which are more exclusively confined to insects than the rest of the tribe, and have small and weak legs.

216. The analogy between the **LANIADÆ**, or *Shrike* tribe, and the rapacious birds, is extremely evident. In the most characteristic specimens of the family, the bill, which is in all short and strong, is abruptly hooked at the end, and the notch so deep as to form a small tooth more or less prominent on each side: by this conformation the bird is enabled to take a firm grasp of its food, and to tear it in pieces. The claws, also, are usually strong and sharp. Like many of the falcons, the shrikes will sit for hours watching for their prey, which consists of small

Bill of Shrike.

birds, and, in the less powerful species, of insects; and will suddenly dart down upon such as come within their reach, seize it with their feet, and carry it home to be devoured at leisure. They not only pursue small birds, but successfully defend themselves against larger ones, even attacking them when they intrude in the vicinity of their nests. Many species feed also upon frogs and other small terrestrial animals. They have various means of attracting their prey. Some have the power of imitating the songs of such birds as live in their vicinity. A species known by the name of the *butcher bird*, which is a common summer visitant in the south of England, impales its prey on the thorns of bushes, to devour at leisure, and is even said to put up insects in this manner as a bait for other birds, which it watches for and darts upon from a concealed place in the neighbourhood. This family contains a large number of species, distributed through all quarters of the globe. They have the same general structure and

263. How is the next group distinguished?

264. What families does it embrace?

habits, differing only in subordinate particulars. Some, which are superior in powers of flight, pursue insects on the wing; others subsist entirely on soft caterpillars, which they search for among the foliage of high trees; and others prowl about among bushes and underwood, preying upon insects and young or sickly birds, and in the breeding season destroying great quantities of eggs. The *caterpillar-catchers* are confined to the Old World, and they are represented in the New by the *tyrant-shrikes*, which have many points of resemblance to the Muscicapidæ. These birds are of considerable size, and possess great boldness, attacking both hawks and eagles which come near their nests. They are very numerous in tropical America: some species feed upon small birds and reptiles; others upon insects; and some plunge after fish, in the manner of the king-fisher, and have even been observed to throw up their food and catch it in the air, like the toucans and hornbills. Some of the shrikes have a remarkably melodious song.

217. The MERULIDÆ, [from the Latin *merula*, a black-bird,] or *Thrushes*, have an arched and narrow beak, but the point is not hooked, and the lateral tooth is not so marked as in the shrikes. Nevertheless, the transition from one form to the other is very gradual. This family is inferior to the shrikes, therefore, in the peculiar organization adapted to rapacious habits, but they possess a greater variety of powers. Their feet are not only stronger, but are equally adapted for perching and for walking, and these birds make their way upon the ground, in the air, and among trees, with equal facility. The indentation of the edge of the bill is sufficient to enable the Thrushes to retain a firm hold of their food, whilst its superior length enables them not only to capture food that is exposed, but to seek for it beneath the surface of the ground. It is in this family that we find the birds most distinguished for the sweetness, compass, and versatility of their song. The Thrushes are not confined to animal

265. Describe the Shrikes, and their habits.

266. What varieties are cited?

food. They live much on fruits and berries; their habits are mostly gregarious in the winter, and in some species, as the common fieldfare, throughout the year.

218. Of this family the common *thrush* (mavis or song-thrush), the *blackbird*, and *fieldfare*, are well-known and also characteristic examples. These, as well as the *missel-thrush*, *redwing*, *ring-thrush*, &c., are closely allied species of the same genus, of which the other species are distributed over the whole globe. The *mocking-birds*, on the other hand, which probably stand unrivalled for their powers of voice, are restricted to America: some of them approximate to the shrikes in their habits. The *orioles* are also nearly allied to the thrushes; they are migratory birds, having longer wings than their congeners, and chiefly frequent the south of Europe, where they build very curious hanging nests. The *ant-thrushes*, again, are a large assemblage, living entirely between the tropics, where they restrain the devastations of those destructive insects. The celebrated *buhl-buhl* of the east is one of a group of thrushes remarkable for the brilliancy of their plumage and for their powers of song. A few species of this family have somewhat aquatic habits. One of these is the *dipper*, or water-ousel, which immerses its whole body without swimming, and walks about in a jerking, fluttering manner at the bottom of streams, in search of the small animals which constitute its food.

219. The chief peculiarity which runs through the numerous family of SYLVIADÆ, or *Warblers*, is the very small size and delicate structure of the species which compose it. Excepting the Humming-Birds, we find among these elegant little creatures the smallest birds in creation. The diminutive golden crests, the nightingale, the white-throat, and the wood-wren, are examples of this family well known to the British naturalist. Its different groups are spread over all the habitable regions of the globe, and appear to have a peculiar function in the economy of nature, being specially designed to keep down

the multiplication of the innumerable minute insects which lurk within the buds, the foliage, or the flowers of plants. The small size of these insects causes them to escape the notice of the thrushes and the larger insectivorous birds; whilst their habits prevent them from being seized by the swallow and such as capture insects only on the wing. The Sylviadæ are for the most part migratory birds; appearing in spring, when the insect world is called into life and activity by the renewal of vegetation, and disappearing in the autumn, when their services are no longer required, and when their supply of food diminishes or ceases altogether.

220. The Warblers may be subdivided into five groups, each of which is characterized by a difference of haunts and some slight peculiarities of structure adapted to them. The *golden-crests* and *wood-warblers*, which are the types of the family, confine themselves principally to the higher trees, where they search for winged insects among the foliage; or capture them, like fly-catchers, when attempting to escape. Of these, the golden-crowned kinglet of the British Isles is one of the most interesting species. It is the smallest of European birds, but is very lively; it constructs a globular nest on trees, with a lateral opening, and suspends itself on their boughs, in all positions like a tit. The *reed-warblers* and *nightingales* haunt the vicinity of waters, or the more dense foliage of hedges, for insects peculiar to such situations. These have some affinity with thrushes, being of larger size than the true warblers, and subsisting in part upon fruits as well as upon insects. The *stonechats*, on the contrary, prefer dry commons and wide extended plains, and feed on insects peculiar to those localities. They are lively birds, rather high upon the legs, and run with considerable swiftness; and they build on or near the ground. The robins belong to this group, connecting it with the last. The insects frequenting humid and wet places are the particular food of the *wagtails* and *tit-larks*, which bear

268. What examples are given?

269. How are the warblers remarkable?

considerable resemblance to the waders in their aspect and habits. They live almost entirely on the ground, where alone they seek their food, which consists wholly of insects; they particularly haunt damp meadows, and the sides of standing or running waters; and in the black and white plumage which generally characterizes them, as well as in their power of running very quickly, they particularly resemble the plovers. Lastly, the *tit-mice* search for insects with the greatest assiduity among the buds and tender shoots of trees; and even pierce the bark, and open seeds, to get at them. They have a slender, straight, and conical beak, somewhat resembling that of the *Coniostres*. They are very active little birds, continually flitting from spray to spray, and suspending themselves in all kinds of attitudes. When piercing seeds, they hold them fast with the foot, and then extract the kernel through a hole which they pick in the husk. They are quite omnivorous, not even sparing small birds, when they find them sick and are able to destroy them, and also storing up provisions of grain.

221. Of the family of *AMPELIDÆ*, [from the Greek *ampeleón*, a singing bird,] or *Chatterers*, the most characteristic examples belong to tropical America, and only one is found in Europe—the *wax-wing*. The birds of this family are distinguished from all the other *Dentirostres* by the enormous width of their gape, which in many extends beyond the eye, and in some is nearly as wide as in the goatsucker. This bill is not defended by bristles, however, at its corners; and the absence of these indicates that its wide opening is *not* for the purpose of catching insects on the wing, as in the swallow tribe. The chatterers live almost entirely on soft berries and small fruits, which they swallow whole; and this food naturally requires a very wide passage. They are perpetually hopping among fruit-bearing trees, and scarcely ever come to the ground.

222. The species which may be regarded as the types

270. Into what groups are they divided?

271. What is peculiar in each?

of this family are very little known, being inhabitants of the deepest and most secluded forests of tropical America. They are oftener heard than seen; their notes being peculiarly loud, and uttered morning and evening from the deepest recesses of the forests. Many of them are clothed in a very rich and brilliant plumage, which rivals that of the humming-birds. Some of them are as large as a thrush; others, known by the name of *manakins*, are of diminutive size. These last live in little bands, and are continually in motion. The nest of one species is often built in the fork of a shrub, in such an exposed situation that the female can look all around and watch the approach of danger. The *wax-wings* are so named from the peculiar character in the secondary quills of the wing, the ends of which are converted into smooth oval red disks, much resembling red sealing-wax. The European species appears in flocks, at long intervals, and without regularity. It is not timorous, is easily captured and kept in captivity, and eats of every thing in great quantity; in the wild state, however, it feeds principally on berries.

223. The MUSCICAPIDÆ, [from the Latin *musca*, a fly, and *capio*, I catch,] or *Fly-catchers*, are a family hardly less numerous than that of the warblers; and are composed, like that group, entirely of small birds. This family is more purely insectivorous than any other of the order, few of the species belonging to it ever partaking of fruits. The legs of these birds are remarkably small and weak, indicating their sedentary habits. They usually place themselves on a spot from which they can dart readily upon such insects as come within their reach; they do not, however, attempt to pursue their prey if unsuccessful in the first instance, but return to the spot they had quitted, or to another near it. These birds have a bill flattened at its base; and the sides of the mouth are defended with stiff bristles, to confine the struggles of their prey. The members of this family are distributed through

272. How are the Chatterers described?

273. What is said of their number and variety?

the temperate and tropical portions of the Old World, and the temperate parts of the New. Between the tropics, however, they are replaced in America by the tyrant-shrikes and fly-catching warblers, both which groups are unknown in Africa and India. The *fly-catchers* of Europe are small birds, about the size of a sparrow. One species is common in Britain, usually arriving about May. It has been observed to take its station on the top of a stake or post, from whence it springs forth on its prey, catching a fly in the air, and hardly ever touching the ground, but returning to the same stand for many times together. To this family belongs the group of *water-chats*, which are restricted to the warm latitudes of America, where they seem to represent the stonechats and wagtails of the Old World. They are furnished with long legs, and run with great facility, feeding upon the insects which resort to the sides of streams and rivers. They never hunt among trees, and rarely perch. One of the most remarkable birds of the family is the *eurylaimus*, which inhabits the hottest parts of India and the adjacent islands. It is distinguished by the enormous breadth of its bill, and also by its very bright plumage. It frequents the most inaccessible parts of the country, covered with forests, and abounding in rivers and marshes; and builds its nest dependent from the branch of a tree overhanging the water.

224. (III.) FISSIROSTRES, [from the Latin, *fissura*, a slit, and *rostrum*, beak.]—The group of Insectores thus designated is a comparatively small one; but it is very distinct from all others in the beak, which is short, broad, horizontally depressed, slightly hooked, and very deeply cleft, so that the opening of the mouth is extremely wide. The birds possessing this kind of bill are adapted for capturing insects on the wing, receiving their prey in full flight into their mouths, which remain open for that purpose; and the victim is secured by a gluey exudation within, and a strong fence of bristles on the outside, which also serves to protect the soft parts of the head from its

struggles. Although such is the typical or characteristic form of the bill in this group, it is not always seen. In some species the bill is stronger and longer; and these also are distinguished by having the external toe nearly as long as the middle one, and attached to it until nearly its end; to these the name of *Syndactyli* was given by Cuvier, who associated them into a separate group. The Fissirostres, as a whole, are peculiarly distinguished by having the powers of flight developed to the highest degree. All the energies of their nature seem concentrated in this one perfection; for their feet are always very short and weak, and serve but for little else than to rest the body after flight. They may be separated into diurnal and nocturnal, like the birds of prey.

225. This group may be divided into the five following families:—HIRUNDINIDÆ, or Swallow tribe; CAPRIMULGIDÆ, or Goat-suckers. Both these present, in a remarkable degree, the organization which has been described as characteristic of the order. The remaining families have a longer and narrower bill, and are syndactylus: MEROPIDÆ, or Bee-eaters; HALCYONIDÆ, or King-fishers; TODIDÆ, or Todies.

226. The HIRUNDINIDÆ, [from the Latin *hirundo*, a swallow,] containing the swifts and swallows, are diurnal birds, remarkable, like the diurnal Raptores, for their close plumage, the extreme length of their wings, and the rapidity of their flight. The *swifts* possess these characters in the highest degree, and surpass all other birds in the power of sustaining a rapid flight for a long time. They are distinguished from the swallows by having the hind toe directed very much forwards: and all four toes are armed with strong crooked claws, which give to the bird such a firm grasp, that it can sustain itself by the side of perpendicular rocks or buildings with great facility. In some species, the tail feathers are very stiff, as in woodpeckers, and serve as an additional support. They spend their time almost entirely in the air, and pursue insects in

275. How is the next group described?

276. How are these divided?

flocks, sometimes at a great height, uttering discordant screams. They nestle in the holes of walls and rocks. The *swallows* are less capable of sustaining a continued flight than the swifts, as is shown by their weariness after or during migration, on which occasions they have been seen to alight flat upon the sea. Several species exist in Europe, and many more in other parts of the world. Among them may be mentioned a small species inhabiting the Indian archipelago, which forms its nest of a species of sea-weed, which it macerates in its stomach and then arranges in layers. These *edible birds' nests*, as they are commonly termed, are highly prized as delicacies in China, and constitute an important article of traffic with that country.

227. The CAPRIMULGIDÆ, or *Goat-suckers*, are nocturnal birds, and have the same light soft plumage which characterizes the owls. Their eyes are large, and their gape still wider than that of the swallows, so as to be capable of engulfing the largest insects. They come forth in the twilight and return to rest before morning; but in their other habits they much resemble the

Head of Goat-sucker.

swifts, with which, indeed, they are closely connected by intervening species; for, whilst there are goat-suckers which fly by day, skimming over the surface of ponds in small flocks, precisely in the manner of swallows, there is also a swift which only flies at night.

228. The family of MEROPIDÆ, or *Bee-eaters*, is confined to the warm regions of the Old World; only one species being known as having occasionally strayed to Britain. They have long and pointed wings and short

277. What of the Swallow tribe?

278. How are the Goat-suckers characterized?

feet, and fly in the manner of swallows. The European Bee-eater annually visits Italy, in flocks of twenty or thirty, and may be seen skimming over the vineyards and olive-plantations, especially pursuing bees and wasps. It is remarkable that they are never stung by these; they seize the insect, and at once crush it by the snap of their powerfully compressive beak. To this family also belong the *rollers*, most of which are natives of the East, but of which one species inhabits Europe. They are in some respects intermediate between the swallows and bee-eaters. One species is stated to perch and watch for prey on the horn of the rhinoceros, giving notice to that animal of the approach of the hunter; but in general they take their food on the wing. They collect no nest, but lay their eggs in holes.

229. The HALCYONIDÆ, or *King-fishers*, are remarkable for the great length of the bill and the extreme shortness of the feet. Their habits are sedentary, much resembling those of the fly-catchers; but their food is more various. The common British species partly lives on small fish, which it takes by precipitating itself into the water, either from the branch on which it had perched, or by suddenly arresting itself during rapid flight, poising for an instant, and then plunging. It returns to its perch to gulp its prey, first killing it by repeatedly beating it against a bough. The King-fishers nestle, like the bee-eaters, in holes of banks; and are found in both continents. Some of them, which inhabit desert regions, prey on snakes and other reptiles; others feed on insects; and some of the largest species on Crustacea. The largest species of this family is found in Australia, and is remarkable for its loud and grating prolonged cry.

230. The TODIDÆ, or *Todies*, are small American birds, resembling the king-fishers in their general form, and may be regarded as representing them in the New World. Their legs are rather long, and their wings incapable of any but the most feeble flight. In their habits,

279. What is remarkable in the Bee-eaters?

280. What of the King-fishers?

they bear much resemblance to the fly-catchers; for they hop about among the slender branches of trees, hanging from the twigs like the tits, and occasionally making short flitting with their wings to capture an insect that attempts to escape. Like the king-fishers, however, they nestle on the ground, and usually near water; and their nest is a natural hollow, or one excavated by themselves, in a bank, but slightly lined with straws and down. They have scarcely any voice except at pairing time; and their colour closely resembles that of the trees in which they dwell.

231. (IV.) *TENUIROSTRES*, [from the Latin *tenuis*, slender, and *rostrum*, beak.]—This group, it has been well remarked, “is among the most interesting of the animal world. Deriving their subsistence, for the most part, from the nectar of flowers, we never fail to associate them in our idea with that more beautiful and perfect part of the vegetable creation, with which, in their delicacy and fragility of form, their variety and brilliancy of hues, not less than by their extracting their nourishment from vegetable juices, they appear to have so many relations.” This tribe is confined exclusively to the torrid zone and southern hemisphere. The length and slenderness of the bill are its distinguishing characteristics. It is not by this, however, but by the long filamentous tongue, that the juices of flowers are sucked up; and to protect this important organ, the peculiar conformation of the bill seems chiefly intended. The tongue is often simply forked, but is sometimes divided into so many slender filaments as to resemble a painter’s brush. The feet are very short and delicate. All these characters are presented in the greatest perfection by the *TROCHILIDÆ*, or Humming-birds, which are the types of the group. In the *CYRINNIDÆ*, or Sun-birds, the feet are more lengthened. The *PROMETOPIDÆ*, or Hoopoes, have the tongue short. The *PARADISIDÆ*, or Birds of Paradise, are separated by the strength of the feet. And the *MELIPHAGIDÆ*, or Honey-suckers, have the bill notched.

281. Describe the Todies.

282. How is the next group divided?

232. The TROCHILIDÆ, or *Humming-bird* tribe, so celebrated for the metallic lustre of their plumage, and particularly for the gem-like brilliancy of some of their feathers, have, within their long slender beak, a tongue capable of protrusion like that of the woodpeckers, and divided almost to the base into two filaments. These filaments are *not* tubular, as they are sometimes described, but are flattened. It is not improbable that the tongue may serve for catching insects, as well as for sucking the juices of flowers; since it is unquestionable that, like others of the order, the humming-birds are partly insectivorous. When hovering over flowers, these birds balance themselves in the air by a rapid motion of the wings, like many flies; and it is by this movement that the *humming* sound is produced, from which they take their name. The flight of these birds, the smallest of the order, is so rapid as frequently to elude the eye. They live solitarily; defend their nests with courage, attacking with their needle-like bills the eyes of intruders, which makes these minute creatures truly formidable; and fight with each other desperately.

233. This family is exclusively confined to America, and, with few exceptions, to the southern part of that continent and the adjacent West Indian islands. More than one hundred and seventy species are at present known, and others are constantly being discovered. The smallest of them, when plucked, are less than a large humble-bee; and one only, which is much larger than any others as yet known, nearly equals the common swift in size. This bird is also one of the dullest coloured, and its general resemblance to the swifts is very manifest.

234. The CINNYRIDÆ, or *Sun-birds*, represent the humming-birds in the eastern continent. They are closely allied to the Trochilidæ in general structure, and in the mode of obtaining their food, but their tongue is not so deeply divided. They are small birds, and the males have the most brilliant colours, rivalling those of the humming-birds during the breeding season; but the garb of the fe-

233. What is peculiar in the structure of Humming-birds?

male, and of the male at other parts of the year, is much more dull. The bill is not so straight as in the Trochilidæ, and the legs less delicate, so that a connection between that and other families is evident through this one. The sun-birds are of a lively disposition, and sing agreeably.

235. The PROMEROPIDÆ, or *Hoopoes*, are also restricted to the Old World; one species, the common hoopoe, annually visits Europe, in company with the bee-eaters and other swallow-like birds; but, unlike its congeners, it seeks its food on the ground. Most of the tribe, however, feed upon the juices of flowers and succulent fruits, and their plumage possesses metallic lustre. The feet, as well as the tongue, are very short.

236. The PARADISIDÆ are among the largest of the Tenuirostres, and seem to live, like the rest of the order, chiefly upon soft vegetable substances. They are confined to New Guinea and the neighbouring islands, and for a long time no specimens were obtained but such as had been deprived by the natives of their legs, whence it was at one time supposed that they were destitute of limbs, and supported themselves entirely on their airy plumes. The extraordinary development of their feathery appendages is well known; but of the purpose these serve in their economy, no plausible account has been given. The very restricted locality of these birds, and the savageness of the people who inhabit it, have prevented naturalists from obtaining much knowledge of their habits. They are partly supported upon insects.

237. The MELIPHAGIDÆ, or *Honey-suckers*, are distinguished from all the preceding families by their notched bill; their tongue is terminated by a bunch of delicate filaments, and the hind toe is so strong and robust, that it serves as a support to the bird during the process of feeding. This group is chiefly confined to Australia, where its members abound in great variety of form, and where they find a never-failing support in

284. How are sun-birds described?

285. What of the hoopoes?

286. Describe the birds of Paradise.

the luxuriant vegetation of that country. But they do not confine themselves to the juices of flowers, for they perforate the bark of trees and draw forth insects from beneath it, in the same manner as the woodpeckers. We have thus an approximation towards the Scansorial order ; but this is much more manifest in a family which may be regarded as intermediate in position between the Scansores and the suctorial Insesores.

238. This family, that of the *CERTHIADÆ*, consists of the Tree-creepers, Nuthatches, &c. Its members strongly resemble the scansorial birds in their habits, but they more closely approximate to the *Tenuirostres*, and especially the *Meliphagidæ*, in general structure. Like those, they are of small size ; the foot has three of the toes directed forwards, and the bill is more slender and delicate than that of the woodpeckers. The *Tree-creepers* bore into trees, however, and rest upon their tail in climbing, much as do the woodpeckers, but they rather seek for their food in the natural chinks of the trees, or among the mosses and lichens which cover the branches. The *Nuthatches* have a stronger bill, which is straight and pointed, like that of the woodpeckers. They use it, however, rather to scale off the bark than to perforate it, and they do not support themselves upon the tail. They feed not only upon insects but upon various seeds, and are celebrated for the instinct of fixing a nut in a chink while they pierce it with the bill, swinging the whole body as on a pivot, to give effect to each stroke. The British species is about the size of a robin, its note loud, and its disposition remarkably fearless.

Order. II.—Raptores, [or ravenous birds.]

239. The rapacious [from *rapax* Latin, *devouring*] birds constitute a well-marked group, which may be compared with that of the *Carnivora* among *Mammalia*. In comparison with the *Insesores*, their number is but few ; for had it been otherwise, they would soon have extirpated the whole race.

287. What of the Honey-suckers ?

288. What varieties are in the next family ?

They usually breed but slowly, leading solitary lives, and never appearing in numerous collections. Most of them are large and powerful birds; and, what is an exception to the general rule, the female is larger than the male, but her plumage is usually of a duller aspect. There are few of this family which do not show great strength of wing; but the power and swiftness of flight that are possessed by the different species, vary with their habits. As among the carnivorous Mammalia, we find some species adapted to pursue and bring down living prey, and these are endowed with the greatest activity and strength of movement. Others feed upon the carcasses of animals that have met their death in various ways, in search of which they have to perform long journeys: these are endowed with great power of wing, but their swiftness is less. The least degree of these faculties among the raptorial birds, exist in those which feed upon decomposing animal matter, or which hunt after such small game as it requires neither swiftness nor power to seize.

240. Rapacious birds are all remarkable for their strong hooked bill and large acute talons. The force of these is indicated by the size of the muscles of the legs and thighs; and the foot is usually but of moderate length, that its power may not be lost by being diffused over too large a space. It is by the talons that the prey is usually struck first; and, when secured by the feet, it is torn open by the bill. For this purpose there exists in the typical *Raptores* a strong and sharp tooth-like projection from one or both of the mandibles, which is of material assistance; but in such tribes as feed on carrion or small animals, it is nearly or entirely deficient. "It is thus that nature preserves in this order a strong analogy to the carnivorous quadruped. The slothful vulture and the cowardly *hyæna* glut themselves upon carrion; the bold and majestic lions, like the noble falcons, feast upon no other prey than what their own courage has procured; while the owls and the stoats

289. How are the ravenous birds described?

290. For what are they remarkable?

prowl during the night after the same feeble and ignoble game."

241. This order is usually divided into two series—the *diurnal* and *nocturnal* Birds of Prey; the former containing the falcons, eagles, vultures, &c., and the latter the owls. As the falcons, vultures, and owls, however, constitute three distinct families of equal rank, it will be preferable thus to consider them. They are chiefly distinguished from each other by the presence or absence of the tooth on the bill, already adverted to; by the degree in which the neck is clothed with feathers or destitute of them; by the size of the eyes, and the presence or absence of a fringe of feathers around them; and other minute characters, the relation of which with the chief peculiarities of the several families will be more obvious when they are particularly considered.

242. The FALCONIDÆ, or *Falcon* tribe, exhibit the perfection of the order, and correspond very closely in their general habits, and the adaptations of structure to them, with the Feline tribe among the Carnivora. Their bodies are of moderate size; their forms light but powerful; their flight graceful; and their courage very great. They are technically distinguished from the vultures, to which (being both diurnal birds of prey) they are most nearly allied, by the bill being toothed, as well as shorter and sharper; and by the acuteness and strong curve of their talons, which like those of the Cat tribe, are retractile. The members of this family are almost universally diffused over the earth's surface, some species of them existing wherever there is a sufficient expanse of land. They are less abundant in islands, for a considerable extent of country is necessary to supply them with food. Their plumage is destitute of a bright or gay assemblage of colours, but is nevertheless in many instances peculiarly elegant. The plumage of the young bird, however, is very different from that of the adult, which it is long in attaining; and, when first hatched, the young falcon, like a new-born kitten, is blind and feeble.

243. The Falconidæ have been commonly divided into the *noble* and *ignoble*; the latter not being susceptible of being trained to the (so-called) noble sport of falconry. The noble division comprehends the *Falcons-proper*, which are distinguished from the rest by the size of the tooth on the mandible, and by the power of their wings, which are long and pointed. They are the most courageous of all the family in proportion to their size; and are especially adapted to pursue and bring down their prey whilst it is on the wing. From the peculiar construction of their wings, it is not easy for them to rise directly into the air; and their forward flight, in a calm state of the atmosphere, is very oblique. When they wish to rise directly they fly against the wind, which raises them as it would a paper kite. A large number of species are known in Europe. The ignoble Falcons have less powerful wings, which are shaped like those of the true falcons, with the tips obliquely cut off. The tooth on the bill is less strongly marked, and is often reduced to a mere festoon.

244. The *Eagles* may probably be considered as ranking next to the falcons. They are the largest and most powerful of the whole group, and pursue and destroy quadrupeds as well as birds. They are distinguished from all other *Raptores* by having the legs and feet feathered quite down to the toes. They usually build their nests in lofty and secluded situations, especially among mountains and precipices, and resist with great courage any attack upon their young. A large number of species, varying considerably in size, exist in Europe, and many others in America. Some of the English ones are no larger than the buzzards, which are nearly allied to them, and may be regarded, in their habits as in their size, as eagles in miniature. They reside in forests, building high in trees, and descending from the top upon their prey. They destroy much game, and are an especial pest to rabbit-warrens.

292. Describe the Falcon tribe, and their peculiarities.

293. What of the Eagles, and their habits?

245. The *Hawks* are also nearly allied to the falcons, and some of them have been employed in pursuit of game, upon which, however, they stoop obliquely and not perpendicularly. The tooth on the bill is reduced to a kind of festoon, towards the middle of its margin, but the shape of the bill, in other respects, is the same as in the falcons, being short, high, and curved from the base; the wings are also more rounded, but not so much cut at the ends as those of the eagles. The *Kites* have comparatively short feet and feeble claws, and they are much less courageous than the rest of the family. They are distinguished by their long wings and forked tail, by which their flight is rendered swift and easy, but it is less powerful than that of other Raptores. The common kite of this country has the power of hovering, balanced on its wings, for a longer time than any other known bird. It principally feeds on reptiles.

246. A few species of this family, mostly included among the *Ospreys* and *Ernes* (both of which, but especially the last, are nearly allied to the eagle), are aquatic in their habits, living upon the sea-shore, and subsisting chiefly or exclusively upon fish. They are at once distinguished by the roughness of the under surface of the foot, which assists them in holding their slippery prey; and the *Ospreys* have also the power of turning backwards the outer toe, and opposing it to the rest, so as much to increase the grasping power of the foot.

247. The birds of the family VULTURIDÆ, or *Vulture* tribe, are on the whole much larger than those of the previous family, but they are much less courageous. The beak is lengthened, and curved only at the end, and it is not in the least toothed. The power of their talons by no means corresponds with the stature of these birds, and they make more use of their beak than of their claws. Hence they are not adapted for a contest with a courageous victim, and rather seek carrion already decomposing, to which they are attracted—whether by the sight or by the smell is still a disputed question. On this they gorge

to repletion ; and, in order that the parts of the bird which come most in contact with this offensive food should not be soiled and matted together (as they would be if covered with feathers,) the skin of the head, and frequently also of the neck, is destitute of covering. The legs, too, at their lower part, are covered with scales, and not with feathers, as in the eagle.

White-headed Erne.

248. The Vultures are most abundant in hot climates where they perform important services, by removing decomposing carcasses, which would otherwise be a source of offensive and noxious exhalations. They are sparingly scattered over the south of Europe ; in Egypt they are more numerous, and in tropical America, although the species are fewer, the individuals are much more plentiful. The two most remarkable species of the family are natives of that continent, the *condor* of the Andes, and the *papu*

or king-vulture of the Brazilian forests. The former is well known for the loftiness of its flight and its great strength; and it appears to have more power than any other bird of adapting itself to different elevations in the atmosphere, having been seen to dart from one of the highest peaks of Pinchincha to the very brink of the sea, thus traversing all climates in a few seconds, and passing from a barometric pressure of 12 inches to one of 29. The king-vulture has a brighter plumage than the rest of its tribe, and the naked parts of the head and neck are vividly coloured. It receives its name from the circumstance of the gallinazo, a smaller species, giving place to it through fear, whenever it settles upon a carcass which the other had begun to devour.

249. The *Griffins* connect the falcons and owls, but strictly belong to the vultures. They are the largest rap-torial birds of the eastern continent. They inhabit high chains of mountains, and build their nests in inaccessible situations. Lambs, goats, chamois, and even children, are carried away and devoured by them. They sometimes destroy their prey by forcing them over the edge of a precipice, and in this manner are said to have overcome even man. They do not, however, refuse dead bodies.

250. The *Neophrons* are birds of the vulture kind, which go even beyond them in cowardliness and in the propensity to decomposing aliment. They are attracted by filth of the most disgusting kinds, which they are very useful in removing. They are common in Africa and on the borders of the Mediterranean, but rarely show themselves in the north of Europe. An American species is known in that country as the carrion crow.

251. The *Gypogeranus* or Secretary Vulture, is a very remarkable bird, whose true place in the scale cannot be assigned without uncertainty, on account of the mixture of characters which it presents. The lower part of its legs is so long that some naturalists have placed it among the Waders; but its thighs, entirely covered with

296. How are they described?

297. What species are cited as examples?

feathers, its hooked beak, and other details of its anatomy, concur to place it in the present order; and it seems to rank between the vulture and falcon. It feeds exclusively upon reptiles, and especially serpents, offering no molestation to poultry or other warm-blooded animals; and it pursues its prey on foot, striding over the ground like an ostrich. It chiefly inhabits the arid plains in the neighbourhood of the Cape of Good Hope.

252. The family of STRIGIDÆ, [from the Latin *strix*, an owl,] or *Owl* tribe, including all the nocturnal birds of prey, is characterized by the large proportion of the head to the body, and by the size of the eyes, which are surrounded by a fringe of feathers. Their soft downy plumage, too, may at once be distinguished from the firm and sharply-cut feathers of the diurnal Raptores. All these peculiarities have reference to their habits. The cavity of the brain is not proportionally larger than in other birds; and the space between it and the exterior of the skull is occupied by large cells, which communicate with the ear, and probably assist the sense of hearing. The size of the eyes, again, has an evident relation to the small amount of light in which they are usually to be employed; the pupils are so large that the birds are dazzled in full day, and hence in part arises the stupid appearance which they exhibit. The fringe which surrounds them probably has for its object to prevent the interference of light from the sides, above, or below, and to enable them to concentrate their whole power of sight upon the object directly before them—as when we look through the hand contracted into a tube at some object which we desire to see more distinctly. In the owls which are partly diurnal in their habits, this circular fringe is hardly perceptible. The owls seek their prey, not by the power of flight, but by stealing upon it unawares: hence the movement of their wings should be as noiseless as possible; and this object is peculiarly answered by the downy character of the whole plumage, and by a particular arrangement of the

298. What other varieties are here named?

299. Describe the structure of the Owl family.

barbs of the feathers at the edge of the wings. The external toe, as in the osprey, can be directed backwards as well as forwards. Their period of activity being twilight, or during moonlight nights, that of their repose is during the day; and, if then disturbed, they make the most ludicrous gestures, which seem principally intended, however, to enable them to get a clear view of the object which annoys them. Owls are feared by all smaller birds, which do not hesitate, however, to attack them during the day. Their food is wholly animal, consisting of mice, frogs, and other small terrestrial vertebrata, small birds, fish in some instances, and insects.

253. The species composing the group of Owls, may be classed under three sections. The first is composed of those commonly termed *Horned Owls*, from the head being furnished with a pair of tufts of feathers longer than the rest, which are placed above the ears. These *egrets*, as they are termed, can be raised or lowered at will in many species. The European *bubo*, *great-horned* or *eagle owl*, is a characteristic example of this group; it is one of the largest of nocturnal birds, being little smaller than the golden eagle; it is very destructive to grouse, hares, and even fawns. It inhabits the mountainous parts of Europe, but is seldom seen in Britain. To this group also belongs the *harpang* or *great snowy owl*, which inhabits the north of both hemispheres, nestling on elevated rocks, and preying on hares and game birds. Its head-tufts are small and inconspicuous, and it is more diurnal in its habits than most of the group.

254. The second section contains all the *tuftless Owls*, with the exception of those constituting the genus *Strix* or Barn-door Owl, which differ from the rest in the extraordinary extension of the fringes of feathers surrounding the eyes; these form a sort of mask, giving to the physiognomy a most peculiar aspect. The species of this second section differ considerably amongst each other in their adaptation to diurnal or nocturnal habits. They are very widely diffused over almost all parts of the globe.

One of them is sufficiently active to pursue swallows on the wing; another inhabits the open prairies of America, abounding in the villages of the prairie marmots, and entering the burrows of the viscacha, one of the South America Rodentia.

Barn Owl.

255. The third section contains those which may probably be regarded as the true types of this family, the *Barn Owls*. They seem to possess in a peculiar degree all those characteristics which constitute them *nocturnal* birds of prey; and at the same time they differ most widely in the form of the beak from the diurnal Raptorial birds; this being long, and curved only at the end. The barn owl seems widely diffused over the globe; but several species probably exist, differing but little from each other. They

prefer habitations distant from the abode of man, nestling in old towers, hollow trees, and, where no such conveniences exist, in the burrows of quadrupeds. They sometimes take up their abode in pigeon-houses, offering no molestation to the inhabitants. They easily become familiar, and are worthy of the protection of man, to whom they seldom do any injury, preying only on small quadrupeds and insects.

Order III.—Scansores [or climbing birds, from the Latin *scando*, I climb.]

256. The peculiar disposition of the toes in the birds of this order, two being placed behind, and all four arising nearly on the same level, gives them great facility in climbing the branches of trees, but proportionally impedes their progression on level ground. By this character they may be readily distinguished from all other birds, notwithstanding many and striking variations in the form of the bill and wings. The nests of this order are generally less skilfully constructed than those of the Insessores; and the birds often employ for this purpose the hollows in decayed trees; one family is remarkable for depositing its eggs in the nest of other birds. Their flight is ordinarily but moderate. Their nourishment consists of insects and fruits; and the species feeding upon each may be distinguished by the greater or less robustness of the beak. This order may be divided into the four following families;—(I.) PICIDÆ, or *Woodpeckers*, which may be regarded as the types of the order, presenting its peculiar characters in the highest degree. (II.) CUCULIDÆ, or *Cuckoos*. (III.) RAMPHASTIDÆ, or *Toucans*. (IV.) PSITTACIDÆ, or *Parrots*. This last family is separated from the rest by so many peculiarities, as almost to constitute a distinct order.

257. (I.) The PICIDÆ, [from the Latin *picus*, a woodpecker,] are chiefly characterized by their long, straight, angular bill, the end of which is compressed into a wedge,

302. What is said of barn owls?

303. How are the climbing birds divided?

adapted to perforate the bark of trees. The tongue is also of peculiar conformation, being worm-like in its shape, barbed at its point, and capable of being suddenly thrown out to a great length. By this mechanism the bird can introduce it into holes and crevices, or even under the loose bark of trees infected by those peculiar insects which it is its province to destroy; and these they obtain, not only by transfixing them with the barbed point, but by causing them to adhere to it by means of a viscid glue with which it is covered. The feet of these birds are short but very strong; the nails are broad and crooked. As an additional and powerful support in their rapid and perpendicular ascent up the trunks of trees, their tail-feathers are very firm, and terminate in points; so that this member, being pressed against the bark, is of assistance to the bird in maintaining its perpendicular attitude. The woodpeckers are shy and wary; they pass the greater part of their time solitarily; and at the pairing season they communicate with each other, not by song, but by rattling the beak against a dead branch.

258. The species of this family are extremely numerous, and are generally distributed over the globe, with the exception of Australia. Some of them are exclusively restricted to insects, which they obtain in the manner just stated. Others descend occasionally, and feed at ant-hills. Others, again, which never descend to the ground, feed much on nuts and acorns. Nearly allied to the woodpeckers, both in structure and mode of life, are the *Wry-necks*. They seldom climb, however, and feed principally on ants. Their flight is swifter than that of the woodpeckers. One species, which is common in Britain as a southern visitant, is coloured in such a manner as to resemble a branch partly encrusted with lichens; and it thus escapes observation even when very near. Instinctively trusting to this means of concealment, it will lie close, and sometimes even suffer itself to be taken by the hand; it will then twist its neck in the most extraordinary

304. What of the structure and habits of woodpeckers?

305. Describe the wry-necks?

manner (whence its name), and perform other ludicrous movements ; then, taking advantage of the surprise of the spectator, it will dart off like an arrow.

259. (II.) The CUCULIDÆ, or *Cuckoo* tribe, are a numerous and diversified race, spread over all the temperate regions of the globe. They are principally distinguished by the short and slender make of the feet, of which one of the back toes can be occasionally brought forwards. The beak is of mean length, slightly arched and compressed at its sides. Most of this family are migratory, and scarcely any build nests of their own. They fly rapidly, and subsist upon insects and fruits. The common cuckoo has long been celebrated for its habit of depositing its eggs in the nests of other birds, generally insectivorous species ; and, what is more extraordinary, the foster parents, often of species inferior in size, bestow as much care upon the young cuckoo as upon their own proper nestlings, even though the rearing of this involves the destruction of their own young. For, if other eggs are hatched with that of the young cuckoo, the latter speedily ejects the rightful tenants from the nest, and receives all the attention of their parents. If it were not for this, it must speedily perish for want, from the frequency and urgency of its demands for food, and its incapability of assisting itself, up to an advanced age. The cuckoo feeds principally on caterpillars, and also devours cherries and the smaller fruits ; it is sometimes seen to pursue insects on the wing. It is an unsocial bird, seldom congregating with its species, except at the time of migration.

260. The foregoing peculiarities, however, do not exist in all of this family. The *couas* of America, also called *cow-birds* from their peculiar note, nestle in the holes of trees, and do not intrust the charge of their eggs to strangers ; they have very feeble powers of flight ; and, like the truly scansorial birds, feed entirely on insects, which they obtain on the branches of trees. The *coucals* of Africa and India, on the other hand, live more upon the ground, feeding chiefly upon grasshoppers, and run-

ning with celerity among reeds and other herbage, from which they are slow to take wing. To this family also belong the *indicators*, or honey-guides, of South Africa, which themselves feed on honey, and are celebrated for guiding the natives to the nests of wild-bees, enticing them to the spot by flitting before them, and reiterating a peculiar cry. Sometimes, however, they conduct their followers in this manner to a spot where a beast of prey lies concealed. The *ani* are birds of hot and humid climates of America, which differ considerably from the cuckoos, but yet are more nearly allied to them than to any other family, though they have also an affinity with the next. They subsist on insects and grain, fly in pairs, and several pairs lay and incubate in the same nest, which is placed on the branches of trees, and is built of a size proportionate to the number of couples which help to construct it. Their sociality when brooding seems partly due to their extreme sensitiveness to cold.

261. (III.) the RAMPHASTIDÆ, [from the Greek, *ramphos*, a beak,] or *Toucan* tribe, are easily recognised by the enormous size of the bill, which is nearly as large and long as the body itself, but internally very light and cellular; its edges are toothed, and both mandibles are arched towards the tip. The tongue is narrow and elongated, and laterally barbed like a feather. Their feet are formed more for grasping than climbing; accordingly, they always live among trees, and proceed by hopping from branch to branch. So light and elegant are their movements, that in the living bird, in its natural situation, the disproportionateness of the bill does not attract observation. Its large size is to give a more extensive distribution to the nerves of smell, for the purpose of enabling the birds to discover their food, which consists chiefly of the eggs and young of other birds, and also to enable them to obtain it, by dipping it into the deep hanging nests which abound in their natural abodes, for which purpose its surface is endowed with considerable sensibility, enabling it

307. What exceptions are there to these peculiarities?

308. What varieties in this family?

to feel the contents of these nests. The size of the bill prevents their swallowing their food in the usual manner, and they accordingly throw it into the air and catch it in the throat as it descends—a habit practised by many other birds also, in which the tongue is unusually short, or of a form unfit to assist in swallowing. Toucans are mostly large-sized birds, and clothed with brilliant plumage. They are peculiar to the warm regions of America, where they live in small flocks, different species often associating together. They nestle in the trunks of trees.

262. (iv.) The PSITTACIDÆ, or *Parrots*, constitute a family which is very widely diffused through the torrid zone in both new and old continents, and is scarcely found beyond it. It contains a large number of species, each of which has its peculiar locality, the short wings of these birds not enabling them to traverse large tracts of sea. They correspond with the other Scansores in little else than the structure of the foot, and this is formed rather for grasping than for climbing. It is also used for conveying food to the mouth, a peculiarity nowhere else seen but in the goat-suckers. Their beak is stout, hard, and solid, curved and pointed very much as in the diurnal birds of prey, which they may perhaps be regarded as connecting with this order. They subsist, however, upon vegetable food at all ages, and have a peculiar provision for supplying their young, analogous to that which will be described as possessed by the pigeons. Their jaws are set in motion by a greater variety of muscles than are found in other birds. Their tongue is thick, fleshy, and rounded; and their larynx, or organ of voice, is more complicated than in other birds—by which peculiarities they gain their facility of imitating the human voice as well as other sounds. Their voice in a state of nature, however, is loud and harsh. They use their crooked bills in clambering upon trees, and nestle in hollow trunks. They subsist upon the succulent parts of vegetables, especially bulbs and fruits. They are distinguished from the rest of the scansorial birds by their intelligence and docility, qualities

in which some species are unsurpassed by any members of the class.

263. The Parrot tribe, nearly all of which are adorned with gorgeous colours, has been distinguished, chiefly by peculiarities of plumage, into many subdivisions, the limits of which, however, are mostly arbitrary. The true *parrots* are square-tailed, and have no crests. They are found in both the old and new continents, and are more easily taught to speak than others of the family. The *cockatoos* are also square-tailed, but have crests upon their heads. The white ones inhabit the Indian archipelago and Australia; they are singularly gentle and affectionate, and easily maintained in captivity in Europe. There is a large black cockatoo in Australia, with a bill of extraordinary strength, and wings capable of vigorous flight, which is not susceptible of the same domestication. The *love-birds* are a beautiful group, found in both continents, nearly allied to the parrots, but of diminutive size. The *parroquets* have a long pointed tail, and chiefly inhabit the Asiatic continent and islands, and Australia. An American species of parroquet is the only member of the parrot tribe found to the northward of the tropic of Cancer. The *macaws* are a long-tailed American species, which exceed all the rest in size, and are superbly coloured. The *lories* are oriental species, with square tails and dense soft plumage, the colours of which are glowing in the highest degree; the beak is in general comparatively feeble, and they feed upon the juices of flowers and the pulp of the softest fruits.

Order IV.—Rasores, [or scratching birds.]

264. This order, corresponding with the *Gallinacæ* or poultry tribes, consists of birds with bulky bodies, and essentially formed to live upon dry ground. They are the most easily domesticated of the whole class; they furnish man with a considerable amount of savoury and wholesome food, and their fecundity is very great. The

310. What of the Parrot group?

311. What variety of parrots is cited?

majority of them are at once known by their strong thick legs, long necks, short wings, and large ample tails; and the heads of many, especially of the males, are ornamented with elegant crests. The form of the bill is well seen in the common cock; the upper mandible is vaulted, and, at the same time, destitute of any notch; the whole is short and strong, having a peculiarly horny appearance. The wings are muscular, but their feathers have rounded ends; and the breast-bone presents a much smaller surface for the attachment of the muscles than in the previous orders, so that the power of flight is comparatively small. Their food, with few exceptions, is entirely vegetable, and their chief support is derived from the seeds and grains of various plants. Many of them eat also the green portions, and are in this respect nearly peculiar among birds. Almost all of them have a large crop and an extremely muscular gizzard.

265. The Rasores are mostly social birds, and are readily domesticable. In general they deposit and hatch their eggs on the ground, in a rudely-constructed nest of straw, but some of them, which reside in forests, build in trees. Each male usually associates with many females; he takes no part in the construction of the nest or in rearing the young, and these are generally numerous and able to run about and provide for themselves the moment they quit the shell. When this is the case, the male is larger and more gaily coloured than the female. But in the few species which associate in pairs, such as the ptarmigan and partridge, the sexes nearly or quite resemble each other, both in size and colour.

266. From the strong resemblance which subsists among all the birds of this order, the division of them into families is difficult. The following may be regarded as the most natural distribution of them into groups:—
(I.) PHASIANIDÆ, *Pheasant* and *Fowl* tribe, distinguished by the shortness of the hind toe, the presence of spurs on the legs, and the beautiful development of the tail.

312. Describe the order of Scratchers.

313. What is said of their habits?

(II.) CRACIDÆ, or *Curasow-birds*, a tribe of poultry restricted to America, the legs of which are destitute of spurs, and the hind toe so much developed, as to give considerable power of perching. (III.) TETRAONIDÆ, *Partridge* tribe, having a very short hind toe, and also very short tails. (IV.) COLUMBIDÆ, the *Pigeon* tribe, which are much isolated from the rest, and may be regarded as in some respects allied to the Insectores. From the well-known character of most of these birds, the description of the families need not be detailed.

267. (I.) The whole of the PHASIANIDÆ, with the exception of the turkey, are restricted to the Old World. The characters by which they are known from the other families, are those which peculiarly distinguish the order; hence there can be no hesitation in regarding this family as its type. It is in the hotter parts of Asia that the most brilliantly coloured birds of this family present themselves in the greatest numbers. The *peacock*, for example, abounds in the forests of India; and the wild specimens even surpass the domestic ones in brilliancy. It was introduced into Europe by Alexander the Great. The plumage of the *impeyan*, also a native of the North of India, resembles that of the humming-birds upon a large scale; it can only be compared to the most refulgent hues of variously coloured and finely polished metals. The *turkeys* are the only representatives of this group in the New World, whence they were brought by the early discoverers, and are now quite naturalized in Europe. A more splendid species than the common one has been lately discovered in the Bay of Honduras. The *guinea-fowl* is originally a native of Africa, where it lives in large flocks, in the neighbourhood of marshes. Its noisy and querulous disposition renders it incommodious in poultry-yards, although its flesh is excellent. Of our common fowls, the original stock, like that of most domesticated races, is obscure; but it was probably a species of *gallus*, inhabiting Java or Sumatra. The *pheasants* were origi-

314. How are they divided into groups?

315. What of the Pheasant tribe?

nally brought from the banks of the Phasis in Asia-Minor; several very handsome species abound in different parts of Asia. Among these, one of the most remarkable is the *Argus* pheasant, inhabiting Sumatra and the south-east of Asia. The wings are large, and are covered with eye-like spots, which give a very remarkable appearance to the bird. There is a large poultry bird in New Holland, which has been sometimes placed among the vultures, but which certainly belongs to this order. This is the *vulturn*; its chief point of resemblance to the vultures is its bald neck; it has also some affinity with the next group, especially in the absence of spurs and the size of the hind toe

268. (II.) The CRACIDÆ, which are restricted to America, offer a remarkable contrast, in their plain colours, to the brilliant plumage of the Asiatic races which occur in nearly the same parallels of latitude. They are equally capable of domestication with the fowls; and their flesh is of excellent quality. The *curasows* are about the size of a turkey, and are handsome birds, having the head adorned with crests of long, narrow, erectible feathers, curled at the tips. They commonly perch upon trees. The *guans* are still more arboreal in their habits. So many varieties of colour are found among them, that it is difficult to trace the limits of the different species. The *hoazin* is a South American bird, which derives its subsistence almost exclusively from foliage, and chiefly from the leaves of a species of arum growing in marshy places. The toes, unlike those of all other gallinaceous birds, are destitute of any connecting membrane.

269. (III.) The TETRAONIDÆ, or *Grouse* tribe, also differ strongly from the Phasianidæ, in the comparative dullness of their plumage, as well as in the extreme shortness of the tail. The *grouse* are formed to inhabit cold climates, and are found in Europe, Asia, and North America. The largest species, commonly known as the capercailzie, is the largest of the true poultry, surpassing the turkey in size.

316. What varieties are here cited?

317. How are the Curasows described?

It particularly feeds on pine shoots. These birds strut with outspread tail in the manner of the turkeys, and are polygamous. The *ptarmigan* live in pairs, and do not strut in this manner; the more generally diffused species become white in winter; there is one species peculiar to Britain, however—the moor-fowl or red grouse—which does not change. Nearly all the grouse have the toes and legs more or less covered with soft feathers—a character which disappears in the *Partridges*, an extensive group, scattered in nearly all parts of the Old World, but unknown in the New. In the *Quails*, we have the miniature resemblance of partridges, but the tail is so short as to be nearly imperceptible. There is in tropical America a singular race of birds, called *Tinamous* by the Brazilians: they have scarcely any tail; the body is thick; and the whole appearance reminds us of a pigmy bustard. These birds live among herbage, and feed upon fruits and insects. Their flesh forms an excellent article of food.

270. (iv.) The family of COLUMBIDÆ, containing a large number of elegant and lovely birds, appears as much isolated from the rest as the Parrots are from the Scansores. Although it is particularly numerous, and spread over every part of the world, there is no difficulty in distinguishing its members from all other birds. One of their chief peculiarities is the *double* dilatation of the crop, which expands on each side of the gullet; and the young are fed with grain disgorged from this receptacle by the parent, and impregnated with a secretion which it forms. These birds live invariably in pairs; they nestle in trees, or in the holes of rocks, and lay but few eggs, though they breed often. This family includes the whole of the well-known tribe of *Pigeons* and *Doves*. Some of the tropical species are of considerable size, and of very rich plumage. The common dovecot pigeon is probably derived from the rock pigeon, which naturally breeds principally among the sea-cliffs, and but sparingly inland. But the ringed pigeon is of a different stock; and though it chiefly

318. What of the Grouse or partridge family?

319. Name the varieties cited.

frequents the districts cultivated by man, it resists his nearer approach. The *carrier-pigeon* is not a distinct species, but only a variety of the common one which has undergone a particular training; and it is probable that other varieties might be similarly trained. Advantage is taken of their fondness for home: being carried out in a basket to a short distance, and then let go, they generally return directly thither; the distance is gradually increased to a few miles, and then to a much greater extent. By means of these birds, intelligence has been conveyed eighty miles in three hours; but they are now much less used for the purpose than formerly.

271. The *passenger-pigeon* is a native of North America, where it breeds in such immense numbers as to darken the air for a considerable period when the flock takes to flight, and to destroy all the herbage where they settle. Wilson and Audubon, each in his own felicitous manner, have described the comings and goings of these countless swarms—the eclipsed sun, the rushing roar, the crash of broken trees as they alight, the report of fire-arms, the shouts of the people, the howls of the wild beasts, the eagles and vultures, the greedy hogs, and the unimaginable confusion and uproar attending such scenes as these. To give some idea of the abundance of these birds, both of these eminent naturalists have made a rough computation of the number contained in particular flocks seen by them. Wilson makes his flock to contain above two hundred thousand million pigeons. Audubon supposed one billion one hundred and fifteen millions to have been contained in the flock seen by him; and the quantity of food necessary for this single flock to be nearly nine millions of bushels per day. The mind is unable to form an idea commensurate with these vast numbers of living beings, except in regard to the space occupied by them. Wilson speaks of them as flying so closely together, that, if shot could have reached them, one discharge could not have failed of bringing down several individuals; and there

320. What of the pigeon tribe?

321. What varieties are described?

appeared to be many strata of them, one over the other. From right to left, as far as the eye could reach, the *breadth* of this vast procession extended, seeming everywhere equally crowded. The *length* of it may be judged of by the fact, that, although the birds were flying with great steadiness and rapidity, the passage of the main body occupied more than six hours, and large detached masses continued to follow at short intervals for two hours longer.

Order V.—Cursores, [or running birds.]

272. This order contains a small number of species, differing so considerably from one another, that almost every one may be regarded as belonging to a different family, and yet all agreeing in one characteristic—the non-development of the wings, and the enormous size and power of their legs—by which they seem justly separated from all other orders of birds. They may be regarded as in many respects intermediate between the Rasores and Grallatores; but they also present many remarkable points of approximation to the Mammalia. The most obvious of these are the loss of the powers of flight, and the dependence on the legs alone for locomotion; and the deficiency (most conspicuous in the cassowary) of barbs upon the feathers, so that they much resemble hair. In their internal structure, moreover, similar approximations exist: thus the ostrich has the rudiment both of a diaphragm and urinary bladder, which organs are wanting in other birds, whilst all Mammalia possess them.

273. Although destitute of the powers of flight, wings exist in an undeveloped or rudimentary state: and it has been observed that, when the ostrich is running, its small anterior members execute analogous motions, which seem to assist it. Their muscles, however, requiring but little strength, the sternum has no prominent keel, but is flat as in man; whilst, on the other hand, the muscles of the posterior extremities are of enormous size and power.

322. What of the passenger pigeon?

323. Describe the running birds.

Only five genera are at present known to exist in this order; and of one more, which seems now extinct, remains are preserved to us which indicate its existence two centuries since. Each of these merits a separate notice.

274. The *struthio*, or ostrich, is a well-known bird in the tropical parts of the eastern hemisphere; its feathers do not differ so widely from other birds as do those of the cassowary, being furnished with barbs; but these do not adhere to one another, so that no continuous resisting surface is formed. Still the

wings present sufficient expanse to assist the bird in running, which movement it executes so swiftly that scarcely any animal can overtake it. The true ostrich has only two toes on each foot; of which the outer one is one-half shorter than the other, and is destitute of a nail. It chiefly inhabits the sandy deserts of Ara-

Foot of Ostrich.

bia and Africa, living in large flocks, and attaining the height of six feet and a half. It subsists chiefly on grain and herbage, and frequently swallows also a large quantity of hard substances, such as pebbles, pieces of metal, &c., which are probably taken to assist in the trituration of the food. Its eggs, which weigh nearly three pounds each, are left, when the animal inhabits the hottest parts of Africa, to be hatched by the solar heat alone; but, in extra-tropical regions, the ostrich incubates them, and defends them with courage. It is said to be the male that chiefly performs this duty.

275. The *rhea*, American ostrich, or naudon, is about half the size of the African ostrich, and more thinly co-

324. Into how many genera is this order divided?

325. What of the structure and habitus of the ostrich?

vered with feathers. It is distinguished by possessing three toes to each foot. Two species exist, one inhabiting the central parts of South America, where it is as abundant in some localities as the ostrich in Africa; and the other in Patagonia, where it is rare. The naudon is easily tamed when young, and its flesh is eaten: it has been observed to swim with facility.

276. The *casuarius*, or cassowary, has wings shorter than those of the ostrich, and quite useless in aiding progression. Besides the peculiarity of the feather, which has been already mentioned as giving it the appearance

The Cassowary.

of hair, there is another, consisting in the great development of the *accessory plume*, so that two or even three equal stems appear to grow from the same quill. In its general form and aspect it much resembles the ostrich, but differs in the structure of its digestive organs. The head is surmounted by a bony prominence, covered with horn. The skin of the head and neck is bare of feathers, and of a

bright blue and flame colour ; it is furnished with wattles, like those of the turkey-cock, which change colour under the same circumstances. It lives on fruit and eggs, but not on grain. It is an inhabitant of the Indian archipelago, and is the largest-bodied of birds, next to the ostrich.

277. The *dromaius*, or emu, is a native of New Holland, and is closely allied to the cassowary ; but its plumage is more dense, from its feathers being more barbed. Its flesh resembles beef ; and it is swifter in its movements than the fleetest greyhound. Either this or probably an allied species, formerly existed in New Zealand, as is proved by the remains of bones which have been found there ; but it seems to have been extirpated by the natives.

278. The *apteryx* of New Zealand appears, of all birds, to have the wings reduced to the most simple rudiments ; and it presents, at the same time, many points of approximation to the Mammalia. It has a complete diaphragm,

The Apterix.

and no air-cells exist in its abdomen ; nor are any of its bones hollow. The bill is long and slender ; the rudiments of wings are terminated by a sharp hook, which seems to be an important organ of defence ; the feet have three toes in front, and the rudiment of a fourth behind, the claw of which is alone externally visible. The size of this

327. Describe the structure of the cassowary.

328. What is the next genus, and its characteristics ?

bird is about that of a domestic fowl, and its colour a deep brown. It runs with rapidity, and defends itself vigorously with its feet. It is nocturnal in its time of action, and subsists on insects. Its native name is *kivi-kivi*, derived from its cry.

279. With this group is probably to be associated the *dodo*, now known to us only by some very imperfect remains, and by the paintings and descriptions of naturalists

The Dodo.

nearly two centuries since, when it seems to have existed in the islands on the eastern coast of Africa, especially Madagascar; though no traces of it can now be found there. A foot preserved in the British Museum, and a head in the Ashmolean Museum at Oxford, are all the actual remains of it now existing. It would appear, however, from the records of the latter museum, that an entire specimen formerly existed in it, which was allowed to decay, and its remains to be lost, with the exception of this head. There is also a picture, copied by Edwards,

an eminent ornithological artist of the middle of the last century, from a Dutch painting said to have been made from the living bird in the early times of the discovery of the Indies by the way of the Cape of Good Hope. From *this picture only*, the accompanying representation, and all the figures that are extant of the dodo (except those copied from still more imperfect delineations, of which a sufficient number exist to confirm the general correctness of this) are derived. The opinions of the most eminent naturalists concur in regarding the preserved head and foot as different from those of any existing bird, and as corresponding in character with those represented in the picture; but upon the place of this remarkable species in the class there is considerable difference of opinion. From the insufficiency of the wings for the purposes of flight, the dodo should probably take its station among the *Cursores*; but in its general structure and economy, it seems from traditionary accounts to have been more allied to the *Rasores*. Others, however, regard it as a bird of prey.

280. As to the cause of the entire disappearance of the species from the islands where it seems to have been once abundant, we can only conjecture. It is spoken of as an excellent article of food; and, from its incapability of flight, joined to the shortness of its legs, it would fall an easy prey to its pursuers. Hence it was not improbably exterminated by the first settlers in the Mauritius and Bourbon—the islands where it seems chiefly to have abounded. Whether or not it yet exists in the adjacent parts of the African continent, is a question that cannot be determined until these parts have been more thoroughly explored.

Order VI.—Grallatores, or wading birds.

281. The Grallatores, Waders or Stilt-birds, derive their name from their habits and conformation. Their long legs raise up their bodies as it were upon stilts; and, thus elevated, they frequent the banks of rivers and lakes,

330. What of the dodo and its remains?

331. Whence is the picture derived?

marshes, the shores of estuaries; and, whilst resting with their feet upon the land, derive their nourishment chiefly from the water—some feeding exclusively upon small fishes, aquatic mollusca, worms, small reptiles, and water insects—whilst others are of more terrestrial habits and food. Such as are more especially aquatic have a short web to their toes. Their wings are long, affording them the power of changing their habitation with the seasons, which most of them enjoy. During flight, they stretch out their long legs behind, to counterbalance their long necks; and the tail is always extremely short, its function as a rudder being transferred to the legs. They mostly construct or choose their nests upon the ground; and the young are enabled to run about as soon as hatched, except in those species which live in pairs. The Waders are remarkable for their power of preserving a motionless position upon one leg for a considerable time.

282. The Waders may be grouped together under four families, principally characterized by the form of the beak:—(I.) ARDEIDÆ, the *Heron* tribe, in which the beak is long, thick, and stout, and has usually cutting edges, as well as a point. (II.) SCOLOPACIDÆ, the *Snipe* and *Woodcock* tribe, in which the bill is long, slender, and feeble. (III.) RALLIDÆ, the *Rail* and *Coot* tribe, in which the bill is less slender; but the chief character is derived from the extreme length of the toes. (IV.) The CHARADRIADÆ, or *Plover* tribe, in which the bill is of moderate size, and the back toe either entirely absent, or not long enough to reach the ground.

283. (I.) The family of ARDEIDÆ includes the *Cranes* and *Storks* besides the true *Hérons*. By the *Cranes* this order is connected with the last, for nearly all of them are large birds, with short powerless wings; their necks long and frequently naked, and their habits more terrestrial than those of any of their congeners. They feed almost exclusively upon vegetables; and have a muscular gizzard. Most of them live in warm latitudes; and those

332. What of the structure and habits of the Waders?

333. Into what families are they divided?

which frequent Europe migrate southwards in the autumn and return in the spring. The common European species sometimes appears as a straggler in Britain. A very curious bird, which seems intermediate between the fowls and cranes, is known in South America under the name of *agami*; it is also called *trumpeter*, from the low deep sound which it produces. It is readily domesticated, and becomes attached to individuals like a dog; and is put in charge of other poultry. It flies badly, but runs with great swiftness.

284. The *Hérons* differ from the cranes in being decidedly carnivorous; they are known by a larger and more pointed bill, and by the greater length of their legs. Their stomach is a large undivided sac, but slightly muscular. As a whole, they are the most beautiful of all the Waders; not so much, however, on account of the colours of their plumage, as from the elegant crests and prolonged feathers which ornament nearly all the species. They build in societies, usually in trees in the neighbourhood of banks of rivers; but generally feed and live solitarily. They are chiefly supported by fish, for which they watch in some concealed situation, transfixing them as they pass with their long and sharp bills. To the tribe of herons belong the *egrets* and *bitterns*, of both of which there are species indigenous to Britain. The *boatbills* resemble the herons in most respects, but differ remarkably in the form of the bill, which is shaped something like a boat with the keel uppermost. The *spoonbills* have a form of bill somewhat similar; but they more resemble the storks in general conformation. They live upon small fish and aquatic insects, which they turn up and catch with this peculiar instrument. The *storks* are less aquatic in their habits than the rest of the family, nestling by preference on towers and chimney-stacks; each pair returning to the same place in the spring, after having passed the winter in Africa. The common white stork of Europe is held in much popular respect, owing to its utility in de-

334. Describe the first family, and their varieties.

335. What of the herons, and the differences?

stroying snakes and other noxious animals; but in England, almost every one that shows itself is shot, whence the species is very uncommon. Allied to the storks are the *adjutants* of tropical countries, which are very voracious and daring in their habits. They feed upon reptiles, fishes, small quadrupeds, and birds, even pursuing the last upon the wing; but they do not attack any large warm-blooded animals. They do not fear the vicinity of man, and are very common in Indian towns, where they are extremely useful in devouring all kinds of offal. They are large birds; the Indian species measuring six feet in height as it usually stands, and seven when it stretches the neck—the expanse of the wings being fifteen feet. With the

Indian Adjutant.

cranes are also probably to be associated the *ibises*, of which one species was held sacred by the ancient Egyptians, and was embalmed after death. This degree of respect arose, according to some, from its devouring serpents, which would otherwise have multiplied to a noxious extent in the country whilst others ascribe it to the fact that its appearance announced the overflow of the Nile. There is a beautiful scarlet ibis, inhabiting tropical America, which is easily domesticated.

285. (II.) The SCOLOPACIDÆ, or *Snipe* tribe, characterized by their long, slender, and feeble bill, which only enables them to bore in the mud in search of worms and small insects, have all nearly the same conformation, the same habits, and the same distribution of colours; so that it is difficult to distinguish amongst them. They are also

remarkable for the delicacy of their legs, and the smallness of the hinder toe. They run with vast celerity, and have considerable powers of flight; and they have also the faculty, in part, both of swimming and diving. The females are usually larger than the males, and lay their eggs on the ground, in little or no nest. Their geographic dispersion is as wide as their locomotive powers are great. The shores of every part of the world abound with *sandpipers* and *curlews*; whilst snipes, woodcocks, &c., frequent the inland waters and marshy grounds. The mention of these well-known species is nearly sufficient to characterize the family; but a few others may also be noticed.

286. The *godwits* have a more attenuated form and longer legs than the snipes; they chiefly frequent salt-marshes and the borders of the ocean, but will pick up and subsist on barley, upon which numbers are fed that are brought from Holland to the London market. The *stilts* surpass all the rest of this family, and probably therefore all other birds, in the length and slenderness of their legs. Allied to them are the *avocets*, which present several interesting peculiarities of conformation. Their feet, which are webbed nearly to the ends of their toes, almost entitle them to rank amongst the swimming-birds; but the length and nakedness of their legs, and their long, slender, smooth, and elastic bill, and the mode of life which results from this conformation, concur to approximate them to the snipes. They are peculiarly distinguished from all other birds (except two species of humming-bird) by the *upward cur-*

Stilt.

vature of their beak, the mandibles of which have been compared to two thin slips of whalebone. The European avocet frequents the sea-shore, where it feeds by *scooping* with its singular bill; it draws this through the sand, from side to side, as it advances, seizing whatever living prey is thus met with.

287. The RALLIDÆ, or *Rail* tribe, are furnished with very long toes, for traversing aquatic herbage; and they are even useful in swimming, especially in some species in which their surface is extended by a border of membrane. They are also distinguished by the form of the body, which is very thin and narrow—a structure adapted to their habits and mode of life, since they live, for the most part, in the thick and tangled recesses of the reeds and aquatic vegetables which clothe the sides of rivers and morasses. Their wings are short, or of moderate length, and their flight feeble; but they run with considerable swiftness. They are, for the most part, solitary and timid birds, hiding themselves at the least approach of danger, but quitting their semi-aquatic retreats morning and evening, to feed in more open spots. The flesh of these birds is delicate; and, as they live chiefly upon aquatic seeds and vegetable aliment, they may be regarded as aquatic Gallinacæ. By the peculiar form of their bodies, and their powers of running, they are able to make their way through dense masses of reeds and high grass, with so much facility as to escape even after being desperately wounded. The females are mostly larger than the males, and exceed them also in brightness of colouring. The *rails*, *coots*, and *crakes*, are the chief British species of this family, and are sufficiently characteristic of it.

288. Under this family are placed two remarkable birds, the place of which is rather doubtful. One is the *jacana*, which is distinguished from all other stilt-birds by the length of all four toes, and the length also of their claws, especially that on the back toe. It is a noisy and quarrelsome bird, inhabiting the marshes of hot climates, where

338. What varieties are here described?

339. Describe the Rail tribe and their habits.

it walks with facility on the floating leaves of aquatic plants, by means of its long toes. In many points of its anatomy it is allied to the preceding family. The other is the *flamingo*, which is perhaps rather to be considered as one of the

The Flamingo.

duck tribe, with an inordinately long neck and legs. The front toes are webbed to their ends, and the hind toe is extremely short. The mandibles are suddenly bent downwards, about the middle of their length; and they are roughened at the edges, like those of the ducks, to which the fleshiness of the tongue also shows an alliance. They feed on mollusca, insects, the spawn of fishes, &c., which they seize by means of their long neck, turning the head downwards, to use to advantage the crook in the upper mandible. They construct their nest in marshy situations, placing themselves astride of them during the act of incu-

340. Describe the jacana and its habits.

341. What is said of the flamingo? -

bation, being incapacitated by the length of their legs from sitting on them in the usual manner.

289. (IV.) The CHARADRIADÆ, or *Plover* tribe, are less aquatic than most of the other families. The legs are long, and the back toe is either quite absent, or so short as not to reach the ground. They live only on sandy and unsheltered shores, or on exposed commons, congregating in flocks, and running with great swiftness. The bill is usually of moderate strength, enabling these birds to penetrate the ground in search of worms, to obtain which they have the habit of patting with their feet, which causes the worms to rise. The species in which the bill is more feeble, frequent meadows and newly ploughed land, where this food can be obtained with greater ease; those which have stronger bills subsist additionally on grain, herbage, &c. Of the plovers, several species exist in Britain, and others are distributed through most other countries. Some chiefly frequent the sea-coast, and others the upland moors. The *Lapwings* are nearly allied to the plovers, and like them are migratory, passing the winter in warm latitudes; they are peculiar to the eastern hemisphere. They are very noisy birds, screaming at every sound they hear, and defending themselves with courage against birds of prey. They derive their name from the stratagem by which they lure away intruders from their nests; they drop their wings in flight, appearing as if wounded, and thus induce their pursuers to follow them to a considerable distance.

290. Three other genera of this family are worthy of notice. The *Bustards* connect the *Grallatores* with the *Rasores*, in the heaviness of their bodies, the small membrane at the base of their toes, and some other characters. They have, however, the long naked legs of this order, and the flavour of their flesh resembles that of the wading-birds. They fly little, scarcely ever using their wings, except (like the ostriches) to assist them in running; but their flight, when they do rise, is easy and capable of consi-

342. Describe the Plover tribe, and their variety.

343. What of the Bustards and their differences?

derable protraction. They feed equally on grain, herbage, worms, and insects. The great bustard is the largest of European birds, and is one of the finest kinds of game: it has been nearly extirpated in Great Britain. The *Turnstone* is at once recognised by a short stout bill, rather turned upwards; the name is derived from the habit it possesses of turning up stones upon the sea-shore, to feed upon the marine animals concealed beneath. The *Oyster-catcher* has a long, strait, wedge-shaped beak, which is strong enough to enable it to force open the bivalve shells of the molluscs upon which it feeds.

Order VII.—Natatores, or swimming-birds.

291. The Swimmers are, of all the orders of birds, the most easily recognisable by the structure and position of their oar-like feet. This peculiarity, which occasions that awkwardness of gait on the land which every one may observe in ducks and geese, is extremely favourable to those birds whose “business is in the great waters.” The body is boat-shaped, and the neck is very long in proportion, for the purpose of reaching prey beneath the water when the bird is floating on the surface. The thick downy covering is rendered impervious to water by the abundant application of the oily secretion. The bones of these birds are not hollow, like those of the rest of the class, but are filled with an oily marrow. In this, and in other points, their structure approximates to that of reptiles. Their circulation is less energetic than that of the other orders, and is capable of being considerably retarded in diving birds, by the obstruction of the respiration, without injury.

292. As the water is the element in which these birds are formed to move, so does it also supply them with food. Some of them live on aquatic plants and submarine insects, but the greater proportion prey upon fish and those innumerable swimming and creeping things which subsist in the sea and cover its shores. In general, several females associate with one male, and the young are hatched in a condition which renders the co-operation of both parents

for their support unnecessary, being able to take to the water and swim about in search of food, the instant they are liberated from the egg-coverings.

293. This order may be divided into five families:— (I.) The ANATIDÆ, or *Duck* tribe; (II.) The LARIDÆ, or *Gulls*; (III.) The PELICANIDÆ, or *Pelicans*; (IV.) The COLYMBIDÆ, or *Divers*; (V.) The ALCIDÆ, or *Penguins*. The three first are distinguished by the length of their wings, which enables them to fly well, while in the two latter these members are so short that they seem perfectly useless for any other purpose than that of fins.

294. (I.) The ANATIDÆ are distinguished by a thick bill, which is horny only at its extremity; the remainder of the mandibles being invested with a soft skin, which in other birds is found only at their hinder part. This skin in the ducks is extremely sensitive, and by it the animals take cognizance of the food contained in the mud, into which they plunge their bills. The edges of the bill are roughened, either by plates or small teeth arising from it; and the tongue is large and fleshy. These birds live more in fresh water than in the sea; and many of them (such as geese and swans) are exclusively vegetable feeders. The ducks, on the other hand, subsist in part upon animal diet; and one tribe of them, the mergansers, feed almost exclusively upon fish. Under the general designation of *ducks*, *geese*, and *swans*, all the birds of this family may be arranged; and as these typical forms are so well known, it is unnecessary to dwell longer on it, although the habits of many species are extremely interesting. This family is very extensively diffused over the earth's surface, and supplies man with an important amount of food, and with the greater part of the *down* which contributes so greatly to his comfort and luxury.

295. (II.) The LARIDÆ, or *Gull* tribe, more resemble the higher orders of birds in their general structure, but are deficient in that which constitutes the perfection of the order—the power of swimming and diving. The

345. Into what families are they divided?

346. What is peculiar in the Duck tribe?

wings are very long, and their powers of flight considerable. The feet, although webbed, are so constructed as to enable them to walk with ease along the shore in search of food; the legs are slender, and sometimes so long as to resemble those of the waders; the hind toe is very small, and sometimes wanting. Many of the birds of this tribe have a tendency to associate in flocks. In consequence of their capability of protracted flight, they are met with at a greater distance from land than most others; many species are almost constantly on the wing, and brave the most violent storms. They seem to devour almost every description of animal and vegetable food.

296. The *Gulls* are the best known members of this family, from their abundance on our coasts. They inhabit the shore, nestling in the sand or in clefts of rocks. They are cowardly and voracious, feeding on fish, carrion, &c. The *Skuas*, which are chiefly abundant round the Scottish isles, are nearly allied to these, but are more powerful and courageous. The largest species, known as the great black-backed gull, builds its nest high in the mountains, and defends it with spirit and intrepidity, even driving off eagles from the vicinity. It pursues the smaller gulls, and causes them to disgorge their food, which it catches before it reaches the water. The *Terns*, or Sea-Swallows, also approach nearly to the gulls; but their long and pointed wings, their short legs, and forked tail, induce a port and flight analogous to those of the swallows. They skim along the water with great rapidity, skilfully raising from its surface the small fishes and molluscs on which they feed, and to obtain which they often plunge. They also penetrate to the lakes and rivers of the interior. The *Petrels* have also a very swallow-like aspect; and they are found at a greater distance from the land than any others of this family. Their name (a diminutive of *Peter*) is applied from their peculiar motion on the surface, which gives them the appearance of walking on it; in this the action of the wings upon the water assists them. Some

347. Describe the Gulls, and the different species.

348. What other species are cited?

of the smallest of these are termed *storm-petrels* (vulgarly, Mother Carey's chickens), from their habit of seeking shelter on reefs and ships when a storm is approaching. The *Albatross* is the most bulky of all aquatic birds. It is nearly allied to the petrel, which it resembles also in

Albatross.

its manner of treading the waves. In its general habits it may be described as a sort of marine vulture. It is extremely voracious, and devours almost any thing that falls in its way. Though its wings are powerful, its flight is by no means lofty. No species of it exist in the northern part of the Atlantic; but it is very abundant beyond the Tropic of Capricorn, and is one of the great enemies of the flying-fish.

297. The PELICANIDÆ, or *Pelican* tribe, are characterized by having the hind toe united to the rest by one continuous membrane: notwithstanding this conformation, which renders their feet perfect oars, they are almost the only Natatores which perch upon trees. All of them fly well, and have short legs. They are a large, voracious, and wandering tribe, living for the most part on the ocean,

349. Describe the Albatross.

350. What of the structure of the Pelicans?

and seldom approaching land but at the season of incubation. The *Pelicans* themselves are remarkable for the length of the bill, which is armed with an abrupt hook at the end; the width of the gape is excessive; and the skin hanging from the lower jaw, and forming the throat, is so extensible as to dilate into a pouch capable of holding a large quantity of fish. The *Cormorants* are allied to these, and are remarkable for being not only voracious but docile, so that they have been trained for fishing, as hawks for fowling. These are very widely distributed over the earth's surface, whilst the pelicans are restricted to the warmer latitudes. The *Frigate-birds* are nearly allied to the *Cormorants*, but differ from them in the excessive spread of wing (which renders them the most powerful flyers in this order—perhaps not being surpassed by any other bird), and in the form of the tail and bill. They feed upon fish, especially flying-fish, both darting at it themselves, when near the surface, and obtaining it from other birds, whom they compel to drop their prey. The *Gannets* are allied to the frigate-birds; but the wings are less extended, and the powers of flight inferior. Some species are termed *Boobies*, from the stupidity they exhibit when attacked. A species about the size of a goose is very common in the British seas, and breeds especially on the Bass Rock, in the Firth of Forth. The *Gannets* take their prey by hovering in the air at some little distance above the surface, and then dropping down upon any fish that they may see rising, within their reach. The air-cells are very largely developed, especially under the skin of the breast, which is almost completely separated by them from the muscles beneath; and it is probable that they may serve as an elastic cushion, to break the force with which the body of the bird would otherwise impinge on the water.

298. (iv.) The COLYMBIDÆ, or *Divers*, may perhaps be regarded as intermediate in structure between the Duck tribe and the next family. They are all marine birds, with a lengthened, strong, straight bill. The wings

are in general remarkably short ; and the feet placed so far behind the point of equilibrium of the body, that they will not allow the birds to walk upon land even so well as ducks. They are few in number, and are chiefly confined to the seas of northern regions. The true Divers, or *Loons*, are chiefly arctic birds, which visit the British shores only in winter. The legs are so completely buried within the body, that they are unable to walk upon land ; but they push themselves forwards upon the belly with facility and tolerable speed. They have a short tail, on which they rest when standing upright on their feet, to view what is going on around them by means of their long neck. They are great destroyers of fish, and pursue their prey under water with extreme swiftness. The *Guillemots* bear more resemblance, perhaps, to the next family—using their wings to propel themselves under water, which the Divers do not. The *Grebes* dive in somewhat the same manner, but their habits are not so completely aquatic. They reside on the borders of lakes and ponds ; and, notwithstanding the shortness of their wings, they fly with considerable speed, when once they fairly rise, which they do with unwillingness.

299. (v.) The *ALCIDÆ*, or *Auk* tribe, exhibit the most remarkable adaptation of the structure of the bird to an aquatic life, with which the entire order presents us. This is best seen in the *Penguins*, whose wings are very small, and covered with mere vestiges of feathers, which resemble scales ; so that they serve as admirable fins or paddles, but are totally useless for flight. The feet are placed very far back, so that when upon land the bird stands nearly erect. Having no power of flight, and not being able to run, the penguin may be overtaken with ease upon land ; but once in the water, it distances its pursuers, swimming with the ease and rapidity of a fish, and springing several feet over any obstacle that may impede its course. Besides the characters which have been already

352. Describe the Divers and their structure.

353. What species are described ?

354. Describe the variety of Penguins.

mentioned as indicating an approach towards the reptiles in this tribe, the penguin is especially remarkable for having that kind of ball-and-socket union of its vertebrae which is peculiar to that class. The penguins are exclusively inhabitants of the southern seas; but there are birds of the northern ocean which approach them in their peculiar characters. Such are the *Puffins* and *Auks*; the former have short wings, which can sustain them for a short time; of the latter, one species flies nearly as well as the Guillemots, whilst, in the other, the wings are adapted to aquatic progression almost as exclusively as in the penguin.

CLASS III.—REPTILES.

300. The class of Reptiles, which is the next to be considered, presents us with more diversity of form amongst its separate orders than any other division of the vertebrated sub-kingdom. Scarcely any animals are more unlike in external aspect than tortoises and serpents; yet we shall find that these extreme forms are connected with each other by a gradual series; and the internal differences are not so great as to prevent their association into one class, distinguished by characters which are common to all. These characters are—their low power of maintaining heat, or cold-bloodedness, arising from the imperfect aeration of their blood, of which only a portion is sent to the lungs at each impulse of the heart; their oviparous reproduction; the respiration of air exclusively during the whole period of life, no metamorphosis taking place in this class; and the protection of the skin by hard scales or plates. By the first two they are distinguished from Mammalia and Birds, and by the others from Fishes and Amphibia.

301. The deficiency in the oxygenation of the blood, combined with the slowness and feebleness of the circulation, is connected with general inactivity of the nutritive

functions, as well as with obtuseness of sensation and sluggishness of locomotion. It is a curious result of the feeble exercise of these functions, that, as in Amphibia, they may be suspended for a considerable time without apparent injury to the animal; and that parts separated from the body retain for a long period much of that low degree of vitality which they usually exhibit in connection with it. Although at present Reptiles appear to perform a comparatively insignificant part in the economy of nature, especially in temperate climates, where their numbers are few and their powers feeble, we learn from the records of geology that there was a period in the earth's history, long antecedent to the creation of Birds and Mammalia, when gigantic animals of this class not only constituted the chief tenants of the earth, but extended their dominion over the waters of the sea.

302. The three well-known forms, *Tortoises*, *Lizards*, and *Serpents*, may be taken as the types of three orders into which this class may be subdivided, namely, the CHELONIA, SAURIA, and OPHIDIA. But, in order to embrace some of the fossil species, which present us with other types of structure, it is desirable to create another order—the ENALIOSAURIA—intermediate between the Turtles and Crocodiles; and this last tribe, though possessing the general form of lizards, so far differs from them in the covering of the body (which consists of large plates instead of scales) as well as in some points of internal organization, that a distinct order, LORICATA, has been formed for it. These five orders may then stand thus:—I. CHELONIA, including the *Turtles*, *Tortoises*, &c.; II. ENALIOSAURIA, to which the *Plesiosaurus*, *Ichthyosaurus*, and other fossil remains belong; III. LORICATA, comprehending the *Crocodiles*, *Alligators*, &c.; IV. SAURIA, including the remainder of the *Lizard* tribes; V. OPHIDIA, the *Serpents*.

Order I.—Chelonia.

303. The order Chelonia differs the most of any of these from the general form of the group. The shell in

356. Which are types of the three orders?

357. What are the names of the five orders?

which the body is enclosed, and into which, in some species, the head, legs, and tail, can be completely withdrawn, would seem a perfectly new organ, to which nothing correspondent exists among vertebrated animals. And the fin-like extremities of the aquatic species remind us more of fish than of other reptiles. The shell, however, is composed of the usual bones of the skeleton, modified only in their form. The upper piece, termed the *carapace*, is usually more or less arched, and is composed of a bony expansion of the ribs, which are consolidated into a firm structure, adhering to each other along their edges, and are covered with horny plates, secreted from the skin-like hair or nails. The lower plate, or *plastron*, is formed by a peculiar development of the sternum or breast-bone, which, instead of being prolonged forwards into a keel, to give attachment to large muscles, as in birds, is extended latterly for the protection of the subjacent parts.

304. Most of the *Chelonia* are deficient in weapons of offence, being destitute of teeth, claws, or other sharp instruments. The jaws are covered with a horny substance, resembling that of the bills of birds; but their surfaces are usually rounded, so as to be more adapted to bruise than to bite. The shell, however, serves as a most effectual means of passive resistance. In the land species it is usually high-arched, and firmly united, so as to bear a very great weight without injury; and the feebleness of the power of motion in these animals is thus compensated. But in the aquatic species it is generally more flattened, so as to oppose less resistance to the water. Some of these have the power of swimming with considerable rapidity, and are altogether more active in their habits than the rest of the order. In those, the shell affords much less complete protection to the body, and its parts are more loosely united, so that it possesses some degree of flexibility.

305. Among the families into which the *Chelonia* are subdivided, it will be convenient to notice first the *CHELONIDÆ*, or *Turtles*. These are distinguished by the incompleteness of their shelly covering, and the peculiar

modification of the feet for swimming. The ribs, by the union of which the carapace is formed, are separated from one another around its margin, and the pieces which compose the plastron do not form a continuous plate, but leave great intervals, which are occupied only by cartilage. All the feet are much elongated, particularly the anterior pair, and are flattened so as to serve for oars or paddles. The toes are seldom at all separated, the whole foot being enveloped in the same skin, closely set with hard plates. They live almost entirely at sea, feeding chiefly upon marine plants, and they only come to the shore to deposit their eggs. The œsophagus (gullet) of these animals is lined with long cartilaginous processes, all directed towards the stomach; these seem to have for their object the prevention of the return of the food, which is swallowed together with a large quantity of water; and, when the stomach afterwards ejects the superfluous fluid, these spikes prevent the food from being regurgitated with it.

306. The *chelone midas*, green or edible turtle, is to man the most important species of the whole group, not only on account of the delicacy of its flesh in epicurean estimation, but as furnishing a wholesome and abundant article of food to voyagers in tropical climates. It is distinguished by the greenish colour of its scales, which are about thirty in number, but they do not lap over one another, and they are not of any use in the arts. The usual length of this species is four or five feet, and its weight from 400 to 800 lbs. It has been known to increase, however, to a length of eight feet and a weight of 1500 lbs.; but the flesh of the large turtles is not so much esteemed as that of the small ones. The turtles feed in great troops upon the sea-weeds in shallow waters, where they may be seen grazing like a herd of cattle. They are occasionally obliged to come to the surface to breathe, and sometimes remain there, basking in the sunshine.

307. Although generally living in the open sea, they are obliged to approach the land for the purpose of laying

359. Describe the Turtle family.

360. What is said of the green turtle?

their eggs. The number deposited by each individual is about one hundred, and the process is repeated three times a year. The eggs are almost unprotected by a shell, and, that they may be covered without injury by the sand (in which they are hatched by the heat of the sun), it is requisite that this should be soft and movable. To obtain a good locality for this purpose, the turtles will travel many hundred leagues. They prefer an insular spot, and on that account Ascension Island, from its central situation is much frequented by them. They lay their eggs by night, and in large companies, and at this time they are secured by those who are employed in catching them. The young turtle, when it emerges from the shell, is not more than two inches in length ; the disproportion between its early and adult state is thus very remarkable. It does not possess sufficient specific gravity to sink in water, and, as its shell is soft, it falls an easy prey to voracious animals of different kinds. After a time, those which remain follow their parents to their old haunts. Turtles are long-lived animals, individuals having been known to exist for a hundred years. They are usually found within a range of 25 or 30 degrees north and south of the equator.

308. The *chelona imbricata*, or hawk's-billed turtle, is the one that furnishes the best tortoise-shell for the purposes of the manufacturer. This has its horny muzzle somewhat prolonged into a sharp point, and the lower jaw is received into a groove of the upper, so that the food can be cut as well as bruised by it. The thirteen plates which cover the whole upper part of the shell are much thicker and stronger, as well as more clouded in colour, than those of any other species ; and they lie over one another like the tiles of a house, so that at least one-third of each overlaps the one behind it. They are separated in the first instance by the aid of heat, and afterwards softened by the same agency, for being worked into various forms. Even the filing and powder which remain from the other processes, are made useful, by being pressed with any small fragments in metallic moulds at a heat of boiling water ; this

process unites them firmly, and they can then be formed into plates of any required thickness. About ten or twelve pounds of tortoise-shell are usually yielded by each individual. This species does not grow to above one-third of the size of the green turtle.

309. The *chelone caretta*, or loggerhead turtle, is a species, nearly confined to the Mediterranean. Its flesh is not held in much estimation, but it is wholesome. A very curious genus, belonging to the same family, is the *sphargis*, or leathery turtle; in this the carapace is not covered by scaly plates, but by a thick leather-like skin. The head is more acute than in the other marine turtles; the jaws are of immense strength, and the edges very sharp; the upper one has three remarkable notches, having points between them which serve as teeth. The eye opens almost vertically, which gives a peculiar and strange aspect to the animal. It acquires a large size, sometimes weighing 800 lbs. It feeds upon various marine animals as well as plants. This species is found in the Mediterranean, the Atlantic, Pacific, and Indian Oceans. A few specimens of it have found their way to our own shores.

310. The EMYDÆ, *Fresh-water Turtles*, or *Mud Tortoises*, are intermediate in form between the family just described and the land Tortoises. The character by which they may be most constantly separated from the marine Turtles, is the distinctness of their toes, which are terminated by claws; but a web still exists between the toes, which assists them in swimming, and also prevents the feet from sinking into mud. Rivers, ponds, and running streams, are the haunts of these animals, of which one species is common in the south and east of Europe, and is fattened for food in Germany and Russia, where it is considered a delicacy. The food of the Emydæ consists of mollusca, aquatic insects, small fish, carrion, and vegetables. The species at present existing seldom attain any great size, their shells varying from one and a half inch to a foot in length; many of the fossil species are much

362. What of the hawk's-bill turtle?

363. Describe the loggerhead turtle.

larger. Their habits are usually active; when disturbed, they bury themselves in the mud, and escape from their enemies by the discoloration they thus occasion.

311. In several of the Emydæ the carapace and the plastron are but loosely united; and the pieces of the latter are movable upon one another. This is the case in the *Terrapins*, or Box-Tortoises, which are able to draw the head and limbs completely into the shell, and to close the latter by folding the anterior, and in some instances the posterior, division of the plastron against the carapace. In this order has been included a very remarkable animal, which is known in America by the name of the *snapping-turtle* or *alligator-tortoise*. It combines the characters of the Chelonia and Sauria, having the shell of the former and the lengthened body and active habits of the latter. The shell is oval and depressed, like that of the Emydæ in general; but the neck and legs are much too long to be withdrawn within it. The animal is principally distinguished, however, by the size of the tail, which is very large, and of about the same length with the shell. This species is much bolder than the others of the group. It goes to a considerable distance from the water in search of food; and bites and hisses with great vehemence. Its claws are sharp; and so forcible and violent is its bite, that one of them has been known to snap asunder a stick half an inch in diameter without difficulty. It feeds upon frogs and other small aquatic reptiles, fish, and even birds and small Mammalia; and it has been seen to combat with alligators, and even to come off victorious. The name by which it is at present known is *chelydra serpentina*.

312. The family of TESTUDINIDÆ, or *Land-Tortoises*, is distinguished by the highly arched carapace, and, still more, by the short clubby feet, of the animals composing it. Their armour is harder and thicker in proportion to their size, and also more firmly united together, than that of the aquatic species. The neck and legs are short, and are capable of being drawn entirely within the shell; so

364. What other species are cited?

365. What variety in this species is named?

that the whole structure of the animal is adapted for passive resistance. The feet, shaped very much like those of the elephant, are adapted for walking on firm ground only, as the surface they present is very small. They are subdivided into toes, of which there are five on the fore feet and four on the hind; and these are furnished with short conical claws, well adapted for digging. These animals are of the most inoffensive character possible. They feed only upon roots and vegetables, and upon the worms and slugs that infest these; during the summer they live in woods or among herbage; and they pass the winter, in cold climates, beneath the earth, where they burrow and sleep. They are generally dispersed in all the warm and temperate latitudes; but they do not naturally extend to Great Britain, although individuals that have been introduced have lived to a great age in this country.

313. The commonest species is the *Testudo Græca*, which is an inhabitant of most of the continent of Europe, as well as of many parts of Asia and Africa; it especially abounds near the shores of the Mediterranean. It seldom attains above a foot in length, or weighs more than three pounds. The flesh forms an article of food in Greece. In the East Indies are found species which attain to a much greater size. An individual in the possession of the Zoological Society of London measures 4 feet $4\frac{1}{2}$ inches along the curve of the back, the breadth of the shell being 2 feet 1 inch, and the weight of the whole animal 285 lbs. Some of the land-tortoises, included in the genera *Pixys* and *Cinixys*, have the pieces of the sternum movable, as in the Terrapins, so as completely to guard the body from external injury.

314. Besides these three families, may be mentioned a genus which cannot be included in them, the *Trionyx*, or soft tortoise. This has no scales or plates; but the bony envelope is covered by a soft skin. A considerable part both of the carapace and plastron is destitute of bone, being filled up in the living state by cartilage. The horny muz-

366. What of the structure of land-tortoises?

367. What other species are described?

zle is closed externally with fleshy lips; and the nose, unlike that of the other *Chelonia*, is prolonged into a small proboscis, having the nostrils at the tip. The feet somewhat resemble those of the *Emydæ*, being flattened, but not lengthened; the toes are distinct, but only three of them are furnished with claws, whence the name of the genus. They live entirely in fresh water; and they are provided with an organ of swimming additional to the feet, for the loose skin of their body forms a thin narrow flap round the edges of the shell, and performs the office of a fin. The trionyx was first observed during the French expedition in Egypt. A species of it is very abundant there, and is of great service in devouring the young crocodiles soon after they are hatched: it is believed to do more in the destruction of this race than even the ichneumon. A species inhabiting the Ganges is observed to feed upon the dead bodies which are constantly floating in the stream. And another, which inhabits the rivers of tropical America, is of peculiarly ferocious habits, lurking in the vegetation on their banks, and darting with energy upon birds and smaller reptiles which come within its reach. It preys upon young alligators; and is in its turn devoured by the full grown ones.

Order II.—Enaliosauria.

315. The order Enaliosauria has been founded upon two extraordinary fossil genera, the *Ichthyosaurus* and the *Plesiosaurus*. Of these little else than the bones has been preserved to us; and it is therefore impossible to speak with certainty in regard to many parts of their organization. The character by which they are especially connected with the *Chelonia* is the flattening of the extremities into fin-like paddles, resembling those of turtles. They must have been, therefore, marine animals, endowed with scarcely any power of movement on land; but, although in many points analogous to fish, it is nearly certain that they breathed air like reptiles in general, and that they must have occasionally come to the surface to

368. What of the last genus?

369. Name the two fossil genera of this order.

respire. Moreover, from the remains found in proximity with them, it may be surmised with probability that they fed upon marine animals alone, especially upon the various forms of Cephalopoda, which were particularly abundant at the epoch of their existence.

316. The general form of the *Ichthyosaurus* (or fish-lizard) appears to have been not unlike that of a crocodile, with the substitution of fins for feet. The head is lengthened into a narrow pointed muzzle, and the jaws armed with sharp and formidable teeth; it had eyes of enormous size, which must have given it an extraordinary aspect, and probably enabled it to see by night. The skeleton of the commonest species (*I. tenuirostris*) usually measures three-and-a-half feet in length; but portions of another kind have been found, which must have belonged to animals of above twenty feet. It is probable that the skin was destitute of scales, like that of the Amphibia; and, from recent inquiries, it appears that it possessed a sort of cartilaginous fin upon its back, like that of many Cetecea. This animal may thus be considered as presenting a very remarkable combination of the characters of other classes. Its remains, which are found in the lias and oolitic formations, are more abundant in England than in any other country in Europe.

317. The *Plesiosaurus* was distinguished by the extraordinary length of its neck, which, in the commonest species (*P. dolichodeirus*), occupies nearly half the entire length. The head is very small in proportion, and the tail is short, stout, and pointed. The cervical vertebrae exceed in number those of any other animal known; and, in their conformation, have a good deal of resemblance to those of the body of a snake. It is the conjecture of Mr. Conybeare, by whom the first scientific investigation of the characters of this strange creature was made, that, as it breathed air and had frequent need of respiration, it generally swam upon or near the surface of the water, arching back its long neck, like the swan, and plunging

370. Describe the first of these.

371. How is this second genus described?

it downwards at the fishes that passed within its reach. The greater length of its extremities would enable it to move on land with somewhat less difficulty than the *Ichthyosaurus*; and it might have very probably lurked in shallow water along the coast, where it could find shelter from its enemies, and a place of ambush from which to dart out its long neck upon its own prey. Its length seems generally to have been about ten feet.

Order III.—Loricata.

318. The order Loricata, including the Crocodiles, Alligators, and Gavials, may be regarded as in many respects intermediate between the fresh-water Tortoises and the true Lizards. The body is enclosed in a sort of plate-armour, of which the separate portions are closely fitted together, and are capable of great resistance. Another character by which they are distinguished is the flattening of the foot, which is furnished with a kind of web between the toes, like that of the *Emydæ*; in the true lizards no such provision for aquatic habits is found. This order includes the most bulky reptiles at present known to exist. Some of them attain the length of thirty feet, and a circumference of seven or eight; so that, with the exception of the elephant, the rhinoceros, and the hippopotamus, there is no terrestrial animal exceeding these in dimensions.

319. Although capable of moving on land, however, the greater number of them prefer the water, and show their chief activity in it. Besides the expansion of the foot, they are adapted for swimming by the lateral compression of the tail, which thus acts as a large and powerful fin. The crocodiles and their allies are all inhabitants of the rivers and fresh waters of warm climates; and they are all purely carnivorous. They destroy their prey by holding it beneath the surface of the water until it is drowned; the position of their nostrils, and the arrangement of the air-passages, being such that they are themselves enabled to breathe during the process. They can.

not swallow under water, however, and their habit is to hide their prey in holes on the bank, until it has become putrid, and then to devour it at their leisure.

320. The conformation of the neck is such, that the head cannot be moved very far from side to side, though its play in the vertical direction is not limited. The animal finds it difficult, therefore, to turn itself round upon land; and thus a sure means of escape presents itself, in those rare cases in which it leaves the water in pursuit of human prey. The tail, however, is very flexible from side to side, and is of great importance in propulsion. It also serves as an important weapon, for it is armed, like the back, with very strong upright plates, which form sharp ridges or crests in their centre; with this weapon the crocodiles can inflict terrific wounds upon their enemies. This group is entirely confined to the countries bordering on the equator. The animals which compose it may be considered in three subdivisions—the *Crocodiles*, chiefly inhabiting the Nile and other African rivers; the *Gavials*, found in the Ganges and other Asiatic rivers; and the *Caymans* or *Alligators*, confined to the New World.

321. The characteristic differences of these three divisions are best marked in the form of the head. The *Gavials* have the muzzle exceedingly prolonged and narrow, somewhat resembling in form the beak of the spoonbill. In the true *Crocodiles* it gradually widens from the point towards the eyes; and in the *Caymans* the snout is much more rounded, and the head is broader in proportion to its length. These last appear less adapted to aquatic habits than the *Crocodiles* and *Gavials*, for the feet are not webbed to nearly the same extent as in the latter, and the ridge which increases the surface of their hind legs is wanting in the *Alligators*. With these exceptions, however, the general conformation of all, as well as their mode of life, is very similar.

322. The *Crocodiles* of the Nile are seldom found at present near the mouth of the river, being nearly confined

373. How is this group subdivided?

374. How are they distinguished?

to Upper Egypt, where the constant warmth prevents them from hybernating as they do in higher latitudes. They seem formerly, however, to have been much more abundant; but a constant war of extermination is now waged against them by man, as well as by their natural enemies. The ancient Egyptians were so well aware of the benefits they derived from them in the removal of the putrefying animal substances that would have corrupted their waters, and in guarding them from the incursions of the Libyan robbers, that they made them objects of adoration, placing them in their temples whilst alive and embalming them when dead. They generally resort to the sedgy banks of rivers, where they lie concealed; and their brown knotty aspect, resembling that of the fallen trunk of a tree, assists them in eluding observation. At other times, they swim just beneath the surface to the place where terrestrial animals may have come to slake their thirst. Sometimes they seize their prey at once with their jaws, but often first strike it a violent blow with their tail. Men, and particularly Negroes, are said to be their favourite prey, and are not unfrequently carried off by them. They are greedy, too, after the flesh of dogs, and the Negroes that hunt the crocodile in the African rivers are accustomed to beat the dogs, that their bark may attract the crocodiles.*

323. The *Gavial*, or crocodile of the Ganges, seems to be more completely aquatic than the true crocodiles, seldom quitting the water, and reposing chiefly on the mud in the shallows. Its food consists almost entirely of fishes, aquatic reptiles, and other living productions of the waters; it seldom meddles with warm-blooded creatures, and never with living man, but it probably assists in destroying the

* According to Bosc, the wild dogs of Florida, that live near the rivers in which alligators abound, have recourse to a curious stratagem. When they wish to drink, they go to the water and bark; this attracts the alligators to the spot; the dog immediately runs as fast as he can to some distant part of the river, where he has time to drink before the alligators can come up with him.

375. What of the crocodiles?

376. What of the habits of the negroes and dogs?

dead bodies which are so constantly floating down the stream. It sometimes attains a considerable size; from a fragment preserved in Paris, the entire animal would seem to have been above thirty feet in length. The Ganges is tenanted by the common crocodile as well as by the gaval.

Alligator.

324. In regard to the *Caymans* of the New World, it is to be remarked, that this term is applied there to all animals of the crocodile form, and thus to the true crocodile, several species of which exist in that quarter of the globe, as well as to the alligator—hence some confusion has arisen. The *alligator* passes much of its time on land, but prefers marshy places. It lies hid there, covered with underwood, and springs upon any animals that may come within its reach. It drags them to the water, however, for the purpose of drowning them. Sometimes it will even attack men. Its voice is very loud, resembling that of a bull; and it is altogether, when of large size, a more formidable enemy upon land than a crocodile, which seems out of its element and comparatively powerless when it quits the water. In the river near Surinam, alligators have been seen that attained the length of twenty-four feet. In many parts of America their flesh is eaten by the natives, but it is described as having a musky and rather fœtid odour.

377. Describe the gaval.

378. What is remarkable in the alligator?

Order IV.—Sauria.

325. The order Sauria comprehends all the animals commonly known as Lizards. They are intermediate between the Loricata and Serpents, for they have a lengthened body, terminating in a tail, like the former; but this, instead of being enclosed in large shields or plates, is covered with small scales, as in the latter. Moreover, they have usually four legs; but in some species one pair disappears, and in others they are all concealed beneath the skin, so that the body presents a snake-like aspect. In this group are found some of the most active, and certainly the most beautiful, of the Reptile class. Many of them are tinged with the most brilliant colours; and as they are called into the greatest activity in the bright sunshine, nothing can surpass the splendour of their ever-changing hues. These colours bear an interesting relation to the habits of the animal, having a general resemblance to that of the places they frequent; thus, tree-lizards are almost always of bright colours, in which green predominates; ground-lizards, brown, more or less speckled; and those which live in stony places are of a grayish hue.

326. The greater part of the Sauria are carnivorous, feeding upon other animals of inferior size and strength to themselves, and almost always preferring living prey. Many of them pursue nothing but insects; others lie in wait for small birds. The Iguanas, however, feed almost wholly upon vegetables. Many of them are possessed of very great agility upon land; some of them can ascend perpendicular walls, and even run along the ceiling with their backs downward; none of them are inhabitants of the water, though a few occasionally resort to it. The activity of the smaller insectivorous lizards, when in pursuit of their food, is exceedingly curious and interesting. They watch with all the caution of a cat, and dart upon their prey with the quickness of lightning. Their movements are effected chiefly by means of their feet, and in

379. Describe the characteristics of lizards.

380. What variety is cited?

the higher tribes exclusively so; but in those species in which the legs are short and the feet very small in proportion to the length of the body, progression is greatly assisted by the lateral motion of the trunk, which works its way along somewhat in the manner of that of the serpents.

327. The order Sauria may be subdivided into five families—(I.) The LACERTINIDÆ, characterized by the small head and thin neck, but particularly by the very long slender forked tongues of the animals composing it. This group includes the common lizards of this country, and most of the saurians whose habits are peculiarly active. (II.) The IGUANIDÆ, having the same general form, but short thick tongues. This group includes some of the largest of the Sauria, both recent and fossil. (III.) The GECKOTIDÆ, which are all nocturnal animals. These have not the attenuated form of the previous families, but are flattened, especially on the head. Their legs are short, and their movements comparatively tardy. Their colour is usually very sombre; and they are reputed, but without foundation, to be venomous. (IV.) The CHAMELEONIDÆ, whose tongue is of immense length, but obtuse at its point. The feet and tail are both peculiarly adapted for climbing; the former having two of the toes opposable to the rest, and the latter being round and prehensile. Their movements are very slow, except when the tongue is darted out to secure its insect prey. (V.) The SCINCOIDÆ, or Serpent-lizards, which are recognised by the shortness of the feet, the non-extensibility of the tongue, and the equality of the tile-like scales which cover the whole body and tail.

328. (I.) The LACERTINIDÆ are the most agile, most innocent, and most beautiful of the Saurians. Though they share, in common with the others, the dislike in which the animals of the class of reptiles are held by most persons, they never injure man, and are in some cases of considerable service to him. The larger ones live on the ground, usually preferring the shelter of underwood or of

stones, and some frequenting marshy situations; whilst the smaller kinds resort to trees in search of their insect food, and in the liveliness of their colours and the rapidity of their motions, bear no inconsiderable resemblance to birds. The family comprehends two subordinate groups—the *Monitors*, characterized by the absence of teeth in the palate, and the *Lacertæ*, strictly so called, which have the back of the palate armed with two ranges of teeth.

329. The *Monitors* derive their name from the idea, entertained in the countries where they chiefly abound, that their presence indicates the proximity of the crocodile and other noxious reptiles. In Egypt, they restrain the multiplication of the crocodile, destroying its eggs and devouring the young. The ancient Egyptians appear to have held the monitor of the Nile in great reverence, for it is delineated on many of their monuments. An allied species is employed by the jugglers of Cairo in their tricks; but they first deprive it of its teeth. Many species, frequenting the rivers of various tropical countries, are in a great degree aquatic in their habits. The *Sauvegarde* of the South American continent is one of these. It runs with great swiftness along the ground, and digs its hiding-place in the earth, but takes to the water when hard pursued. This species attains the length of six feet; its flesh is considered a great delicacy, and it is hunted with avidity. The tail is flattened vertically, by which its aquatic habits are indicated; but there are other species, included in the genus *Ameiva*, in which the tail is round, and which more resemble the common terrestrial lizards. These are confined to the New World.

330. The true *Lizards* inhabit all warm countries, and many of those which are considered temperate. In the latter, they pass the winter in a state of torpidity. When excited by the heat of the sun, they exhibit great energy and activity; but they can subsist a long time without food. The tail is round, and without any crest: this indicates the strictly terrestrial habits of the tribe. It

382. Describe the first of these.

383. What of the *Monitors*, and the several species?

is, moreover, exceedingly brittle, and a portion of it can be separated by a very slight touch; but it is reproduced again in a short time. Although extremely inoffensive, lizards will often defend themselves with great energy when attacked, and will bite more keenly than would be supposed. The greater number of them feed upon insects; but some of them prey upon small animals, such as mice or frogs. Two small species inhabit England,—the *lacerta agilis*, or sand lizard, a beautiful little animal, which is sometimes of a brown and sometimes of a greenish hue; it is found on sandy heaths, and occasionally seen basking on the sunny sides of green banks. A more common one, however, is the *lacerta vivipara*, which inhabits most districts of England, and even extends into Scotland; it is also one of the few reptiles found in Ireland. It frequents heaths and banks, and may be seen on the watch for its insect prey, during the warm parts of the day, from the early spring until summer has far advanced. Its name is derived from a peculiarity which it shares with the viper—its eggs are retained and hatched within the body, so that the young are produced alive. There is a beautiful green lizard, which is found in Guernsey, and abounds on the continent of Europe, but is not an inhabitant of Great Britain. Even this is reputed poisonous by the vulgar, but the prejudice is entirely without foundation.

331. Some gigantic fossil bones have been discovered, which seem to be the remains of enormous saurians, allied in structure to the Lacertidæ of the present time. One of these has been termed the *mososaurus*, and it appears to have been intermediate between the monitor and the iguana. From the proportional length of its head, which is nearly the sole part preserved, this lizard must have been at least seventy feet from head to tail. The *geosaurus* is another large fossil saurian, which seems to have been intermediate between the crocodile and the monitor.

384. Describe the habits of true Lizards.

385. What fossil variety is named?

332. (II.) The family of IGUANIDÆ approaches pretty closely to the true lizards in many of its general characters; but it contains several most extraordinary forms, widely differing from each other. The true iguanas are confined to America; but some genera of this order are found over the greater part of the tropical zone. Like the previous family, the Iguanidæ may be divided into two sections, according to the absence or possession of palatal teeth.

333. In the first of these, we find many genera which bear a great similarity with the true lizards, and which offer nothing worthy of especial notice. Next to these, however, is placed a tribe which is interesting alike from its peculiarity of conformation and from its being the only living representative of the fabulous dragons of the olden time. This is the genus *Draco*, the animals included in which are distinguished at the first glance from all other saurians, by the possession of a pair of wing-like appendages to the sides of the body. These are formed by extensions of the skin, supported by the false ribs, which are greatly prolonged. They can be folded up or extended at the will of the animal, but they cannot be made to strike the air and to elevate the animal like a bird or bat. They serve rather as a kind of parachute, on which this little dragon, not many inches long, flutters from branch to branch in search of its insect prey; and also as a support to it when shooting, like the flying-squirrel, from tree to tree. These animals are found in the woods of tropical Africa and Asia, especially in the Indian archipelago.

334. The existence of monstrous and horrible animals of this kind seems to have been believed in all ages, and in every part of the world. As Cuvier observes, the dragon exists everywhere except in nature. The Chinese make it their national emblem, like the lion in England. In ancient writings, particularly those of eastern countries, we find frequent accounts of hideous dragons, ravaging whole provinces, or spreading terror and desolation through a kingdom. Many frauds have been practised to give an

appearance of truth to these fictions. It was formerly not uncommon to manufacture a monster from a ray or other fish, adding one or more heads as might be required. Linnæus tells us that he narrowly escaped being murdered for having exposed such a deception. In spite of the authority of historians, the traditions of the church, and the matter-of-fact representations of the older naturalists, we are obliged to relinquish the favourite idea of the existence of the dragon, or at least to reduce it to the form of the mild, elegant, and insignificant animal above described.

335. This is perhaps the proper place to notice the very extraordinary fossil, to which the name *pterodactylus* has been given. In its general character it was certainly a lizard; but it seems to have been adapted to raise itself and fly in the air, like a bat or bird. The membrane of the wing was not extended, however, over the whole bony apparatus of the limb, but only one finger, which was enormously developed to support it. It is ranked by Cuvier among the most extraordinary of all the extinct animals that had come under his consideration; and the one which, if we saw them all restored to life, would appear most strange, and most unlike to any thing that exists in the present world. In the form of its head and the length of its neck, it resembled birds; but it had the bones and teeth of a lizard; its wings approached those of bats in form and proportion; and its body and tail resembled those of ordinary Mammalia.

336. In general external form, the *pterodactylus* probably most resembled a vampire bat; but in most of the species, the snout was elongated like that of a crocodile, and armed with conical teeth. Their eyes were of enormous size, apparently enabling them to fly by night. From their wings projected fingers, terminated by long hooks, like the curved claw on the thumb of the bat. These must have formed powerful members, with which

387. What of the fabulous accounts of dragons?

388. What extraordinary fossil is cited here?

389. Describe its structure.

the animals were enabled to climb, or creep, or suspend themselves from trees. With regard to their food, it has been conjectured that they preyed upon insects; and the number of fossil remains of insects in the strata in which they are found, proves that such a source of aliment was within their reach. The head and teeth of two species, however, are so much larger than would be required for the capture of insects, that they may have possibly fed on fishes (as there were at that epoch few or no small land animals), darting upon them from the air after the manner of many sea-birds.

337. From this account of the pterodactylus, it is evident that it is a most remarkable connecting link between the classes of birds and reptiles. That it is to be associated with the latter can scarcely be questioned; but if, as has been recently stated, the covering of the skin was more analogous to hairs or feathers than to scales, its affinity to birds must have been extremely strong.

338. In the second section of IGUANIDÆ, distinguished by the existence of palatal teeth, we first meet with the true Iguanas. These are confined to the New World, and frequently attain considerable size. They have a kind of spine or crest along the back, and a hanging pouch under the throat, which seems analogous to the dew-lap of oxen; this pouch can be inflated, but under what circumstance is not exactly known. They have also in some degree that power of changing the hue of the skin, which is so remarkable in the chameleon. They are very agile, the legs being long in proportion to the body, and their food is almost exclusively vegetable. Some of them attain the length of five or six feet, of which the tail constitutes a large proportion. Their flesh is much esteemed as food; and, in the countries where they abound, they are sought for with this object. They are extremely tenacious of life. When attacked, they assume a formidable, though not a dangerous aspect. They open their mouths, vibrate their tongues with rapid motion, inflate their throats, and erect their crests, while their eyes glance with great bril-

liancy. All this, however, is a demonstration for defence and not for attack. They are never known to combat with any animals but those of very small size.

339. Some gigantic fossil remains, allied in conformation to the Iguana, indicate the former existence of animals of similar character which attained enormous bulk. The chief of these was the *iguanodon*, of whose bones, fragments have been found in Tilgate Forest. The teeth are so precisely similar to those of the iguana in the principles of their construction, as to leave no doubt of the near connection of this gigantic saurian, which must have probably attained a length of at least seventy feet, with the herbivorous lizards of our own time. The examination of these teeth discloses some remarkable mechanical contrivances, adapting them to the function of cropping tough vegetable food, such as that afforded by the plants found imbedded with it.

340. Under the name of *Basilisk* is at present designated a genus of reptiles allied to the Iguanas, which has as much resemblance to the basilisk of old marvel-relators as the draco to the fabulous dragon. The most ancient authors have mentioned it as a serpent which has the power of striking its victim dead by a single glance; and the approved mode of catching it was to carry a mirror, by which the animal's death-striking glances would be reflected upon itself. Pliny assures us that it has a voice so terrible that it strikes terror into all other animals, so that it chases them from the spot which it inhabits, retaining the sole and undisputed dominion of it. The name, indeed, imports its kingly authority. According to the representations of the older naturalists, it had eight feet, two large scales for wings, and its head "the likeness of a kingly crown had on." It is well to know something of such fables, however absurd they may seem, since in ignorance of them we lose the force of many fine passages in poetry and fiction. Thus, in the play of *Richard III.*, Shakspeare makes the Lady Anne retort to Richard, who is praising the beauty of her eyes, "Would they were

basilisk's, to strike thee dead !” The cockatrice seems to have been a kind of basilisk, and is still reputed among the vulgar as a real being, hatched by a serpent from the egg of a cock.

341. The animals now known as *basilisks* are harmless and rather elegant lizards, of somewhat aquatic habits, and confined to a few localities in tropical climates. They resemble the iguanas in their general organization, but they do not possess the pouch under the throat, and the crest which runs along the back is much higher, and extends as far as the middle of the tail. This crest serves as a vertical fin of considerable power, by the action of which the animal can swim readily through the water, and it can be depressed, so as not to impede its motions on land. The want of a membrane or web between the toes, which would have been inconvenient to animals intended to spend a great part of their life in trees, is thus compensated. They have also a curious bag or pouch at the upper and back part of the head, which is capable of distension with air, like that beneath the throat of the iguana. This is particularly large in one species, which, from the form it presents, is called the *mitred basilisk*. When this was first discovered, the fabulous basilisk was referred to it, but probably without foundation, as this species is only found in South America, and its peculiar form could scarcely, therefore, have served as the origin of the marvellous ideas attached to the name.

342. The third family, the *GECKOTIDÆ*, consists of a large number of animals bearing a strong resemblance to each other in general characters. They are all nocturnal, and pass the day in obscure places ; their eyes are large, and their pupil contracts under the influence of light, like that of cats, into a very small aperture. Their flattened form and broad head give to them a very striking and peculiarly disagreeable appearance, which is aided by their sombre and somewhat toad-like hue ; hence, although timid and harmless, they are always regarded by

392. What of ancient fabulous animals ?

393. Describe the true basilisks.

the vulgar as having a venomous character, but without the least foundation in truth. Most of them possess claws at the extremities of the toes, and these are capable of being retracted like those of the *Felinæ*. They appear more useful to their possessor in climbing, however, than in securing their prey, which consists principally of insects. The Geckos are found in most warm countries in both hemispheres. They frequent buildings; and some species have a peculiar organization of the feet, by which they can climb smooth perpendicular walls, or even run beneath ceilings. They are often useful in cleaning houses of musquitoes and spiders; but it is said that articles of food over which they have passed acquire poisonous properties, in consequence of an acrid exudation from the feet. It is difficult to know how much credit to give to such statements; equally positive ones, which are entirely destitute of foundation in fact, being circulated in this country in regard to the toad.

343. The CHAMELEONIDÆ, or *Chameleon* tribe, are few in number; but they present so many anomalies of organ-

Chameleon.

ization, that it is necessary to separate them from all the other saurians, and to rank them as a distinct family. They are characterized, in the first place, by the structure of the feet, which are adapted for climbing like those of the scansorial birds (such as the parrot), having two of the toes opposed to the other three. The tongue also affords

a remarkable character ; it is fleshy, and capable of enormous elongation ; the extremity is thickened or club-shaped, and is furnished with a viscous secretion at its extremity. It is by this organ that the chameleon entraps its insect food ; for, by suddenly darting out the tongue, the insect is glued, as it were, to the end, and instantly conveyed to the mouth. This is the only part of the body that moves quickly ; the limbs are often quite motionless for hours. When the chameleon walks, it advances with the greatest circumspection, and there seems a want of power to combine the actions of the different members. But when once attached to a branch or twig by the grasping of its feet, it seems to have little disposition to quit its hold.

344. The peculiar conformation of the eyes of the chameleon adds much to the general singularity of its aspect. They are large and prominent, but so much covered by the scaly skin of the orbits, that there only appears a small hole in the middle opposite the pupil. It is no uncommon thing to see the animal directing its eyes in two different ways at once ; one eye looking forwards, for example, the other backwards, sideways, or upwards. This power must be very useful in compensating for the fixity of the body itself, so as to give information of the proximity of food in any direction. The powers of abstinence possessed by this singular race are very great, and hence most probable arose the fable of their living on air. They do not appear inclined to take food in confinement ; and have yet been seen to shrink but little during many weeks of almost entire abstinence.

345. The chameleon has been most remarkable, however, for its power of changing colour, which was known to the ancients, and is commonly supposed to be peculiar to it ; but, as already stated, other animals possess it in a greater or less degree. Much exaggeration has prevailed, as might be expected, in the description of this phenomenon. All the colours of the rainbow, as well as white and

395. What of the Chameleons ?

396. What is peculiar in its structure ?

black, have been represented to be assumed by it. Its natural hue, when at rest and in the shade, seems to be a bluish gray; from this it easily changes to a brownish gray, or into a green. Sometimes the colour fades to a pale gray, and sometimes it deepens to a dark brown; but these are the extremes. The phenomenon has been variously accounted for. Of late, it has been generally supposed that the hue of the skin depends upon the degree in which the colour of the blood is combined with that peculiar to the membrane; and that it is altered by a change in the quantity of blood sent to the surface, which is increased by the distension of the lungs occasionally practised by this animal. But the recent inquiries of Milne-Edwards have shown that this is only a partial cause, and that the change is principally owing to an alteration in the relative position of two layers of colouring matter which the skin contains, so that they may be displayed singly or in various degrees of combination.

346. The last family of the Saurian Reptiles, the SCINC-
CROIDÆ, or *Skink* tribe, conducts us so gradually towards the Serpents, that it is difficult to know where to draw the line of demarcation between them. They are recognised by the shortness of the feet, the roundness of the body, and the equality of the tile-like scales over the whole surface; their tongue is not capable of extension. They have all more or less of a snake-like form; and in some of them only two feet are developed. The true *Scincus* probably approaches to the general saurian type more closely than the rest of the group. It is furnished with four short but strong feet, and runs with considerable agility. The species which inhabits the south of Europe has been in repute from ancient times for its medicinal virtues, but probably with as little foundation as there is for the idea of the noxious qualities of others. This one burrows in the sand with great quickness. There is a West Indian species, frequenting the hollows of trees, termed the *galley-wasp*; this is falsely reputed to have an extremely venomous bite, when it is really scarcely capable of inflicting

any injury whatever. These reptiles inhabit warm and dry situations; and, from the appearance of the teeth, it may be concluded that insects constitute their chief if not their only food.

347. The *Seps* has a more serpent-like body than the skink, and the feet are smaller and wider apart. These gradually become simpler in structure in various species; the number of toes being reduced, until the feet seem like simple hooks protruded from the body. The *Chalcis* is another snake-bodied, small-legged saurian, which, in some peculiarities of its conformation, approaches a different group of serpents. In the *bipes* the anterior pair of feet is not developed; and in the *chirotes*, the posterior pair is wanting. In both these, the general conformation of the body, and the habits, so far as known, correspond with those of the common blind-worm, which is ranked among the Ophidia.

Order V.—Ophidia.

348. The animals composing this order are at once distinguished, not only from all other Reptiles, but from all other Vertebrata (except certain fishes of the *eel* kind) by the entire absence of the members or appendages for locomotion. Although no trace of these is ever perceptible externally, there are some species bordering upon the saurians, in which rudimentary legs can be detected; and these approximate, therefore, towards the lizards in their own tribe, just as the two-legged, long-tailed lizards approach the serpents in theirs. Although apparently so different from other reptiles, Serpents are to be distinguished from lizards by little but the absence of extremities; since, in the possession of teeth, and in the scaly covering of their bodies, as well as in their general interior organization, they closely correspond with them. The elongated form of their bodies reminds us of the Worm tribe among the Articulata, which they may be regarded as representing among the Vertebrata, just as the class of birds represents that of insects; and they correspond with

398. Describe the last family in this order.

399. What variety is cited?

them in another very curious particular—the periodical exuviation of their skin. All serpents pass the coldest part of the year in a state of torpidity; and it is on emerging from this that they slough or cast their skin. This is first detached round the head, and is gradually pushed off by the animal, being turned inside out like the finger of a glove.

349. The serpent, from various circumstances connected with its organization and habits, and from the reference made to it in the early history of the human race, has been employed emblematically more than almost any other animal. From its smooth and sinuous course, and its hurtful powers, it is commonly used to denote that subtle and insidious eloquence which deceives while it persuades; and on that account it was placed by the ancients on the caduceus of Mercury. From the venomous powers of many of the race, the serpent has also been used as an emblem of torment; and the Furies were represented with snakes wreathed round their heads instead of hair. A serpent, coiled in a circle, and biting its tail, is the usual emblem of eternity. If we could abandon these ideas, and attend to the simple forms and movements of these animals, and their adaptation to the circumstances in which they are to exist, we could scarcely regard the greater part of them as otherwise than beautiful and graceful.

350. The progression of serpents on the surface of the land is accomplished in two ways; sometimes the whole body creeps along the ground, the scales on its under side serving (like the minute bristles of the earth-worm) as so many points of resistance to a backward movement, when the trunk is elongated, after being contracted; and sometimes it is bent upwards into a series of arches, by which the tail is brought near the head; and when these are straightened, the head is thereby projected forwards. In crawling along the ground, they are much assisted by the points of the ribs, which do not meet again in a sternum,

400. How is the order of Serpents characterized?

401. What allegorical uses of the serpent are cited?

but bear upon the ground, and serve as so many short feet, having a certain power of movement in themselves by means of the intercostal muscles. Most serpents can swim when placed in the water; and there is one group which is pre-eminently aquatic, and is distinguished by its vertically flattened tail. So closely do the members of this group resemble certain species of the eel tribe, that it is not always easy to determine to which a specimen belongs, until its respiratory organs have been examined. The great flexibility of the body is partly due to the very large number of vertebræ (from 200 to 300) composing the spinal column, each of which is united to those before and behind it by a very beautiful ball-and-socket joint.

351. A large group of serpents is distinguished by the possession of venomous teeth, or *poison fangs*, in addition to the ordinary teeth. These are sharp, long, and tubular; they are connected at their roots with a gland by which the poison is secreted; and this is instilled into the wound through the tube in the tooth. The jugglers in the east, who exhibit their power over the most venomous serpents, prevent them from doing mischief, either by extracting the poison fangs altogether, or by stopping their apertures with wax, or by causing them to bite frequently upon some soft substance, by which the supply of the poison is temporarily exhausted. It is in the tribe of venomous serpents that we meet with the remarkable phenomenon of the production of the young alive; this is due to the hatching of the egg, before it is laid, by the parent; and in the viper (in which the fact has been chiefly observed) either mode of production may take place, under the influence of circumstances which can be regulated by the experimenter.

352. As in the case of other reptiles, we find that serpents only attain their full development in warm climates, having very little proper heat of their own. The species inhabiting the temperate zone are not nearly so remarkable,

402 How is locomotion performed?

93. What is remarkable in their structure?

14. What of their teeth, and jugglers' experiments?

either for size, brilliancy of colour, or poisonous properties, as those which exist between the tropics. The order may be divided into five families:—(I.) The COLUBERIDÆ, consisting of the *Boas*, *Pythons*, *Colubers*, and other non-venomous snakes not belonging to the subsequent orders. (II.) The CROTALIDÆ, containing the *Rattlesnake*, *Viper*, and all the venomous species. (III.) The HYDROPHIDÆ, or *Water-snakes*. (IV.) The AMPHISBÆNIDÆ, or *Double-walkers*. (V.) The ANGUINIDÆ, or *Slow-worms*. These last approximate the Lizards, in the possession of rudimentary legs under the skin, as well as in other points of their organization.

353. The COLUBERIDÆ are particularly distinguished by the power of dilating the opening of the jaws to an enormous extent, so as to permit of animals being swallowed which are much larger than the diameter of the serpent itself. This is accomplished by the separation of the jaw-bones into various pieces, which are very movable on one another and on the skull. The most remarkable species of this family, which is the most numerous of the order, are the *Boa Constrictors** of the New World and the *Pythons* of the Old; these, when full grown, attain the length of from thirty to forty feet, and in thickness nearly equal a man's body. They do not fear to attack any animal; and, if they can once coil themselves round it, crush it by the enormous combined power of their muscles, in spite of all its means of resistance and defence. Their power is much increased by coiling the tail round a tree, so as to give a point of support from which the muscles may act more efficiently; and it is in this manner that they commonly wait for their prey. When they have seized and entirely destroyed it by crushing, in which process all the principal bones are broken, they begin to swallow it. This process lasts

* The name *Boa Constrictor* is commonly applied to the immense serpents of the East Indies; but only those of the western hemisphere possess the characters which the naturalist now assigns to the genus *Boa*.

some time ; and when it is complete, the position of the mass in the alimentary tube is at once known by the external protuberance. The process of digestion takes some days or even weeks for its performance, according to the size of the prey ; and during that time the monster lies in

Boa Constrictor.

a very inactive state, only issuing forth to seek a new victim when the digestion of the last has been for some time finished. The hair, horns, and other least digestible parts, are usually disgorged during the process. The Boas are distinguished from other serpents by the presence of two projecting bones near the vent, which are called *claspers*, and which may be regarded as the rudiments of posterior extremities.

354. The *Colubers*, strictly so called, are usually of comparatively small size ; but their habits are the same in proportion. The common snake of this country attacks small quadrupeds, frogs, birds, &c., in precisely the same

406. What is remarkable in the first of these ?

407. What different species does it include ?

408. How are they formidable enemies ?

manner that the boa seizes its larger victims. It is fond of marshy situations, and takes to the water readily, inflating its lungs so as to render itself buoyant. The flexibility of body, which is their means of obtaining support, is greater in the non-venomous serpents than in the Crotalidæ, which have another mode of procuring it. This is shown by suspending a coluber by its tail; it can bend its body so as to bring its head to the point at which it is held; this the venomous serpents cannot do. All the smaller species of this family are perfectly harmless to man, and may be handled without fear. Many of them are remarkable for the brilliancy of their colours, and others for the extreme regularity of their markings.

355. The CROTALIDÆ, or *Venomous Serpents*, do not differ much in external characters from the preceding family; but the character of their teeth is quite sufficient to distinguish them. The poisonous properties of the different species vary considerably; in general they are more severe in the serpents of warm climates than in those of temperate regions. Cases of death from the bite of the British viper are very rare, and are generally to be attributed in part to some previously existing derangement of the system. There are many serpents in the torrid zone, however, whose bite is fatal to man and other large animals in a few hours, and to small animals much sooner.

356. This family contains two principal series—the *Rattlesnakes* and the *Vipers*. The former are generally regarded, but probably incorrectly, as the most venomous of all serpents. The rattle at the end of the tail, which is their distinguishing characteristic, is formed of several separate pieces of a dry horny substance, one of which is received within another. They are quite loose, and receive no nourishment after they are once formed. A new piece is said to be added every time the skin is cast, which usually takes place twice a year. The sound

409. Describe the Colubers.

410. What is said of the family of venomous serpents?

411. How are they subdivided?

made by the rattle is not great in the ordinary motion of the serpent, and cannot be heard at more than two or three yards' distance. Several species of *Crotalus* are described, varying in length from four to eight feet. They are all natives of America. Their ordinary food consists of birds, squirrels, and other small animals. It was once supposed that they possessed the power of charming or fascinating these animals, so as to draw them by degrees to enter their throats. This is certainly an error; but it is equally certain that most animals are so terrified at the sight of the rattlesnake as to lose the power of escape, and to become an easy prey when it darts upon them. There is a peculiar savageness about the aspect of these venomous serpents, when looked at in front, which to a certain extent announces the danger to be apprehended from them. In their ordinary habits they are tranquil and sluggish, not wantonly injuring man, moving slowly, and biting only when provoked; but they are more dangerous in proportion to the heat of the season.

357. The *Vipers*, being destitute of the peculiar characteristic of the Rattlesnakes, are more like the Colubridæ; their forms, however, are less elegant, their colours less splendid, and their movements less active. In general, they are remarkable for the dark lurid tints of their covering. The most celebrated species of this group is the *cobra di capello* or *spectacle-snake* of the East Indies. Its first name, given to it by the Portuguese, signifies hooded snake, and is derived from the power of dilating the skin behind the head, when irritated, so as to give the appearance of a hood or cowl. The common English appellation is bestowed in consequence of a mark, in the shape of a pair of spectacles, behind its head. This is one of the most deadly serpents of the East. An equally, if not still more, venomous snake, however, exists in some of the West Indian Islands. This is the *trigonocephalus*, which in many of its characters approaches the Rattlesnakes, but has no appendage on its tail. It is of large size,

412. Describe the structure and habits of rattlesnakes.

413. What of vipers, and their variety?

having been observed to attain the length of eight or nine feet: in consequence of the incessant warfare now made against it, however, it seldom attains its full size. It is found abundantly in sugar plantations—a field of canes being seldom cut, in the islands it frequents, without several being found in it; and as its bite, when severe, is almost certain death, it is much dreaded by the negroes. It usually feeds on lizards, small birds, and especially on the rats which have been introduced from Europe into these colonies, and which have multiplied to an immense extent. The bite of this, as of other venomous serpents, varies in its consequences according to the state of health of the bitten subject, the depth and number of the wounds, the time which has elapsed since the animal last made use of its fangs, and consequently the amount of poison which has penetrated into the system.

358. The common *viper* of this country is remarkable for its variations in colour, which have caused many new species to be formed that have really no existence. These variations appear to have some relation with the aspect of the ground on which the individual lives; a dark red soil, for example, being accompanied by a corresponding shade in the viper. It has a greater preference for dry situations than the common snake, and is often found basking on rocks and sands exposed to the sun. It lives on the same food as the coluber, destroying it, however, in a different manner. It feeds at considerable intervals, and may be kept altogether without food for a length of time: three or four mice are said to be sufficient for a viper during a year. The *Cerastes*, or horned vipers, are so named from the presence of a pair of little hornlike bony projections on the forehead; these give to the animal, which is of a livid gray, quite a terrific appearance. This is an extremely venomous species. The group contains some species of partially aquatic habits, which are indicated by the vertical flattening of the tail.

359. The *HYDROPHIDÆ*, or *Water-Serpents*, are comparatively few, and are limited in their geographical range.

They are mostly found in the seas and rivers of the East Indies, and in some localities they are by no means uncommon. They are chiefly known by the very decided vertical compression of the tail and hinder part of the body, which may thus be compared to the tails of fishes; hence they swim with considerable facility, occasionally coming to the surface to respire. They possess poison-fangs, and are more dangerous than crocodiles or sharks to persons entering the water where they abound. One species exists in the rivers and canals of India, and attacks animals which come to bathe or drink, as well as devotees whilst performing their ablutions; others are confined to the sea, where they feed upon fish. It is stated that they will occasionally make their way into boats. Their colours are generally bright.

360. The AMPHISBÆNIDÆ, or *Double-Walkers*, are a still smaller group, intermediate in some respects between the true serpents and the slow-worms. They derive their name from the power of moving either backwards or forwards with equal facility. The two extremities of the body are so much alike, that they would not be distinguished by a superficial observer, the eyes being so very small as sometimes to appear wanting; the whole body is of nearly equal diameter. This group is restricted to the warmest parts of South America. Notwithstanding the common idea of its venomous properties, it is quite harmless, and subsists on ants and other small insects. It has not the power of separating the bones of the jaws, which distinguishes the true serpents.

361. The ANGUINIDÆ may almost be called either lizards or serpents, so remarkably do they combine the characters of the two orders. In one species the rudiments of hind legs form a visible projection near the vent; and in another the anterior ribs are connected by a cartilage which is the rudiment of a sternum. The common *slow-worm* or *blind-worm* of this country has received its second name from the supposed absence of eyes; this is an ab-

415. What of Water Serpents?

416. What is peculiar in the Double-Walkers?

surd error, however, as the eyes, though small, are very brilliant. It is a perfectly harmless animal, feeding on insects, slugs, &c. It is said to swallow frogs, birds, and mice ; but this is impossible, as the bones of its jaw do not separate in the middle, and its swallow is consequently small and not dilatable. When alarmed, it throws the whole of its muscles into contraction in a peculiar manner, and is then very brittle, so that it frequently loses its tail by various accidents ; in the course of a year, however, this member is replaced. There is a large species of this family existing in America, which attains the length of two feet, and from its extreme fragility is called the *glass-serpent*.

362. The Serpents are connected with the Amphibia by the curious genus *Cæcilia*, or naked serpent, which will be described as a member of that class.

CLASS IV.—AMPHIBIA.

363. The animals composing the class Amphibia were included by Cuvier and many other zoologists under the general designation of Reptiles. There seems, however, sufficient reason for separating them into a distinct group of equal rank. They may be regarded as intermediate in their structure, and in their habits and mode of life, as well as in many of their forms, between Fishes and true Reptiles ; and they bear a still more remarkable relation to these classes, in that change which many of them undergo at a certain period of life, by which they become transformed from the nature and habits of the former to those of the latter class, by a metamorphosis analogous to that of Insects.

364. “To any person,” it has been well remarked, “capable of appreciating the interest attached to the study of physiological phenomena, the contemplation of an animal which, at one period of its life, is endowed exclusively with the organs of aquatic respiration, resembling the gills of fishes, with means of locomotion adapted only to a constant residence in the water, and with a digestive apparatus

417. Describe the last variety.

418. What of the Amphibia ?

fitted exclusively for the assimilation of vegetable food, assuming by degrees the function of atmospheric respiration, acquiring limbs which are formed for leaping on land with great strength and agility, and manifesting the most voracious carnivorous appetite, will not only excite feelings of the deepest admiration, but necessarily lead to the investigation of the laws by which such remarkable changes are governed."

365. By the term *amphibious* animal, in popular language, is understood a being adapted to live on land or in water. Of such we shall meet with many instances; but we always find that the organization of the animal is constructed for only one of these modes of life, and that it only resorts to the other under peculiar circumstances. Thus, some insects can maintain life, even in their perfect state, beneath the surface of water, although it is the habit of the class to breathe air; but this is only by means of a peculiar modification of their structure, which enables them to carry a supply of air down with them. On the other hand, many Crustacea can leave the water, even for a long period, although they breathe by gills; but this is only by means of a special provision for the purpose of keeping them moist. The cetaceous mammalia are adapted, like the rest of the class, to breathe air; but they are enabled to carry down with them a sufficient supply of it to last them for some time under water.

366. The class we are now considering offers us the only instances of animals possessing two sets of respiratory organs, one adapted to breathe air, and the other to aerate the blood, by exposing it to water. In most of the species composing it, lungs and gills do not exist at the same time, at least in a state of activity; the latter gradually disappearing as the former are developed. But in a few species the gills are retained during the whole of life, even after the lungs are capable of aerating the blood. These are, then, the only true amphibious animals; but the term

419. What extraordinary transformation is cited?

420. How is amphibious to be understood?

421. What of the respiratory organs?

AMPHIBIA may be very properly applied to all such as undergo this kind of metamorphosis, breathing by gills alone at the commencement of life, and afterwards acquiring lungs by which air can be respired.

367. The general peculiarities of the Amphibia may be thus stated:—Like fishes and reptiles, between which they are intermediate, they are oviparous and cold-blooded, but their skin is soft and naked, being destitute of scales or plates. Most of them undergo a metamorphosis which has reference to a change of condition, from the form of a water-breathing fish to an air-breathing reptile; and, when they have attained their perfect condition, they closely resemble true reptiles in general character. In many species, however, little change is seen from the time that the animal emerges from the egg to its adult age. With the exception of the frogs, they have much the form of lizards (among which several of them were formerly classed), and have generally four feet and a lengthened tail.

368. The class, which contains but a small number of different genera, may be best subdivided into orders chiefly according to the degree to which the metamorphosis proceeds. Thus, in the first, ANOURA, embracing the *Frogs* and *Toads*, the gills are entirely lost in the perfect state, and the tail also disappears. In the URODELA, including the *Salamanders*, *Water-Newts*, &c., the gills disappear in the perfect state, but the tail is retained. The AMPHIPNEURTA, to which the *Proteus* and *Siren* belong, retain their gills during the whole of life; the tail continues to form a large part of the body, and in some instances only two legs are developed. In the ABRANCHIA, an order which consists only of two little-known genera, no gills have been found at any period of life, but the body and tail are evidently formed for swimming. And in the APODA, including only one genus, the *Cæcilia*, the body is altogether destitute of feet, and has a serpent-like form.

422. Describe their general peculiarities.

423. How are they divided into orders?

Order I.—Anoura.

369. The principal subdivisions of the first order are the *RANIDÆ*, or *Frog*-tribe, and the *BUFOIDÆ*, or *Toad* tribe. The former frequent water, and are adapted for swimming in it; the latter are usually found at a distance from water, and are much less adapted for active movements of any kind. The metamorphosis of both these is attended with the same general phenomena; and as the animals themselves are so well known, a description of this process will be a sufficient account of those which inhabit Britain. It is one very easily observed, for, by obtaining a little water containing young tadpoles, the whole process may be made to go on under our eyes, and the young naturalist is earnestly recommended to watch it for himself.

370. The spawn, soon after its disposition in pools, consists of a transparent gelatinous mass, enveloping a number of little black dots, which are regularly distributed through it, and which are the eggs. These are abundantly found in stagnant pools in the month of April, being usually deposited (in this country) at the end of March, and hatched about a month afterwards. When the tadpole first emerges, it is seen to present, in every respect, the appearance of a fish. It has a large oval head, and an elongated tail, flattened vertically, by the vibrations of which it swims actively through the water. The gills are found hanging in tufts on each side of the head; and if examined with a microscope, the motion of the blood through them may be very beautifully seen. The circulation may be observed, also, with great facility, in the fin-like expansion on the upper and under edge of the tail. Very soon, however, the gills are withdrawn, as it were, into the head, being covered over by a fold of skin, analogous to the operculum, or gill-plate of fishes. The little creature, which at first seemed to derive its subsistence from the fluid absorbed within the body and on its surface, now seeks its food amidst softened or decomposing vegetable

matter ; and, to give greater power of movement, the surface of the tail is considerably increased.

371. The tadpole now undergoes but little change in its external form for a considerable time, but increases rapidly in bulk. The first appearance of limbs is seen in a little tubercle or knob which projects at the back of the head : this is the rudiment of the hind leg. It soon acquires somewhat the form of the perfect limb, the toes budding, as it were at the extremity ; but it still continues very short, even in proportion to the diminutive size of the animal. Meanwhile, the fore legs are also budding out in the same manner, and gradually assume their distinct and ultimate form. During this process, the development of the body goes on at the expense of the tail, which is gradually removed by absorption, so that the hinder part of the body becomes rounded. The gills disappear by a similar process.

372. The little animal has now undergone its complete development, and having, at the same time, become capable of respiring air by true lungs, and of moving freely on land by means of its hinder legs, it comes to the shore to feed on small insects and worms, which are henceforward to constitute its nutriment. Such multitudes of these newly-perfected little beings are often found in damp weather enjoying their new scene of existence, as to have given rise to many stories of showers of frogs having descended from the sky, which are still believed in some parts of the country. They now grow with great rapidity during the remainder of the year ; but on the approach of winter they retire to the mud at the bottom of the water, where they congregate in large masses, remaining torpid until the return of spring.

373. Frogs, in various stages of their growth constitute an important article of the food of other animals. In their tadpole state, they are devoured in large numbers by the different species of newts, and by small fishes ; and when

425. Describe the metamorphosis here named.

426. How is the development of the animal marked ?

427. What of showers of Frogs ?

adult, by larger species of fish, especially pikes, by many of the smaller Carnivora, such as the weasel and polecat, and by almost every species of water-fowl, as well as by other birds; of the common snake they serve as the principal food. Such is the destruction occasioned by all these enemies, that probably not one in a thousand of those that had emerged from the egg in the spring ever reaches its winter retreat. The species which is eaten by man in continental countries, is not a native of England; but the common frog of this country is equally palatable and wholesome, though it does not contain quite so much muscle on the hind legs, the part employed for the table. In some of the West Indian islands, a large species is bred for this purpose, being very highly prized by the French inhabitants.

Frog.

374. Some remarkable exotic species of this family deserve notice, especially the *Rana paradoxa*, or Surinam frog. The tadpole of this frog is much longer than the

Surinam Frog; half of real length.

adult; in one specimen, of which the metamorphosis was carefully observed, the length, at the time when the legs began to show themselves, was eight inches, whilst the adult frog did not measure much more than three. The decrease was occasioned by the absorption of the tail; and, from this remarkable circumstance, the idea took its rise

that the frog changed itself into a fish—it not being conceived possible that the animal could *grow smaller*. The Surinam frogs are, like the bull-frogs of North America, extremely noisy at night. The latter are the largest of the whole tribe, measuring eighteen inches from the muzzle to the extremities of the hind feet. Other clamorous species exist in Asia and in the oriental isles; so that, in comparative freedom from them, Europe may be regarded as particularly favoured.

375. The *Hylæ*, or Tree-frogs, have suckers, like those of the cuttle-fish, at the extremities of the toes, by which they obtain a facility in climbing trees, and can attach themselves even to smooth surfaces. They are in general elegantly coloured, their aspect in some degree resembling that of their usual habitation. Those of America are ornamented with the most pleasing variety of colours. Although living upon trees during the summer, they are produced from pools in the spring, and hibernate in the mud during winter, like other frogs.

376. The *Bufoïdæ*, or *Toads*, are a perfectly harmless and inoffensive race, although certainly not inviting in their general aspect. The idea of their venomous character is altogether unfounded. The body is of a dull hue, its shape awkward, and its movements appear difficult, but it is by no means deserving of that disgust which it has inspired in some naturalists as well as in the popular mind. “The true lover of nature,” observes Mr. Bell, “who, in the simplicity and singleness of heart which always belong to that character, seeks even in the less attractive of her works for those proofs of wisdom and beneficence by which they are all characterized, will rather find in the very peculiarities which excite spleen and disgust, only fresh indications of the same discriminating wisdom, and the same never-failing, though often, to the superficial observer, mysterious and veiled beneficence.”

429. What variety of species is named?

430. What of the bull-frogs of America?

431. Describe the Tree-frogs.

377. Unpossessed of any power of active defence, or of rapid escape from its enemies, the dullness of its colour serves to shield it from observation. Its eye bears a remarkable expression of mildness and patient endurance, rather fitted to excite pity and compassion than disgust or repugnance. It issues forth from its concealment at twilight in search of food; and this consists of insects, worms, slugs, &c., the inordinate increase of which it is very useful in repressing. It seems to prefer that which is actually alive and in motion. When about to feed, it remains motionless, with its eyes turned directly forwards upon the object, and the head inclined towards it; and in this attitude it remains until the animal moves, when, by a stroke like lightning, the tongue is thrown forward upon the victim, which is instantly drawn into the mouth. So rapid is this movement, that it requires some little practice, as well as close observation, to distinguish the different motions of the tongue. This organ is folded back upon itself, as in the frog; and the under surface of the tip is imbued with a viscid mucous secretion, which adheres to the prey. This is generally swallowed alive; and its motion within the stomach may often be perceived for some time afterwards.

378. The toad, like the rest of the Amphibia, becomes torpid in winter; but, instead of returning to the water, like the frog, it chooses for its retreat some retired and sheltered hole, or a space amongst large stones. Like the other Amphibia, too, it is endowed with great tenacity of life, and can exist for a very long time deprived of food and almost of air. The knowledge of this fact has occasioned a disposition to give too ready credence to the various wonderful accounts which have been circulated, at different times, of toads being found alive, completely enclosed in solid rock, or in the heart of trees. It is not at all unlikely that a toad which has retired to a hollow in a tree in the autumn, may find itself so far enclosed in the spring as to be unable to escape; and that, through the opening, it may obtain the requisite supply of air, and even of food.

In process of time new wood may be deposited around it, so that the cavity shall be completely moulded upon its body ; and the opening will be gradually diminished. Still, a very small aperture will be sufficient to admit air, moisture, and minute insects, by which it may be supported for many years, being a long-lived animal ; and in none of the cases on record does there seem to have been such a minute examination of the cavity as to disprove the idea that a connection with the external air still existed.

379. In a similar manner it is fair to explain the accounts of toads found in stones, &c. Such clefts as furnish these animals with winter quarters, often become filled up with gravelly and other fragments, which solidify to such a degree as almost to seem part of the rock itself. This process is taking place on a large scale in the fissures of the rock of Gibraltar. Toads may thus be gradually enclosed, in the same manner as in the wood of trees, and may still maintain some communication with the external air. That they should be found alive in solid masses of rocks, which were deposited long before toads were created, is what no one accustomed to scientific inquiry can believe ; and yet such are the kind of statements which come under the review of the naturalist. From the experiments which have been made to clear up the subject, by enclosing toads in plaster of Paris or hollowed pieces of wood, or by burying them in garden pots deep under ground, it would appear that, when cut off from all supplies of food, and with a very limited supply of air, their lives might be prolonged many months, but in no case longer than two years ; and that, when *entirely* deprived of air, they speedily perish.

Order II.—Urodela.

380. The animals of the order Urodela bear so strong a general resemblance to Lizards, that they were united with that group by Linnæus, and are still popularly regarded as such. The *Salmanders* and their allies, how-

433. What other peculiarities of the toad are named ?

434. How are they sometimes found in stones, &c. ?

435. What is the result of experiments with toads ?

ever, are easily distinguished by the smoothness and softness of their skin, which is entirely destitute of those scales which all lizards possess. Moreover, they undergo a metamorphosis similar to that of the frogs, except that the change of form does not proceed to the same extent. Like the Anoura, this order may be subdivided into two families, of which one, that of the TRITONS, is of aquatic habits even in the adult state, like the frogs; whilst the other, that of the true SALAMANDERS, bears more analogy with the toads in its aspect and habits.

381. Of the TRITONS several species exist in this country, and are known under the names of *Elat*, *Eft*, *Newt*, &c. The largest is about six inches in length: it is not at all uncommon in ponds and large ditches, where it lives upon aquatic insects and other small living animals: it even devours the smaller species of newt. The eggs are laid in the spring, upon aquatic leaves, which are folded together by the animal; and the young tadpole, when it comes forth, bears considerable resemblance to that of the frog. The gills, however, are in larger tufts, and they afford a most advantageous opportunity for observing the circulation. The anterior legs are the first developed; and even after they have arrived at nearly their full growth, the gills are very large, and actively performing their functions. The lungs are, however, gradually developed; and, towards the end of autumn, the gills are absorbed, and the animal breathes air only. Still it does not quit the water, but remains an inhabitant of that element, coming occasionally to the surface to breathe.

382. The movement of the Tritons through the water is effected chiefly by means of the tail; and during the act of swimming, the legs are turned backwards, so as to afford the smallest possible degree of resistance. At the bottom of the pond or vessel they creep by means of their little weak feet, which also serve for their progression on land. The large *newt* seldom quits the water, however; but the small one is often found on land at the end of the summer,

436. Describe the Salamander family.

437. What of the several species of the Tritons?

creeping about amongst the herbage in the neighbourhood of the water, or in damp places, and sometimes even venturing into damp cellars. In both kinds the male is distinguished from the female by a kind of membranous crest, which runs along the back and tail; but this disappears by absorption at certain seasons, and is afterwards again renewed; whence the same animal, in its different states, has been accounted to belong to different species. Its colour also undergoes some change.

383. It was on the smaller *newt* that Spallanzani tried his well-known experiments on the reproduction of portions of the limbs and tail. He found that the same member is regenerated by the animal several times in succession on being cut off; and this with the bones, muscles, vessels, and nerves, belonging to its original state. Like other *Amphibia*, it becomes torpid in the winter; and this torpidity has been prolonged by artificial cold for three years. The animal has been completely frozen, too, in a solid block of ice; and, when slowly thawed, it has appeared scarcely injured. The idea of its poisonous character, so generally believed by the lower classes in this country, is wholly unfounded.

384. Still more ridiculous are the stories which have been handed down from ancient times in regard to the marvellous powers of the *salamander*, which was supposed to be capable of living uninjured in the midst of fire, and is even vulgarly reputed to be *produced* by a very intense heat. This is a land animal, of the same general character with the water-newt, but possessing a rounded instead of a flattened tail, and a surface somewhat warty, like that of the toad. It discharges, when alarmed, an acrid secretion from the tubercles in the skin, which is said to be poisonous to small animals. In other respects it is quite harmless, and is not possessed of any remarkable properties. The eggs of the salamander are hatched within the body, so that the young are produced alive, and the progress of the metamorphosis has been considerable

438. What of their aquatic habits?

439. What curious experiments are referred to?

before it sees the light. Nevertheless, it at first inhabits the water, and, when it has finally quitted it, frequents damp in preference to dry situations. No species exists in Britain, but the salamanders are pretty extensively diffused over other parts of the globe.

Order III.—Amphipneura.

385. The animals belonging to the order Amphipneura exactly resemble salamanders, the development of which has been checked just at the period of their transformation from aquatic to air-breathing animals. They retain their gills during their whole life, and acquire lungs in addition by the partial metamorphosis they undergo. The legs bear but a very small proportion in their degree of development to the tail; and in some instances only one pair is formed. The first discovered animal of this order was the *proteus*, an inhabitant of the underground lakes of Carniola and Styria, and of the passages between them. So strongly does this resemble the larva of a salamander, that it was at first believed by naturalists to be such; and it was only after the discovery of others of the same character, that its true nature was understood. Unlike most other animals, it appears to suffer injuriously from light; for not only does it prefer dark places, but even dies if it be exposed to open day for any length of time without the power of hiding itself.

386. The *siren* is an animal of similar character, inhabiting the North American rivers, where it feeds upon earth-worms, aquatic insects, &c., in search of which it burrows in the mud. Only the anterior pair of feet is developed, and there is no rudiment of the other. The body has very much the form of that of the eel; and sometimes it attains the length of three feet. The *menobranchus* is another genus of this order, also an inhabitant of the rivers of North America. It grows to the length of about two feet, possesses four legs, and is said to be carnivorous and gluttonous. The *axolotl* is another genus of the same

440. What is true and what is fabulous of the salamander?

441. What peculiar family is here described?

general description, retaining the gills during the whole of life, and the body resembling in form that of the tritons. It abounds in the lakes near the city of Mexico, and is commonly sold in the markets as an article of food, being esteemed a luxury by the inhabitants.

Order IV.—Abranchia.

387. The order Abranchia contains only two genera, and these both peculiar to North America, the *menopoma* and the *amphiura*. They are not known to undergo any metamorphosis, but breathe by lungs during the whole period of life, and have never been seen destitute of legs. These are, however, very short, and seem almost useless appendages to the body, which is shaped like that of an eel. It is not improbable that, as in the salamander, the egg may be hatched within the body of the parent, and that the young may not come forth until it has passed through its tadpole state.

Order V.—Apoda.

388. The order Apoda contains but one genus, the *Cæcilia*, blind-newt, or naked serpent. This was placed by Cuvier among the Serpents, from the snake-like form of the body, which is destitute of any rudiments of legs. But, in the absence of scales on the skin, as well as many anatomical characters, it rather corresponds with the Amphibia, forming, however, a most interesting transition to the next class. It is now known to undergo a metamorphosis. Its name was conferred by Linnæus on account of its supposed blindness. The eyes are exceedingly small, and are nearly hidden under the skin, and it is believed that, in some species, these organs are altogether wanting. These animals frequent the rivers and marshy grounds of many tropical countries: further information in regard to them is much needed. They are said to burrow in the ground, and to live very much in the manner

442. Name the other species here cited.

443. Describe the fourth order and its genera.

of earth-worms. As far as is known, they are perfectly harmless.

389. From this sketch of the class AMPHIBIA, it will be seen that, in a scientific point of view, it is one of the most interesting in the whole animal kingdom. Though of little direct benefit to man, it is certainly as harmless as any tribe. And thus, although the forms of many of the species offend against our notions of beauty, and their love-songs give them the character of "horrible musicians," the aversion and prejudice with which they are ordinarily regarded would be justly replaced by the pleasure of intelligent curiosity.

CLASS V.—FISHES.

390. The animals of this class are the only Vertebrata which, in their adult state, are formed for respiring beneath the surface of the water they inhabit. The whale tribe, which so much resemble them in external aspect and in mode of life, are all air-breathing animals, and they are as certainly drowned by being prevented from taking in air at the surface, as are any species which ordinarily live on land, though, by their peculiar conformation, they are enabled to sustain the want of it for a longer time. The same is true of frogs, salamanders, and other reptiles, which pass a large part of their time under water. But with fishes the reverse is the case. In these, as in the Mollusca, the blood receives its necessary purification by being exposed to the air contained in the surrounding fluid. This is done by its transmission to a series of delicate filaments, constituting the *gills*, each of which consists of two minute blood-vessels (one to convey the blood from the heart, and the other to return it) enclosed in a delicate membrane, through which the chemical changes between the blood and the air take place. But these filaments do not hang loosely in the water, as in the greater part of the Mollusca. They are attached to bony or car-

tilaginous arches, which are arranged in pairs behind the head, and are more or less protected by a special covering; and there is a provision which insures a proper change of the fluid in contact with them. The cavity in which they lie is connected with that of the mouth, and water is constantly taken in by that opening, and forced by muscular action over the surface of the branchiæ or gills, passing off through the apertures which are seen behind the head.

391. The quantity of air contained in water is very minute; and if the fish have need of a larger supply, it takes it in at the surface from the atmosphere. This is often seen in the summer, when the increased temperature renders the organic functions more active, and occasions a greater demand for air. It may also be seen when the quantity of water is limited, so that all the air is soon exhausted from it. Fishes that are kept in such water, and are prevented from coming to the surface, are *drowned* as truly as an air-breathing animal would be under similar circumstances. Hence the desirableness of frequently changing the water in which gold-fish are kept, and of exposing as large a surface of it as possible to the atmosphere, that absorption from it may supply the air removed by the animal. The death of a fish out of water is attributable chiefly to the clogging together of the filaments of the gills, so that the air cannot act upon them, and the drying up of those which, being at the surface, are in contact with the air. Hence, if the branchial arches are kept separate, and their filaments be preserved in a moist state, respiration will go on. There are some fishes in which this is naturally effected by a peculiar contrivance, and in others it may be artificially accomplished.

392. But there is another way in which the atmosphere acts injuriously upon fishes. Not only from the gills, but from the whole surface of the body, a very rapid evaporation of fluid takes place in dry air; so that the weight diminishes considerably, and the tissues are incapable of performing their proper functions. Hence, if it be de-

445. What is peculiar in the class of fishes?

446. Describe their organs of respiration.

sired to keep fishes alive in air as long as possible, they should be surrounded by moist grass, or some other substance which will effectually saturate with dampness the air in their neighbourhood.

393. Whilst the respiratory organs of fishes immediately indicate their adaptation to pass the whole of their lives in the water, the conformation of almost all of them exhibits an adaptation to rapid and energetic movement in that element. The form of the body is such as to oppose the least resistance to progression, whilst it is also such as to confer great propelling power. It is usually flattened in a vertical direction; and the surface is extended by a finny prolongation of the spine above, and of corresponding rays below, and by the expansion of the tail in the same line. In this manner, a very large lateral surface is produced, whilst the resistance to forward movement is very small. The propulsion of the fish is chiefly effected by the movement of the whole body and tail from side to side, which operates in precisely the same manner as the oar of the sculler; and this is facilitated by the great flexibility of the spine, the bones of which are so united together as to move with the slightest possible effort.

Fish.

a, dorsal fin; *b*, pectoral fin of one side; *c*, ventral fins; *d*, anal fin;
e, caudal fin, or tail.

394. But though the propulsion of the fish is chiefly accomplished by the movement of the body itself, it is

447. What of the presence of air in water?

448. What of their locomotion?

usually aided by lateral fins, which answer to the legs and arms or wings of higher Vertebrata. Besides the fins which have been already spoken of as existing on the central line of the body, above and below (of which the one running along the back is called the *dorsal* fin, and the one under the body the *anal*), there are generally found two *pairs*, of which one, corresponding to the anterior extremities of other Vertebrata, is always situated near the head, and is called the *pectoral*; whilst the position of the other, corresponding with the posterior extremities of land animals, and called the *ventral*, is extremely variable. Sometimes the ventral fins are placed far back, in the usual position of hind legs; and sometimes they are fixed far forwards, even anteriorly to the pectoral. The pectoral fins are usually connected more intimately with the spinal column than the ventral. These fins are composed of a membrane stretched over a set of bony or cartilaginous rays, which may be regarded as representing the bones of the hand or foot. The bones which connect them with the spine are very short, and are hidden under the flesh; so that the chief movement of the fin is, as it were, at the wrist and ankle joints. It is chiefly by their vibrations that the animal is raised or depressed in the water, and they also assist in changing its direction from side to side. The forward position of the ventral fins is chiefly noticed in those species whose habits involve a considerable variation of their depth in water. Sometimes one, and sometimes both pairs of these fins are absent; in the latter case the fish is said to be *apodal* or footless. In other instances the pectoral fins are enormously developed, like the wings of birds, and even enable the animal to rise out of the water and to skim for a short time along its surface.

395. Fishes being the lowest animals in which we find an internal skeleton for the special support and protection of the nervous system and its appendages, we might expect that it should sometimes present a comparatively imperfect form. This is found to be the case. In a very

large proportion of the class, the skeleton is not bony but cartilaginous; in some, nothing but a spinal column exists; and in a few, scarcely any traces exist of a division of this into vertebræ. In such animals the whole conformation of the body is so low as to remind us of the worm tribe; and some among them, as the *lamprey*, were classed by Linnæus with that group. On the other hand, there are some fishes which exhibit a distinct transition in the structure of their teeth, vertebral column, and respiratory organs, to the class of Reptiles. Such are the *lepidosteus*, or bony pike, of the North American lakes, and a still more remarkable animal recently discovered—the *lepidosiren*. From the researches of Agassiz it would appear that the proportion of these *sauroid* fishes (as they are termed from their resemblance to lizards) was much larger in a former epoch of the earth's history, fossil remains of them in the earlier strata being not uncommon.

396. It is by the examination of such connecting links as these, that we arrive at the knowledge of the true character of an organ which has been usually supposed to be peculiar to this class—the *swimming-bladder*. This is not universally present; but where it exists, it is usually found in the form of a bag more or less divided into two along the central line, lying under the spine. Sometimes this has a direct connection with the intestinal canal (usually between the stomach and mouth), and occasionally it is altogether closed. In the highest forms in which it exists, its correspondence with the lungs of air-breathing animals is very evident; and there is little doubt that air is taken into it from without for the purpose of respiration. In this lower or rudimentary condition, however, its office is more doubtful, especially where it is entirely closed. It is usually believed to contain air, and to serve as a means of regulating the specific gravity of the animal, the swimming-bladder being compressed when the fish desires to sink, and allowed to expand when it desires to rise. In this manner it would seem the gold-fishes are

450. Describe the peculiar structure of fishes.

451. What variety is named?

enabled to ascend and descend in the water, without any muscular effort visible to those who watch them. But it is remarkable that this organ is sometimes absent in a species nearly allied to one in which it is present, and that the want of it does not seem to make any difference in its powers. As a general rule, it is more constantly present in river fishes than in the inhabitants of the sea; and it is more frequently absent in those which live habitually near the bottom of the water.

397. The surface of the body is generally covered with numerous scales, which vary considerably in form and size in different species. Each scale is composed of several plates, of which every one extends on all sides beyond the one on its exterior; hence the appearance of numerous concentric lines on all sides, which mark the stages of growth, the larger plates being the latest formed. They thus resemble the shells of mollusca in their mode of increase. Each scale is attached to the skin of the fish by its anterior edge, which is covered by those in front of it, whilst its posterior edge overlaps the scales behind it. This arrangement is not universal, however; for the scaly covering is sometimes formed by a series of bony or even enamel plates, united to each other by their entire edges. Such an arrangement was very common in the fishes existing at the time of the coal formation, but is now much more rare.

398. When we consider that more than two-thirds of the earth's surface is covered with water, often to a very great depth, and that, as far as is known, the whole of this element is habitable by fishes (each stratum having some particular species formed to exist in it), little doubt can be entertained that they form the most numerous class of vertebrated animals. Their numbers are kept up by their extreme fertility. The cod-fish has been ascertained to lay not much fewer than four millions of eggs at a single deposit; and in other species the number may even be greater. Their voracity is also extreme. Almost all of

452. What of the swimming-bladder and its use?

453. What of the scales?

454. What of their comparative fecundity?

them are adapted to devour and digest animal food, some of them living chiefly on crustacea, mollusca, and other invertebrate inhabitants of the ocean; and others having it for their especial function to keep down the inordinate multiplication of their own kind. Some of these attain a considerable size. The pike has been found nineteen feet long; and there is evidence of one having lived for 267 years. The sun-fish has reached the length of twenty-five feet; and some rays and sharks have exceeded forty feet.

399. The teeth of fishes are not usually instruments of mastication, but serve principally to hold their prey; and they are ordinarily conical in form, sharp at the points, and curved backwards. They are not only placed on the jaws, but also on the tongue, the palate, and other parts of the passage into the stomach. In many fossil fishes, however, as in some at the present time, we find the jaws and palate furnished with hard enamelled plates, set together like a pavement, and fitted to bruise and break down the hardest substances that can afford them food. Thus the *sparus* browses, by means of these well-protected jaws, upon the branching coral, for the sake of the animal matter which its cells protect. The food is usually, however, swallowed entire, and is digested in the capacious stomach of fishes, like the prey of the *hydra*, or fresh-water polype, in its simple but powerfully reducing cavity.

400. The classification of Fishes proposed by Cuvier is probably the best that, in the present state of our knowledge of this group, can be adopted. It is obvious that, from the peculiarities of the habitation of these animals, and the very imperfect manner in which the depths of the ocean, over a large part of the earth's surface, have yet been explored, a great number of existing species probably yet remain to be discovered. And it is also certain that the number of species formerly existing in the waters, and of which we have at present but very scanty re-

455. What of their habits, size, and age?

456. What of their teeth?

main, was considerable, and that their forms often differed widely from those familiar to us. Hence, when these shall have been more completely investigated, it is not improbable that this classification must be greatly modified in order to include them.

401. The primary division of the class is into the *Osseous* and *Cartilaginous* Fishes, the former having a hard bony skeleton, and the latter having one of less firm consistence, possessing but little calcareous matter. The former group is divided into six orders, which are principally characterized by the structure and arrangement of the fin rays. These are distinguished as either consisting of a single piece—in which case, whether stiff or flexible, they are said to be *spinous*—or as consisting of a number of jointed pieces, divided at their extremities, when they are called *soft* or *articulated*.

402. (I.) ACANTHOPTERYGII, or *spiny-finned*. In this order, which contains the greatest number of ordinary fishes, there are spinous rays in the first or anterior part of the dorsal fin, and sometimes these have no connecting membrane. The anal fin has also its first rays spinous, and there is generally one such ray in the ventral.

403. The three next orders are all *soft* or *jointed-finned*, and come, therefore, under the general designation MALACOPTERYGII. They are distinguished from each other by the position or absence of the ventral fins.

404. (II.) MALACOPTERYGII ABDOMINALES. In these, the ventral fins are attached to the abdomen behind the pectorals. They are a very numerous order, and include the greater part of the fresh-water fishes.

405. (III.) MALACOPTERYGII SUB-BRANCHIATI. In this order the ventral fins are brought forwards under the pectorals, and the fish, which are chiefly marine, enjoy a considerable power of ascending and descending in the water.

406. (IV.) MALACOPTERYGII APODA. These are fishes in which the ventral fins are always wanting, as are not unfrequently the pectoral also.

457. How are they primarily divided?

407. The two remaining orders of Osseous Fishes are separated from the rest by other peculiarities.

408. (v.) **LOPABRANCHII** (Tuft-Gilled). In these, the gills, instead of hanging in regular fringes, like the teeth of a comb, from the branchial arches, are disposed in tufts, and the gill-covers open less freely than in the preceding orders.

409. (vi.) **PLECTOGNATHI**. The members of this order, though retaining many of the characters of the Osseous Fishes, exhibit an evident transition to the Cartilaginous, both in the less complete ossification of the skeleton, and by the union of the bones of the upper jaw to each other and to the head. The opening of the gill-covers is still smaller.

410. The **Chondropterygii**, or Cartilaginous Fishes, cannot be considered either superior or inferior to the others, but form, as it were, a parallel series with them. Some tribes exhibit the lowest organization which exists in the class, whilst others present many points of affinity to reptiles. The different parts of the skeleton, which, in the Osseous Fishes, are united by distinct joints, here frequently form one continuous piece. This is most remarkable in the head, which is composed of a single piece, in which, however, the principal parts found in the bony fishes may be distinguished by various ridges, furrows, and holes. This group contains three orders, distinguished from each other by the conformation of the mouth and the arrangement of the gills.

411. (vii.) **CHONDROPTERYGII BRANCHIIS LIBERIS** (Free-Gilled Cartilaginous Fishes). In these, consisting chiefly of the sturgeons, the gills hang freely, and are covered with a gill-lid having a single wide opening, as in Osseous Fishes.

412. In the other two, the gills are attached at the outer edge, and there is a separate opening for the escape of the water that passes over each arch. These, which are termed **CHONDROPTERYGII BRANCHIIS FIXIS**, or Fixed-

458. Describe the several osseous varieties.

459. What of the cartilaginous fishes?

Gilled Cartilaginous Fishes, are distinguished from each other by the conformation of the mouth.

413. (VIII.) SELACII, or *Sharks* and *Rays*. Here the jaws are not united into a ring.

414. (IX.) CYCLOSTOMI (Round-Mouthed). These have a round fleshy lip, by which they adhere to their prey, obtaining their food by suction, and this is supported by a cartilaginous ring, formed by the union of the jaw-bones. It is in the fishes of this order that we find the vertebrated structure in its lowest form.

Order I.—Acanthopterygii.

415. The Spiny-Finned Fishes are divided by Cuvier into fifteen families, the most important of which will now be noticed.

416. (I.) PERCIDÆ, the *Perch* tribe. These are very numerous in the waters of all warm climates, some species inhabiting the rivers, and others the open sea. Their bodies are oblong, and covered with hard or rough scales, and the gill-covers are toothed at the margin. They are mostly *thoracic*, or have the ventral fins under the pectoral. Some, however, are *jugular*; that is, have the ventral-fins placed upon the throat, farther forwards than the pectorals; and some are *abdominal*. Their teeth are very minute, and set close together in numerous rows. Their flesh is in general agreeable and wholesome. This family includes all the fish known as *Perches*, of which some species are found in almost all the rivers in the world, and a large number of marine fishes used as food on different shores. Some of the most remarkable are the *trachinus*, or *weaver*, which has a very prolonged and sharp dorsal spine, capable of inflicting a severe injury, and which fishermen believe (but erroneously) to have poisonous properties; the *uranoscopus*, or *star-gazer* (so called from the position of the eyes upon the top of the nearly cubical head), which lies concealed in the mud, and attracts its prey by a filament which it protrudes from

460. Describe each of the three varieties.

461. Into how many families is the first order divided?

its mouth, and which serves as a bait to small fishes; the *polynemus* (many fillets), whose pectoral fins are prolonged on each side into threads twice as long as the body, and of which a species inhabiting the Ganges, termed the mango-fish, is esteemed the most delicious in India; the *sphyræna*, or sea-pike (to be distinguished from the common pike), of which one tropical species, the *barracuda*, is much dreaded for its size and voracity; the *red mullets*, or, more properly, *surmulletts*, of the British seas; and many others.

417. (II.) TRIGLIDÆ, the *Gurnard* tribe. These bear a general resemblance to the Perches, but have the head peculiarly armed with spines or hard scaly plates. In several species the pectoral fins are very much extended; but in none except the flying-fish are they sufficiently powerful to raise the animal out of the water. Many species of this tribe are found in the temperate seas, which, though inferior in flavour to the surmulletts, supply wholesome and agreeable food. To this family belong the *gurnards* and *sticklebacks* of our own coast; the *scorpæna*, a gregarious fish living among the rocks; the *sebastes*, or Norway haddock, rather a large species, the spines of which are used by the Greenlanders as needles; and a large number of others. The most interesting of all is the *dactylopterus* or *flying-fish*. This has a kind of supplementary pectoral fin on each side, formed of a membrane stretched over finger-like processes, which in the gurnards are unconnected. By the impulse of these on the surface of the water, the flying-fish can raise themselves to the height of several feet into the air, and can suspend themselves above the surface for a few seconds, often skimming lightly over it for a considerable distance; but they cannot sustain themselves in the atmosphere for any length of time. They are gregarious fish; and it is when a shoal of them is chased by the *coryphæna* (commonly but erroneously termed *dolphin*) or some similar enemy, that the most remarkable leaps are taken. They not unfrequently

462. Describe the Perch tribe, and its species.

463. What of the Gurnard variety and species?

fall upon the deck of a large vessel that may be passing amongst them. The finger-like processes are usually prolonged beyond the fins, and appear to possess an amount of sensibility unusual in such parts.

418. (III.) The SCIENIDÆ, or *Maigre* family, have a general resemblance to the Perches, but differ from them in the absence of teeth from the palate, and some other particulars. They principally belong to tropical seas, a few inhabiting the Mediterranean.

419. (IV.) The SPARIDÆ, or *Sea-bream* tribe, resemble the last in general form, but have no spines on the gill-covers. Some of these, including the genus *sparus* already mentioned as grinding down the stony corals, have the sides of the jaws covered with round flat teeth resembling a pavement. Others have teeth with cutting edges.

420. (V.) Another small family, MENIDÆ, differs from the last chiefly in the great extensibility of the upper jaw.

421. (VI.) The next family, SQUAMIPENNES, is so named because the soft and even the spinous parts of their dorsal fins are so covered with scales as not to be distinguished from the rest of their bodies. The most interesting genus is the *Chætodon*, of which several species, remarkable for the beauty of their colours, abound in tropical seas. One of these, the *C. rostratus*, which has a very prolonged snout, has the faculty of shooting insects with drops of water projected from the mouth, and it then seizes them as they fall. This power is the more extraordinary, as, according to the laws of the refraction of light, the place of the insect will appear to the fish different from the reality—the rays passing from a rarer to a denser medium; and the drop must not, therefore, be projected in the line in which the insect *appears* to be, but somewhat below it. This little fish, which is a native of India, is often kept in glass vases by the residents there, as gold-fish are in this country, for the purpose of affording amusement by its dexterity.

464. What other families are here named?

465. Describe the fifth and sixth family.

422. (VII.) The next family, *SCOMBERIDÆ*, or the *Mackerel* tribe, is one of very great importance to man. It comprises a large number of genera, a vast collection of species, and numberless individuals. The aspect of the common *mackerel*, with its spindle-shaped, beautifully-coloured, smooth, and small-scaled body, is well known. It very rapidly dies out of water, and soon becomes tainted. Mackerel has been supposed to be a migratory fish, on account of its appearing on our shores in immense shoals at particular epochs. But it may be caught all the year round on our coasts, which shows that it does not wholly desert them, as is done by the really migrating tribes. The fact is, that it passes most of the year in the open sea, and that its object in approaching the shore is to deposit its spawn; after which, those that have escaped being entrapped by the ingenuity of man, return to their former quarters. The extent and importance of the mackerel-fishery of Britain, especially in the south and east, are well known. The *tunny* is an allied species, attaining a much greater size, and also valuable as an article of food. This frequents the Mediterranean, and is occasionally seen on our own shores. It sometimes attains the length of fifteen or even eighteen feet. To this order belongs also the *xiphias*, or *sword-fish*, distinguished by its long pointed beak.

Sword-Fish.

This is a most powerful offensive weapon, and with it this fish attacks the largest inhabitants of the ocean. By its high dorsal fin and expanded tail, it is able to impel itself forwards with great force; and when attacking a large

animal, it makes a violent dart against it, quite transfixing it with its sword. It has been known in this manner to drive its beak into the timbers of a ship, and, not being able to withdraw it, to break it off and leave it. The sword-fish abounds in the Mediterranean, but is less frequent in the Atlantic. It is very palatable as food; and often attains the length of fifteen feet. The *dory*, of which one species is highly prized by epicures, is another fish of the same family. It is remarkable for the filamentary prolongations from its dorsal fins. And, lastly, may be mentioned the *coryphæna*, commonly known as the *dolphin*. This is a large and splendidly coloured fish, which darts through the water like a radiant meteor, exhibiting an extraordinary play of colours when brilliantly illuminated. It has long been celebrated for its change of colour when dying. It swims with great rapidity, and is very voracious, committing great havoc among the flying-fish and others of like size. The influence of light on the colour of animals is remarkably shown in the far superior brightness of the Indian *Scomberidæ*, when contrasted with the blackish hue of those of northern seas.

423. (VIII.) The family of TÆNIDÆ, or *Ribbon-shaped Fishes*, is a small one allied to the *Scomberidæ*, differing chiefly from it in the remarkable lateral flattening of the body. Few species are known on our shores; one of the largest, *lipidopus argyreus*, the *scabbard-fish*, occasionally appears on these coasts; it is about five feet long, swims with extreme rapidity, and often with the head above water. Allied to this is the *trichiurus*, some of the Indian species of which have been said to possess electric properties; but this is doubtful.

424. (IX.) The THEUTYES, or *Lancet-Fish* tribe, are another small family allied to the Mackerels, but are peculiar for their cutting spines on each side of the tail, and a horizontal spine before the dorsal fin. They have only a single row of teeth, and feed chiefly on marine plants. They use their powerful lancet-shaped spines very dex-

467. Describe the sword-fish, and other species.

468. What of the eighth and ninth families?

terously as weapons of defence ; and in this respect they may be compared to the horns of the Ruminantia.

425. (x.) The fishes of the tenth family, PHARYNGINÆ LABYRINTHU-FORMÆ, are characterized by a very peculiar structure, from which they derive their designation. The membranes of the pharynx (or back of the mouth) are divided into small irregular leaves containing cells among them, which the fish can at pleasure fill with water ; and, by ejecting a portion of this water, it moistens its gills, and may thus continue its respiration out of its proper element. By means of this apparatus, which resembles that possessed by the land-crabs, these fishes are enabled to quit the pool or rivulet which constitutes their usual element, and move to a considerable distance over land. Such a provision is especially desirable in tropical climates, where shallow lakes are often dried up by a continued draught, and their inhabitants must perish if not enabled to migrate. The people of India, who often witness the appearance of these fishes where they were known not to exist, believe that they fall from heaven. Some of them are able not only to traverse plane grounds, but can climb steep banks, or even trees, in the course of their journeys. Of these the most furious is the *anabas*, commonly known as the *climbing-perch* of Tranquebar, which climbs bushes and trees in search of its prey, a species of land-crab, by means of the spines on its back and gill-covers.

426. (xi.) The MUGILIDÆ, or *Mullet* tribe, are lengthened and often nearly cylindrical fishes, with a somewhat projecting snout, and a very small mouth placed beneath it. They are gregarious in their habits, frequenting the mouths of rivers in large troops, and constantly leaping up out of the water. There are several species found in European seas, of which the flesh is much esteemed. That best known on the British coast is the *mugil chelo*, or thick-lipped gray mullet. The fishes of this family feed in part upon crabs and other small Crustacea.

427. (xii.) The members of the family GOBIODÆ, or *Goby* tribe, are known by the thinness and flexibility of

their dorsal spines. Many of them are remarkable for producing their young alive, the eggs being hatched within the body of the parent. This is the case with the *blenny*, of which several species frequent the British shores, living in small troops among the rocks. They are remarkably tenacious of life, being capable of being kept a good many days in moist grass or moss, but they are of little value as articles of food. One of the most interesting species of this family is the *anarrichas lupus*, or *sea-wolf*. It inhabits the northern seas, and is often met with on our shores, attaining the length of six or seven feet. It is very formidable in aspect, and the size of its teeth, with the colours and peculiar physiognomy of its head, remind the observer of the carnivorous Mammalia. Its manners accord with its aspect, for it is remarkably strong, very active, and equally ready to defend itself or to attack an enemy. It often enters the fishermen's nets, for the purpose of plundering them of the entangled fish; and when the fishermen attack it, and it cannot escape, it fights like a lion. After receiving very severe injuries, and seeming dead, it will often inflict a sharp bite if incautiously irritated. It is seldom eaten in this country, through dislike to its appearance, but it furnishes light and wholesome food. The Arctic seas appear to be its appropriate locality, and there it attains a larger size than farther south; it is very valuable to the Icelanders, who salt its flesh for food and employ its skin as shagreen. The true *Gobies* have the ventral fins placed far forwards, and united at their bases; they are chiefly remarkable for the *nest* which they construct among the sea-weed for the protection of their young, which was observed by the ancients. They prefer a clayey bottom, in which they excavate canals, and in these they pass the winter.

428. (XIII.) The next family, PECTORALES PEDUNCULATI, derives its name from the peculiar structure of the pectoral fins, which have a kind of wrist formed by the elongation of the bones to which they are attached.

470. What other tribes are here described?

471. What of the sea-wolf?

This conformation gives these fishes a very strange appearance, and enables them to leap suddenly up in the water in pursuit of their prey, and even to leap over the mud. In many of them the skeleton is demi-cartilaginous. One of the most curious is the *lophius*, or *fishing-frog*, of the British seas, which is met with chiefly on muddy shores. It derives its name in part from its wide gaping mouth, and in part from the peculiar manner in which it angles for its prey. It has some curious appendages to its head, which terminate in long, round, and rather brilliant filaments, having a resemblance to worms. The animal lurks in the mud, and puts these appendages in vibration; they are mistaken for worms by small fishes, which they attract, and these are gulped down the capacious swallow of the *lophius*. To such an extent is this voracity carried, that the *angler* (as it is sometimes called) is often an article of value for the fish which it has in its stomach, although its own flesh is worth but little. There is an allied genus, the *chironectes*, of which a species abounds on the north coast of Australia. When the tide ebbs far back in the dry season, these frog-fishes are so abundant, and capable of taking such vigorous leaps, that those who have visited these places have taken them at first sight for birds. The fishes of this genus can inflate their large stomachs with air, in the manner of the Tetrodons.

429. (xiv.) The LABRIDÆ, *Wrasse* or *Rock-fish* tribe, are easily known by the thickness and fleshiness of their lips, whence their name. Those of the genus *labrus* are known on the British shores by the name of *old wives*; some of them vary considerably in their colour. They frequent deep pools among the rocks, hiding themselves in sea-weed, and feeding mostly upon crustacea. This family contains a large number of species, chiefly inhabiting tropical seas, and remarkable for the beauty of their colours, but they are usually of small or moderate size; their habits are little known, and they are of but slight direct importance to man. Some of them have received the

472. Describe the thirteenth family and species.

473. What of the variety of Rock-fish?

name of *parrot-fishes*, on account of the brilliancy of their markings and the form of their jaws.

430. (xv.) The last family of the Acanthopterygii consists of the FISTULARIDÆ, or *Pipe-mouthed Fishes*, at once recognised by the very prolonged muzzle. Some species have the bodies also long and cylindrical, whilst in others it is oval and compressed. They are chiefly found in warm latitudes ; but one species, *centriscus scolopax*, *sea-snipe*, *sea-trumpet* or *bellows-fish*, is occasionally found on the Cornish coast, as a straggler from the Mediterranean.

Order II.—Malacopterygii Abdominales.

431. This order, consisting of soft-spined Fishes which have the ventral fins under the abdomen, contains five families, all of which are highly interesting to the naturalist.

432. (I.) The CYPRINIDÆ, or *Carp* tribe, are all fresh-water fishes. They have the mouth shallow, the jaws feeble, and very often without teeth, but the pharynx is strongly toothed. They are among the least carnivorous of fishes, feeding chiefly on seeds, the roots of plants, and decomposing vegetable matter. The common *carp* is imported into England from the warmer parts of Europe ; it thrives better in ponds or lakes than in rivers, it feeds on insects and worms, as well as on vegetables, and it is very tenacious of life, so that it is easily transported from place to place. The *barbel* is an allied species of considerable size, sometimes growing to the length of ten feet. It frequents the sluggish parts of the Thames and its tributaries, and is said to plough up the mud with its nose, which, setting various minute animals adrift in the water, attracts the small fishes on which it feeds. The *cobitis*, or *loche*, is another British species, which is interesting in some of its habits. It inhabits the mud of stagnant waters, and can subsist a long time after the water has been dried up or covered with ice. When the weather is stormy, the loches rise to the surface of the water, and keep it in

474. What of the Pipe-mouthed family ?

475. Describe the species of the first family in the second order.

a state of agitation by their motion ; and, when cold, they bury themselves in the mud. They have been observed to swallow atmospheric air at the surface, and to discharge it at the vent in the form of carbonic acid. On account of their lurking habits, however, they are not often seen in their natural haunts. The *anableps*, a genus allied to the cobitis, has a remarkable peculiarity of structure in the eye, each cornea and iris being divided by transverse bands, so as to give the fish the appearance of having four eyes. The object of this conformation is unknown. The fish inhabits the rivers of Guiana.

433. (II.) The ESOCIDÆ, or *Pike* tribe, contains the most voracious of the fresh-water fishes, as well as several important marine species. They are distinguished by the absence of fatty matter in the dorsal fin (which exist in the Salmon tribe), and by the position of this opposite to the anal fin. The *pike* is very destructive of the smaller fishes in the ponds and rivers in which it exists, and sometimes attains a considerable size, weighing between thirty and forty pounds. The *gar-fish*, or *sea-pike*, is an allied species, frequenting the British shores, and stretching into the Arctic regions. Some of this kind have been known to attain the length of eight feet, and to bite very severely ; hence they may be considered as the sharks of northern seas. The *mackerel-pike*, or *saury*, is another British fish of this family ; it is gregarious in its habits, and is followed and preyed upon by porpoises, tunnies, and other large Scomberidæ. To this family belong the most common of the flying-fish, though, as already stated, it is not the only one which deserves the title. The *exocætus* is at once distinguished from the rest of the family by the immense size of its pectoral fins, by the impulse of which upon the water it is enabled to rise into the air ; but it can scarcely be said to *fly*, since it is unable to do more than partially sustain itself without again dipping into the water, and to direct the movement to which the impetus was given at the moment of quitting the water. Nevertheless, the common flying-fish can leap

more than two hundred yards in distance, and upwards of twenty feet in height. They are not unfrequently found upon the decks of large vessels, across which they had endeavoured to pass. This power appears to be conferred upon them to enable them to escape from the pursuit of the *Coryphæna*; but, in avoiding one enemy, they put themselves in the way of others, for voracious birds watch them and seize them as they rise into the air. They furnish an excellent article of food, and are very abundant in the neighbourhood of some tropical islands; individuals have occasionally appeared as stragglers on our own coasts.

434. (III.) The *SILURIDÆ* are distinguished from all the rest of the order by the want of true scales; having only a naked skin, or large bony plates. The fishes of the genus *silurus* inhabit the rivers of warm countries: they have a strong spine in front of the dorsal fin, which can be laid flat on the shoulder, or perpendicularly erected so as to become a formidable weapon; and the ragged wounds inflicted by it are reputed (but probably erroneously) to be poisonous. One species, belonging to the sub-genus *Malapterurus*, an inhabitant of the Nile and of the rivers of Central Africa, has electric properties, similar to those of the torpedo and gymnotus.

435. (IV.) The fishes of the order *SALMONIDÆ*, known as *salmons* and *trouts*, are very extensively, indeed almost universally, diffused over the globe, some of them being confined to fresh water, and others passing a part of their lives in the sea, but resorting to rivers to deposit their eggs. They are distinguished by the fatty deposition in the dorsal fin, from part of which the spines often disappear. All of this family are clouded with dusky patches when young, as occurs in all the species of *Cats*. Many remain permanently spotted. The flesh of most of them is esteemed as food. The *sal-*

The Salmon.

477. Name the variety of this family.

478. Describe the third tribe.

mon inhabits the seas of comparatively cold regions, ascending the river for the purpose of spawning, at seasons varying with the climate. The efforts which they make to overcome difficulties in the ascent are very great; they will not only swim against powerful streams, but will leap up cascades of considerable elevation, and find their way to the brooks and small lakes of lofty mountains. They return to the sea after this operation is accomplished, and are followed by the young produce from the eggs they have deposited. These, in their turn, ascend the rivers for the same purpose, and are understood to resort to those in which they were produced. The *trout* appears to vary much in size and colour, according to the climate and other conditions of its residence, so that it is difficult to distinguish species from mere varieties. Besides these may be mentioned, as belonging to the same family, the *smelt*, which is sometimes found abundantly, but locally, in the estuaries of British rivers; and the *capelin*, which is employed on the shores of Newfoundland as a bait for cod, and is sometimes taken in such quantities as to serve as manure for the land. A large species of this family, the *serrasalmus*, inhabiting the American rivers, seems possessed of an unusual degree of ferocity, pursuing ducks, and even men whilst bathing, and wounding them severely with its teeth. Most of the family exhibit great voracity.

436. (v.) The CLUPÆIDÆ, or *Herring* tribe, is one of the most important families in the whole class, for the amount of food it supplies to man. The fishes belonging to it resemble the Salmonidæ in many characters, but differ in having no fatty matter in the dorsal fin. They chiefly inhabit the seas of the temperate zone. The *herring*, which periodically visits our shores in such immense shoals, was formerly supposed to migrate from Arctic seas; but this is now ascertained to be a mistake, the fish being almost unknown there, and often appearing on the southern coast of Britain before the northern. The fact is rather that the herring, like the mackerel and many other fish, usually lives in the open ocean, and resorts to

the nearest coast to deposit its spawn. There are many well-known species, differing but little from the herring, which frequent separate localities. Thus, the *pilchard* is caught especially on the coast of Cornwall, and other shores to the southward of those on which the herring most abounds. The *sardine* is taken on the west coast of France and in the Mediterranean, where the herring never appears. The *sprat*, *white-bait*, *shad*, and other British species, belong to the same family, as does also the *anchovy*, well known for its rich and peculiar flavour, which is abundant in the Mediterranean. Other species inhabit the American, African, and Indian seas and rivers, but they are less abundant than those already mentioned.

Order III.—Malacopterygii Sub-Brachiati.

437. The soft-rayed Fishes, which have the ventral fins brought forwards beneath, or even in advance of, the pectoral, are divided into three families, one of which is equally important to man with the last, if not more so. This is—

438. (I.) GADIDÆ, the *Cod* tribe. The fishes of this genus are easily known by the softness of all their fins, and by having the ventrals inserted under the throat, and pointed. The greater number live in cold or temperate seas, and furnish a most important article of food, their flesh being wholesome, easy of digestion, and agreeable to the palate, and their numbers (owing to their extraordinary reproductive power) extremely abundant. The *cod* is nearly the largest of the family, but is usually surpassed by the *ling*, which is commonly from three to four feet long; both these are especially valuable for their excellence when salted. The *haddock* is a smaller species, nearly allied to the cod; for eating in the fresh state, it is perhaps the most delicate of the whole family. Many other species are useful to man, occurring in large numbers in particular localities. Such are the *whiting*, the *coal-fish*, the *pollock*, the *haak* (of which some species frequent high southern latitudes), the *burbot* (which as-

cends rivers), the *rockling*, and many others. Besides their use as food, those fish are valuable on account of the oil obtained from their large livers, which is very serviceable in the arts.

439. (II.) The second family is that of PLEURONECTIDÆ, the *Flat-fish* or *Flounder* tribe. The form of these fish is peculiar, not only for the extreme flattening of the body, but for its deficiency in symmetry. The two flat surfaces—one of which (in the ordinary position of the fish during life) is above, and the other below—are in reality the two *sides* of the fish, differing in several important respects. Both the eyes are placed on the upper side; and its colour is usually much deeper than the other. The body, from the head backwards, partakes a little of the same peculiarity. The two sides of the mouth are not equal, and the pectoral fins rarely so. On the other hand, the dorsal fin, which runs along one of the lateral edges, corresponds with the anal, which occupies the other, and with which the ventrals are sometimes united. So that, when we look at the fish in its usual position, its body appears more symmetrical than it really is. These fishes are destitute of air-bladders, and they frequent the bottom of the sea, from which they seldom rise far. The colour of their upper surface usually corresponds closely with that of the ground on which they lie, and thus they escape the observation of their enemies, and are unnoticed by the small fishes on which they prey. Individuals are occasionally found, however, in which both sides are alike; these are called “doubles:” it is usually the dark side which is doubled. The fishes of this family are found along the shores of almost all countries, and are, generally speaking, wholesome and agreeable as food. The form and aspect of the different species exhibit little variation. The *flounder*, *turbot*, *brill*, *plaice*, *dab*, and *sole*, are the chief species of our own coasts; the *halibut* is a very large species, attaining the length of six or seven

481. Describe the Cod family.

482. What different species are named?

483. How is the Flat-fish or Flounder tribe described?

feet, and weighing 500 lbs., occasionally taken in the British seas; and other species inhabit the Mediterranean.

440. (III.) The DISCOBOLI, so named from having their ventral fins formed into a sucker or disk, are the last family of this order. By this curious provision, the fishes belonging to this family have the power of attaching themselves to rocks and other hard substances, and thus to remain and find their food in situations where every other species would be swept away by the current of water. Several species are found on the British coasts, but they are mostly small; the most considerable is the *lump-fish*, which is occasionally eaten. The *echeneis remora*, or common *sucking-fish*, is placed under this family, but probably ought to constitute a distinct group, since its disk is not formed by the ventral fins, but by a series of thin and movable cartilaginous plates fixed to the head, by means of which the animal can attach itself to any kind of surface. It seems to prefer bodies in motion; and is not unfrequently found adhering to larger fish, and to the bottoms of vessels, whose course it was once absurdly believed capable of arresting. It is abundant in the Mediterranean.

Order IV.—Malacopterygii Apoda.

441. The fishes in which the ventral fins are wanting form but one natural family, the MURENIDÆ, or *Eel* tribe. They are all lengthened in form, have the spine extremely flexible, the skin thick and soft, and the scales almost invisible. In most of them the external gill-apertures are very small, and open very far back; by which arrangement they are enabled to keep the gills moist for a long time when out of water, whilst the roundness and flexibility of their bodies facilitate their motion upon land. Many of them inhabit rivers, whilst others are exclusively marine. The *eel* is the kind most abundant in Britain. It is, strictly speaking, a fresh-water fish; but, when living in rivers or other collections of water communicating with

484. Name the various species.

485. How is the last family diversified?

the sea, it migrates towards the ocean in the autumn. This is probably for the purpose of receiving the influence of a higher temperature ; as the eels which inhabit closed ponds or lakes do not seem to suffer any other inconvenience from the deprivation of the power of migration, than in the later production of the spawn in the ensuing spring. During the winter they bury themselves in the mud ; and in the spring, those which have migrated usually return up the rivers, together with the young fry produced from the spawn, the number of which is enormous. Some, however, continue to frequent the mouths of the streams, seeming to prefer brackish water to fresh. Like trout, eels are much affected in appearance and quality by the waters they inhabit. They are very voracious, especially during the spring and summer months, not only devouring insects and small fry (on which last account they are often excluded from fish-ponds), but also attacking larger fish ; and even quitting the water, and travelling over moist banks by night in search of frogs, slugs, and other prey. Occasionally they eat vegetable substances. By means of a long and capacious air-bladder, eels rise to various elevations in the water with great ease.

442. The *conger* is a marine eel frequenting the European seas ; it is one of the largest of the family, being from four to six feet long, and as thick as a man's leg. The *muræna* is destitute of pectorals as well as ventrals ; one species of it was much esteemed by the ancients, who carefully fed it in ponds ; and it is recorded that offending slaves were sometimes flung alive into the ponds for their supply. The *gymnotus*, or *electric eel*, is a native of the South American rivers. It attains the length of five or six feet, and communicates shocks so powerful that men and horses have been stunned by them. This power seems voluntary, and can be sent in a particular direction, or even through the water, the fish in which are killed or stunned by its shocks. By giving these, it is greatly exhausted, and requires rest and nourishment before it can

486. Describe the Eel family of fishes.

487. What variety of Eels is here described ?

renew them. The electric organ extends along the under side of the tail, occupying about half its thickness. It consists of parallel layers of membrane, joined by numerous transverse folds, so that a number of canals or cells are formed, which are filled with gelatinous matter. This apparatus is largely supplied with nerves. Some species of this family (which is commonly known under the name of *anguilliform* or eel-like fishes), approach very closely to the lower Reptiles in the structure of the air-bladder or lung; and in these the external opening of the gills is usually very small.

Order V.—Lophobranchii.

443. This order is a very small one, containing but one family, of which the genera are few. Their appearance is very peculiar. The tufted gills are covered by a large operculum; but this is bound down by membranes on all sides, so that there is only one small hole for the water to escape. The body is covered, not with small scales, but with shields or plates, which often give it an angular form. In general they are of small size, and almost without flesh. The *syngnathus*, like the *Fistularidæ*, possesses a long tubular snout; it is peculiar for the protection which it affords to its young, which resembles that provided in the marsupial mammalia. The eggs are conveyed into a sort of pouch under the body of the male and are hatched there, the young fry afterwards finding their way out. Some of these are found in the British seas, as are also the *hippocampi*, commonly called sea-horses, from the resemblance of the upper part of the body (especially when the dead specimen bends in drying) to the head and neck of a horse in miniature. Their tail is prehensile and they climb or hold on to the stalks of marine plants by its means. Some of this family are almost destitute of fins, having none but the dorsal; in others, as the *pegasus*, or flying-horses of the Indian seas, all the fins are present, and the pectorals are very large, whence their name.

488. Describe the fifth order of fishes.

489. What of the variety of sea-horses?

Order VI.—Plectognathi.

444. This order, the last of the Osseous Fishes, approaches the cartilaginous in many points of its organization; principally, however, in the slow ossification of the skeleton, and the imperfect structure of the mouth. They derive their name, as already stated, from the union of the upper jaw to the skull; so that its motion is obtained, not from a distinct joint, but by the mere flexibility of the half-ossified cartilages. The gill-lid is concealed under the thick skin, with only a small opening; the ribs are scarcely developed; and there are no true ventral fins. This order contains two families.

445. (I.) The GYMNOdontES, or naked-toothed fishes, are distinguished by having the jaws covered with a substance resembling ivory, arranged in small plates (which are reproduced as soon as destroyed by use), and really representing united teeth. They live on crustacea and sea-weed, and their flesh is not palatable. Some species are reputed to be poisonous, at least at particular seasons. The most remarkable species of this family are the spinous globe-fishes, *diodon* and *tetraodon* (their technical names being derived from the apparent division of their jaws into two and four tooth-like pieces respectively), which have the power of blowing themselves up like balloons, by filling with air a large sac which nearly surrounds the abdomen. When thus inflated, they roll over with the belly upwards, and lose all power of directing their course; but they are remarkably defended by spines over their whole surface, which are erected as they are inflated. They are mostly inhabitants of warm seas, but a specimen is occasionally drifted to our coasts. The *sun-fish* has a body of somewhat similar form, but incapable of inflation; the tail is so short that it looks like the anterior half of a fish cut in two in the middle. Some species attain an immense size. One which is occasionally taken on the British coast has been known to weigh 300 lbs., and others are much larger.

490. Describe the sixth order.

491. What variety in the first family?

446. (II.) The second family, *SCLERODERMI*, contains fishes which are remarkable for their very hard and granulated skins. They have a prolonged muzzle, with distinct teeth. Their skin is covered with scales in some species, and in others very rough, like a file, whence they are commonly termed *file-fishes*. They are principally inhabitants of warm seas, living near rocks or on the surface of the water, their brilliant colours sparkling in the sunshine like those of the *Chætodons*. The *Balistes*, or file-fishes, are generally remarkable for the appendages of various kinds attached to the surface of the body. One of the most curious species in this respect is the *B. pencilligerus*, whose body is covered with little branched

Balistes Pencilligerus

stalks resembling aquatic plants. Not improbably, these may serve as baits for the animals upon which the fish preys, its body lying concealed among the rocks, whilst these curious little prolongations are gently agitated by the water. The *ostracion*, or trunk-fish, also belongs to this family. It is remarkable for having its head and body covered in such a manner with plates of bone united together, as to form an inflexible cuirass, having openings for the tail, the fins, the mouth, and a small margin of the

gill-cover. It thus bears no inconsiderable analogy to the *Chelonia*.

Division II.—Chondropterygii, or Cartilaginous Fishes.

447. The skeleton of these fishes is not entirely devoid of calcareous matter, but this is disposed in separate grains, and does not form fibres or plates. Hence the hardest portions of the framework remain quite flexible. The freedom of motion of the spinal column, which is characteristic of fishes in general, is here still further increased, in many species at least, by the continuation of the sac containing gelatinous matter (which in the osseous fishes was simply interposed between each pair of vertebræ) through the whole column, the bodies of the vertebræ being pierced in the centre so as to form a continuous tube; and in the lowest of this group, which, as formerly mentioned, approach most nearly of the whole order to the vermiform tribes, the membranous tube filled with gelatinous matter is almost the only rudiment of a spinal column existing. This division contains two subordinate groups: in the first, the gills are attached by one edge only, hanging in fringes as in the osseous fishes; in the second, they are so attached to the skin by the second edges, that the water cannot escape from their intervals except by holes in the surface. Accordingly, instead of having a single pair of large apertures, with a valve-like cover, or *operculum*, behind the head, they have as many apertures on each side as there are arches of gills. The first series contains but one order, and the second the other two.

Order VII.—Chondropterygii Branchiis Liberis.

448. This order contains only one family, the STURIONES, or *Sturgeon* tribe. In many of its characters, as well as in the disposition of its gills, it is intermediate between

493. What species are named?

494. How is the second division of fishes characterized?

the Osseous Fishes and the Shark tribe, which may be regarded as the types of the Cartilaginous division. Sturgeons are chiefly river fish, and from their large size, vast numbers, and the quantity of food and other important products they afford, are extremely valuable to man. The common sturgeon of the British shores is about six feet long, and its flesh is somewhat like veal. The rivers falling into the Black and Caspian Seas, however, produce several other species, of which the largest not unfrequently attains the length of fifteen feet, one individual being recorded as having weighed 3000 lbs. The roe of the sturgeon furnishes the caviar, so much esteemed in Russia; and its air-bladder furnishes isinglass. The *chimæra*, of which a northern species, known as the king of the herrings, often accompanies herring shoals, is a genus intermediate between the sturgeon and the sharks, having the gills fixed, but having only one external gill opening, covered by the rudiment of an operculum; this leads, however, to five interior passages.

449. The section of CHONDROPTERYGII BRANCHIIIS FIXIS is divided into two orders, the first having teeth, and the second having the mouth formed into a sucker.

Order VIII.—Selachii.

450. This order only comprises one family, that of *Sharks* and *Rays*. A great metamorphosis here takes place in the condition of the bones of the mouth, those which are commonly termed the jaws, in which the teeth are fixed, being very different in position and character in osseous fishes, and the true jawbones not being here developed. This tribe is distinguished from other fishes by many peculiarities: in several members of it the young are produced alive, the eggs being hatched within the body of the parent; and in others the eggs are enclosed in a peculiar horny casing, which has often long tendril-like appendages, that coil around and attach them to other bodies. This is the case with the eggs of the common

dog-fish of our coast, vulgarly known as *sea-purses*. The Sharks much resemble ordinary fishes in their form, having the gill-openings on the sides of the neck, and the eyes on the sides of the head, in both of which respects the Rays differ from them. The *dog-fish* of the British coasts differs but slightly from the true sharks, and is, in its way, equally voracious.

451. The *white shark* is the most celebrated species of the tribe, being, from its size and voracity, the terror of

White Shark.

mariners in the seas it inhabits. It frequents warm latitudes, but has occasionally visited the British shores. It has been known to attain a length of thirty feet, and the opening of the jaws in the largest individuals is sufficient to admit with ease the body of a man. The mouth is placed on the under surface of the head, from which circumstance the fish cannot bite whilst in the act of swimming forwards, so that a dexterous person has been known to defend himself from its attack. The teeth are triangular and lancet-shaped, with acute points and edges, and form several rows; they are not fixed in the jaw itself,

but in a muscular membrane, by which they are erected and made to project when in use, lying flat in the intervals. As the foremost are torn away, they are replaced with others, which are brought up from the rows behind. So acute and strong are these teeth, that they are used by many savage nations as the armature of their weapons. The shark, possessed of this powerful apparatus for attack, and having a very hard and rough skin for defence, with great muscular power, is a match for almost any of the inhabitants of the ocean. All the smaller fishes and Cetacea fall an easy prey to it, and the only animals that can master it are the spermaceti whales. A shark seventeen feet long has been found in the stomach of one of these. The shark is very tenacious of life, and from young ones having been found swimming alive in the stomach of an old one, it has been inferred that the latter swallowed them for protection; but it is little probable that they ever find their way out again, the voracity of these creatures not restraining them from preying on their own species. The *blue shark*, which frequents the Mediterranean, is not unfrequently a source of great trouble to the fishermen of our coasts, on account of the injury which it does to their nets, and the loss of the fish they contain. The *fox shark*, or *thresher*, is another of the second-rate species which occasionally makes its appearance on British coasts; it is distinguished by the size of its tail, and the use it makes of it as a weapon, both of offence and defence—whence its name. The *thresher* is in constant hostility with the smaller Cetacea. The *porbeagle* is another species of this tribe which occasionally shows itself on our shores; it associates into small companies in pursuit of prey. Its length is about six feet.

452. A remarkable genus allied to the Sharks is the *zygæna*, or *hammer-headed shark*, so named from the projection of the head at each side in the form of a double-headed hammer, with an eye in the middle of each ex-

497. Describe the white shark.

498. What different species are named?

499. Describe their structure and habits.

tremity. The *pristis*, or saw-fish, is another interesting genus. Its general form and character are like those of the sharks, but the snout is extended like the blade of a sword, with strong and cutting tooth-like spines on both edges. With this formidable weapon the fish, which sometimes attains the length of from twelve to fifteen feet, will attack the largest whales, and inflict dreadful wounds. To the shark tribe also belongs the *angel fish* of our own coasts, which forms the link to the rays in its general structure and aspect. The eyes are situated on the back or upper surface of the head; the body is broad and flattened horizontally, and the pectoral fins widely expanded. It commonly grows to the length of seven or eight feet; its appearance much belies its name, being (according to our ideas of beauty) one of the ugliest of fishes, but its flesh is by no means unpalatable.

453. The *Rays* are less numerous than the Sharks, and abound rather in temperate than in tropical seas. They are characterized by the extreme horizontal flattening of the body, in which, however, there is not (as in the *Pleuronectidæ*) any want of lateral symmetry. The two sides are spread out horizontally, and unite with the expanded and fleshy pectoral fins to form one continuous surface. The eyes are placed on the back or upper surface, whilst the mouth, nostrils, and gill-openings, are below. To this group belong the *rays* and *skates*, *thornbacks*, and other species; but the most interesting of all is the *torpedo*, or electric ray, sometimes found on the Channel coast of England, but more abundantly in the Mediterranean. The electric apparatus is of very similar structure with that of the *gymnotus*, and it is disposed in the space between the pectorals and the head and gills. The shocks given by this fish, though smart, are not so benumbing as those of the *gymnotus*; their use in its economy is not apparent, as the animal can obtain its prey without them. The flesh of the rays is wholesome, and that of most species agreeable as food. The skin of some of them is employed

in the arts for polishing, and from that of others shagreen is made.

Order IX.—Cyclostomata.

451. The third order of the Cartilaginous Fishes, and the last of the class, is one which contains comparatively few species, and these exhibiting but a very low degree of organization. They take their name from the adaptation of the mouth to the purposes of suction, by its transformation into a round fleshy disk, having the oral opening in the centre, and the margin supported by a ring composed of the cartilaginous jaws united together. The spinal column loses its distinct division into vertebræ, the space elsewhere occupied by their bodies being traversed from end to end by a cylindrical membranous tube filled with a mucilaginous fluid; and this, in the higher species, presents cartilaginous rings at intervals, which are the rudiments of vertebræ; whilst, in the lower, there is no vestige of these bodies, and the whole structure is reduced to the level of that of the Annulida. The pectoral as well as the ventral fins, are absent; and the skin is soft and mucous, with scarcely a vestige of scales. This order contains but a single family. The *lampreys* are the most allied to other fishes in their general organization; they possess teeth within the ring, and with these they tear the bodies of the animals to which they attach themselves. There is a marine species two or three feet long, and other smaller ones which inhabit rivers. The *myxine*, or hag, is destitute of eyes, and is altogether of lower organization than the lamprey; but the species that differs most in its general characters from the rest of the class is the *amphioxus*, or lancelet. This is a very small animal, about an inch long, sometimes found lurking under stones in pools left by the ebbing tide. It is destitute of almost every one of the characters which have been mentioned as peculiar to vertebrated animals, and, nevertheless, can scarcely be classed anywhere else than with this family.

501. What of the last order?

502. Name the several species.

SUB-KINGDOM—ARTICULATA.

455. It is the necessary result of any natural system of classification, that, in pursuing one type or plan of organization through all the forms in which it manifests itself, we are led from the lowest and simplest, up to beings so complicated and so elevated in the general scale, as to be far above the lowest members of the series next to be considered. From the Vertebrata we might pass, in descending the animal scale, either to the Mollusca or the Articulata, both of which exhibit some points of approximation with them. In both we meet, as in the Vertebrata, with very highly organized as well as very simply constructed beings. In both we find animals much superior to the lowest Vertebrata; and in both, also, we find species which are in many respects below the highest Radiata. It is the necessary consequence of a *natural* arrangement, which aims at grouping together the different forms of living beings according to the type or plan on which they are constructed, that such should be the case.

456. Neither of these two sub-kingdoms can be regarded as in all respects superior to the other. The high development of the locomotive power in the Articulata, strikingly contrasts with its usually slight possession by the Mollusca. On the other hand, the digestive and nutritive systems in the Mollusca are much more complex, and attain a higher organization; so that the heart, for example, of the Tunicata is as powerful in its action on the circulating fluid as that of the highest Articulata. On the whole, however, the Articulata should be regarded as ranking above the Mollusca in the animal scale, since it is in the *animal* powers that the former have the superiority.

457. The general character of the series has been already stated as being the jointed or *articulated* character of the skeleton, or hard portion of the structure, and the

503. What of the next sub-kingdom?

504. Wherein do the Articulata rank above the Mollusca?

enclosure of the whole body in this. Nothing can be found in the Mollusca at all approaching in character the shell of a lobster, or the horny case of the beetle. It is the peculiarity of the skeleton in the Articulata, that it not merely encloses the body, but is prolonged over the appendages for locomotion where they exist; and the portions of it which cover these are also jointed, for the sake of conferring upon them the requisite flexibility. This structure is more apparent, however, in some cases than in others. In the lowest animals of this series, where there are no appendages for locomotion, and where all movements are effected by the body itself, this is endowed with great flexibility, and the whole envelope is so soft that the division into segments can scarcely be recognised. This is the case, for example, in the leech and earthworm. The articulated character is most apparent in the Centipede tribe, where the segments are all of nearly equal size, and where each possesses a short pair of legs, which are themselves also articulated. But in the highest classes of this sub-kingdom, we again lose the appearance of the division into segments from an opposite cause—the consolidation of several rings into one piece. In proportion as the locomotive power is more intrusted to the extremities, so does it become unnecessary that the trunk should possess much flexibility; and in the same proportion does it become necessary that the portion of it, from which arise the muscles of those extremities, should be very firmly framed. Accordingly, the part of the body behind the head, which is called the *thorax*, and from which the legs and wings of Insects, and the principal walking legs of Crustacea, have their origin, very commonly appears as if composed of one piece, although it is really made up of three or more segments, each one of which gives origin to a pair of members.

458. The Articulata are almost invariably of small size; and the bulk of their bodies is made up, not by their digestive and nutritive apparatus, but by the muscles which move it. It is only in those which approach the

Mollusca in the vegetative nature of their existence, that we find any considerable dimensions attained. As the Mollusca are an essentially aquatic group, so are the Articulata principally adapted to atmospheric respiration; and the most active among them can even quit the surface of the ground and mount up into the air. We find their respiratory apparatus constructed, therefore, upon an opposite plan. Instead of the blood being sent into external prolongations of the surface, the gills, to meet the air contained in the surrounding fluid, the air is introduced into the body to meet the blood, this being distributed on the sides of cavities or tubes into which it enters. In Insects, these tubes have a very complex and beautiful distribution through the body. A structure of this description, which may be regarded as characteristic of the Articulata, will be noted to exist in certain species of Echinodermata (§ 868), which approach most nearly to this series; and it is interesting to find the approximation existing not merely in outward form but in internal structure.

459. The Articulata exhibit a peculiarity in the nervous system, which often enables the real character of doubtful animals to be distinguished. A double cord runs along the centre of the *lower* surface of the animal, studded with knots or *ganglia* at regular intervals, which are so many centres from which the nerves pass off to the different segments. The head also has its ganglia, in which the double cord terminates anteriorly. Where the members, however, are not uniformly distributed along the whole body, but are concentrated to one part, as in Insects, Arachnida, and the higher Crustacea, we observe a corresponding concentration of the ganglia in that region. The degree of this concentration indicates the elevation of the animal in the series.

460. The following classes must be arranged in the Articulated series, though in some of them the characteristic structure is very indistinct;—

461. ANNELIDA, or *Worm* tribe. In these, the body is prolonged, without any distinct appendages for locomotion.

The habitation is usually aquatic, though sometimes terrestrial. The division into segments is not very distinct, the entire skin being soft.

462. MYRIAPODA, or *Centipede* tribe. These have also a prolonged body; but it is provided with legs, and the articulation of the covering both of the body and legs is very distinct.

463. INSECTS, which are distinguished in their perfect state by the possession of one or two pairs of wings: by the restriction of the legs, which are never more than six in number, to the thorax; and by the division of the trunk into three portions—the head, thorax, and abdomen—which are usually very distinct from one another. They are also distinguished by their remarkable metamorphosis, commencing from a form which resembles that of the Annelida.

464. ARACHNIDA, the *Spider* and *Scorpion* tribe, which differ from Insects in having the head and thorax united, in undergoing no metamorphosis, and in having eight or more legs.

465. CRUSTACEA, which have a hard envelope, principally composed of earthy matter, and which are adapted for aquatic respiration. Many of them have the form of Insects; but their legs are never less than ten in number.

466. The foregoing constitute a tolerably regular series, into which we must also introduce the ENTOMOA, which seem to exhibit the characters of the Worm tribe in their most degraded condition, and the animals composing which are parasitic upon or within others; the ROTIFERA, or *Wheel-Animalcule* tribe, of which some approach the Polypifera and Polygastrica, whilst others approximate the Crustacea; and the CIRRHOPODA, or *Barnacle* tribe, which bear a strong general resemblance to the Mollusca, but unquestionably belong to this series.

507. Describe the Worm tribe.

508. What of the Centipede family?

509. How are insects distinguished?

510. What of the Spider and Scorpion family?

511. How are the Crustacea characterized?

512. What other varieties are named?

CLASS VI.—INSECTS.

467. The class of Insects is perhaps the most interesting in the whole animal kingdom, both in regard to the number, variety, beauty, and complexity of the different forms which it contains—the vast assemblages of individuals of the same species which not unfrequently make their appearance together—and their consequent importance in the economy of nature. “When we consider attentively these little beings,” says an eminent and pious entomologist, “the multiplicity and diversity of their organs, whether of sense or motion, of offence or defence, for mastication or suction; or those constructed with a view to their several instincts, and the exercise of those functions devolved upon them by the wisdom of their Creator; the different kinds also of sculpture, which is the distinction of one tribe, and of painting which ornaments another; the brilliant colours, the metallic lustre, the shining gold and silver, with which a liberal and powerful hand has invested or bespangled many of them; the down, the hair, the wool, the scales, with which He, who careth for the smallest and seemingly most insignificant works of his hand, hath clothed and covered them; when all these things strike upon our senses, and become the subject of our thoughts and reflection, we find a scene passing before us far exceeding any or all of those that we have hitherto contemplated in our progress from the lowest towards the highest members of the animal kingdom; which, for its extent and the myriads of its mustered armies (each corps distinguished, as it were, by its own banner and under its proper leaders), infinitely outnumbers all the members of the higher classes; and which stands, as it were, between aquatic and terrestrial animals, many of its tribes under one form inhabiting the water, and under another the earth and the air.”*

* Kirby's Bridgewater Treatise, vol. ii. p. 313.

468. The class of Insects does not, in modern systems of classification, include nearly so many different forms as Linnæus arranged under it. It was made by him to comprehend all the higher groups of Articulata which exhibit a distinct division of the body into segments, and are superior in general organization to the Vermes or Worm tribe, under which he placed the remainder. Thus, the Crustacea, the Myriapoda, and the Arachnida, were included, with those now known as Insects, under this general designation. The appellation is now restricted, however, to those Articulata, which, in the adult state, have but six legs; and animals of this character are also distinguished by being adapted for breathing air through a system of tubes which conveys it over the whole interior of their bodies; by the division of the body into three distinct parts, head, thorax, and abdomen; by the possession of one or two pairs of wings; and by undergoing a metamorphosis, or change of form, between their exit from the egg and their attainment of the adult condition. These two last characters, however, are not as constant as the former, being absent in some of the subordinate divisions of the class.

469. The true Insects are distinguished from the Crustacea by their peculiar apparatus for atmospheric respiration; from the Arachnida by having but six legs (eight being the number in that class), and by the division of the body into three parts; and from the Myriapoda by the limited number of legs and segments, the latter seldom exceeding thirteen. In the perfect Insect it is sometimes difficult to distinguish the division into segments; they may generally be seen, however, on the lower side of the body, especially on the abdomen. But in the larva or caterpillar state they are never obscure, and their number is very constant, being almost always thirteen, one forming the head. Of the twelve segments of the body, three in the perfect insect form the thorax, or division succeeding the head, whilst the remaining nine consti-

514. How is the class now restricted?

515. How are they distinguished from other tribes?

tute the abdomen. It is more common for one or two segments to be apparently deficient (being consolidated with the rest), than for any increased number to be present.

470. The *metamorphosis*, or complete change of form, which may be seen in the greater number of insects during their development, has attracted much attention from the earliest ages to the present time. The *larva*, which afterwards changes to a beetle, a butterfly, or wasp, bears no resemblance whatever to the perfect or *imago* form, and is in fact allied, in almost every particular of its conformation, to a class far beneath. Moreover, it has to go through an intermediate form—if any thing still more remarkable—that of the *pupa* or *chrysalis*; in which there is an almost complete cessation of activity, but in which preparation is being made for the exit of the perfect insect at its final change. The alteration of the entire character of the animal is no less remarkable than its change of form. In the *larva* condition, its whole energies seem to be concentrated upon the nutritive functions; the voracity is extreme, and the increase in the weight of the body is very rapid; whilst, in the perfect insect, the body undergoes little increase of size, but it is provided with powers of active movement, and these are principally destined to enable it to seek its mate for the purpose of propagating its race.

471. The *larva*, when it first emerges from the egg, bears but a very small proportion to its subsequent bulk. According to Lyonnet, the comparative weight of a full-grown caterpillar of the goat-moth to that of the young one just crept out of the egg, is as 72,000 to 1. During its increase, it throws off its skin several times, like the Crustacea. The larvæ in the different tribes vary extremely as to the degree of their development. Some have no distinct head or legs, and closely resemble the *leech* or earth-worm in general structure; of this kind are most of

516. What of the segments, and their number?

517. What of the twelve segments, and how divided?

518. What of metamorphosis, with examples?

the larvæ of the Diptera (two-winged flies). Another grade is furnished by those larvæ which, though still vermiform, are provided with a distinct head, as are those of the Hymenoptera (bee and wasp tribe); these may represent the *Naiades* among the Annelida. A third grade is furnished by larvæ which has lateral gills, and reside in tubes which they construct for themselves; such is the *caddis-worm*, which may be regarded as analogous to the *Tubicola*. And, lastly, a still higher grade is reached by those which not only possess a distinct head, but also the rudiments of legs, which serve for walking, such as we find in the caterpillars of the Lepidoptera (Butterfly tribe); and this grade corresponds in organization with the *Aphrodita* and others among the higher Annelida. When the larva is possessed of *any* legs, it may be observed that they appertain to the three first segments of the body, and are the rudiments of the legs of the perfect insect. But very frequently the posterior segments are supported by legs also; these, however, are nothing more than fleshy tubercles, which are cast off in the metamorphosis, and are termed *pro-legs*.

472. The foregoing account of the larva applies to those tribes only which undergo what is termed a *complete* metamorphosis; that is, which differ most widely in their early condition from the form they are ultimately to assume. In many groups, such as the Orthoptera (Grasshopper and Locust tribe), the larva issues from the egg in a much more advanced condition; differing but little, in fact, from the perfect insect or *imago*, save in the absence of wings, which are gradually developed. These are said to undergo an *incomplete* metamorphosis. There are no insects which possess wings when they issue from the egg, but there are some which never obtain them, and in which no metamorphosis can be said to take place.

473. After attaining its full growth in the larva condition (the bulk of the body in this state often much exceeding that of the imago), the insect undergoes a very remark-

519. Describe the variety in different larvæ.

520. What other variety is described?

able change, ceasing to take food, and apparently losing all appearance of vitality. In this state it is termed the *pupa*, or *chrysalis*. Many larvæ enclose themselves in a silken cocoon, or in some other kind of envelope, before undergoing this change, and remain in it during the whole period of inactivity, which is sometimes many months in duration. Others bury themselves in the ground; and others, again, suspend themselves in the air. The *pupæ* of different orders of insects vary, like the larvæ, both in form and in degree of torpor. Some have the whole body enclosed in a horny case, without vestige of members, and are totally inactive, except when disturbed; whilst others present the general form of the perfect insect, but appear as if the body and limbs were separately bandaged, and laid in close opposition; whilst others retain all their limbs free, and suffer no diminution in their locomotive powers or in their appetite for food; these, indeed, can scarcely be said to pass into the pupa state at all, their condition being only indicated by the gradual development of the wings. This development is equally taking place beneath the envelope of the *pupæ* that are enclosed and inactive.

474. The perfect insect, or *imago*, when it emerges from its pupa case, exhibits in all respects the *form* which is characteristic of the species, and, in general, the *size* also; few growing much after they have attained this condition, and many scarcely eating at all. As already mentioned, the twelve segments forming the body of the larva may still be recognised here, but very much changed in their character. The three anterior ones are

often soldered, as it were, together, forming but one strong sheath for that portion of the body from which the wings and legs proceed ; and this sheath affords firm attachment for the powerful muscles which move these organs. Those which constitute the abdomen, however, retain much more of their original aspect. The head is now quite distinct from the body, and connected with it by a neck which is often very narrow. From each of the segments of the thorax a pair of legs proceeds ; and the second and third usually give origin to a pair of wings each. Where, however, only one pair of these organs exists, they proceed from the second segment. The segments of the abdomen never show any vestige of legs. The accompanying diagram represents the chief parts of the perfect insect. The three segments of the thorax are separated from each other, to show the organs attached to them.

475. The especial function of the perfect insect is the continuance of the species ; and the wings enable it to seek its mate, and to obtain a situation fit for the deposition of its eggs, which are always laid in the neighbourhood of whatever substances will supply the *larva* with nourishment, although it most commonly happens that the *imago* does not feed upon them. Many insects, such as the *silk-worm* moth and the *ephemera*, or May-fly, die soon after having fulfilled this object, to which they proceed very soon after their last change. It has been well observed that there is a beautiful correspondence between the metamorphoses of insects and the development of flowers. Every species of plant exhibits itself in the course of a year, in different states. First are seen the succulent stems adorned with the young foliage ; then the calyx opens, and permits the tender and lovely blossoms to expand. The insects destined to feed upon each plant, must be simultaneous in their development. If the butterfly came forth before there were any flowers, she would in vain search for the nectar that forms her food ; and if the caterpillar were hatched after the leaves had begun

522. Explain the diagram and its segments.

523. What is said of reproduction by insects ?

to wither, it would not exercise its functions in devouring them. The eggs of many insects are laid in the autumn, and remain unchanged during the winter; their development being excited, like that of plants, by the genial warmth of the spring. Others, again, pass the chrysalis part of their existence at the same season, and come forth as perfect insects early in the ensuing year.

476. However extraordinary is the metamorphosis of insects, it is by no means *unique*, as was formerly supposed. The change of the tadpole into a frog is an exact parallel to it, for the tadpole is for the time a fish, resembling that class in its entire organization; just as the maggot is for the time a worm. Moreover, we shall hereafter see, in some of the lower classes, a change which is fully as remarkable. There is much more difference between the gemmule of the polype, for example, and the structure into which it will be afterwards developed, than there is between the caterpillar and the butterfly. But such changes are not confined to the classes in which they ordinarily come under our observation. It seems to be a general law, applying to all organized beings, plants as well as animals, that the germs of new individuals shall at first possess a structure much less complex than they are ultimately to present, and adapted to different conditions of existence. Thus the germ of the fowl, seen as a spot upon the transparent membrane of the yolk-bag, does not bear the slightest resemblance in form or structure to the future bird; and it is only adapted to live, grow, and develop itself, whilst supplied by the nourishment previously stored up by the parent. In the same manner, the germ of the plant contained within the mature seed, often presents little that can be recognised as part of the future structure; and nothing of it can be recognised at an early period of the formation of the seed.

477. Now, upon examining the gradual development of the germs of the higher animals or plants, into their respective perfect structures (such as may be easily traced in the egg of a bird), it is seen that the several organs

pass through a series of conditions which bear an evident analogy with those which are permanent in the lower parts of the scale. Thus the heart of the bird is at first constructed upon the same model or type as that of the Vermiform tribes, being a long pulsating vessel, without division into distinct cavities; it afterwards assumes a more concentrated form, with fleshy walls, as in the Crustacea. Subsequently, a division into two cavities takes place, and the heart resembles that of a fish; and not only does the heart itself correspond in all essential particulars, but the distribution of the vessels also. One of these cavities then subdivides, and thus three are formed, which is the character of the heart in the reptile; and, at the same time, the circulating system undergoes corresponding changes. Finally, the other cavity also subdivides, and four are thus produced; the perfect heart of the warm-blooded animal being thus gradually evolved, and the changes in the blood-vessels proceeding at an equal rate. Such changes take place during the development of all the higher animals, not excepting man; and they affect every important organ in the body.

478. It is not meant to say, however, that the embryo of the bird or of the human being ever exhibits the condition of a worm, fish, or reptile. The fact is, that each of its organs passes through a series of forms corresponding in degree of organization to those which are permanent in the lower classes, but not adapted to lead their life. For, during all this time, the embryo is being supplied with nutriment, either directly from the parent, or from the store laid up by the parent in the egg; and there is not that degree of harmony amongst its different organs, or of adaptation to the supply of its wants, which should enable it to live in any other condition. But in the larva of the insect, and in the tadpole, there *is* that harmony. The embryo does not receive sufficient nutriment from the store within the egg to enable it to arrive at its full development without quitting its envelope; and it comes

525. What of the gradual development of organs?

526. What phenomenon in the heart is named?

forth in a state which, as regards its ultimate condition, is imperfect. But it is enabled to support itself in this state by the adaptation of its organs to each other, and to the conditions of its temporary existence—the insect leading the life of a worm, and the frog that of a fish. But if the larva of the insect, which is ultimately to subsist upon the juices of flowers, had been furnished with a long trunk for sucking them, instead of with jaws to gnaw the leaves, it could not have existed, since the absence of wings would have prevented it obtaining its food. And if the tadpole, destitute of legs, had been adapted to breathe air, it could not have existed, because it would have had no power of moving about upon land in search of its food.

479. Thus we see that the *metamorphosis* of insects is only a peculiar example of the curious changes which occur during the development of all organized beings; and it is much more interesting to regard it as a result of a general law, differing from other results in subordinate particulars only, than to consider it as something altogether destitute of analogy with what is to be observed elsewhere. To view it thus with the philosopher, need not prevent us from enjoying the poetical views, of which it has been so fertile a subject.

480. Insects, in their perfect state, are distinguished beyond all other animals for their power of locomotion, and for the perfection of their instinctive actions. In estimating their power of locomotion, the space traversed is of course compared with the length of the body; and thus it is seen that, rapid as is the flight of many birds, that of most insects far surpasses it. The senses of insects appear to be acute. They have generally large eyes, formed, in fact, by the union of a great number of small ones, often several thousand; and although these are fixed, yet from their being directed at various angles to each other, a great range of vision is obtained. It is believed that insects possess the power of hearing, and also of smell, though no distinct organs for receiving such impressions have been satisfactorily determined. That they have a deli-

cate sense of touch in some part of the body, even where the general envelope is firm, cannot be questioned; and, from observations made upon the social insects, such as bees and ants, there is reason to believe that they communicate with each other by this sense.

481. The different organs on the head of insects furnish, by their varieties of conformation, important characters in classification. It will, therefore, be necessary to describe these in some detail. The most important characters—upon which, in fact, the primary subdivision of the class is founded—are drawn from the structure of the mouth; in one large group it is furnished with *mandibles*, or jaws, adapted for biting and bruising; whilst in the other it is provided with a *haustellum*, or proboscis, adapted for suction. Hence the first group is termed MANDIBULATA, and the second HAUSTELLATA. These organs are, however, but different modifications of the same elements.

482. In the mouth of the Mandibulata, six principal pieces may be readily distinguished. Of these, four are arranged in two pairs, which work against each other laterally; a fifth piece is above the upper pair, and a sixth below the lower. The two lateral pairs are the jaws; of which the upper pair is distinguished by the name of *mandibles*, and the lower by that of *maxillæ*. The mandibles are usually the largest, and are very powerful organs; sometimes they are provided with sharp or toothed edges, working against each other like those of a pair of scissors; and sometimes with hooked points, more formidable, for the size of the animal, than the teeth of the tiger. These are the principal organs by which the food, of whatever description, is usually obtained; but in the bees and wasps, of which some species are adapted to obtain their nourishment by suction, they are the instruments by which their curious edifices are built up. In a word, as has been well remarked, they supply the place of trowels, spades, pick-axes, saws, scissors, and knives, as necessity may require. The *maxillæ*, or under pair of

jaws, are of similar construction, but usually smaller and less powerful. The pieces which are applied, above and below, to the spaces left between the jaws, are termed *lips*; the upper one being particularized as the *labrum*, and the lower one as the *labium*.

483. Various modifications of these parts are seen in the different orders of insects, but their existence may always be detected under some form or other. The most remarkable alteration in the structure of the mouth, is that which we find in the Lepidoptera or Butterfly tribe. Instead of cutting jaws, we observe a tubular appendage or trunk, which is often of considerable length, and coiled spirally beneath the head, but capable of being unrolled when its point is required to descend into the corollæ of flowers. This tube is composed of two long narrow filaments, which are in fact the *maxillæ* excessively drawn out; these filaments are channelled on the sides at which they approach one another; and by the adhesion of the edges of these channels, which lock together by means of minute teeth, a complete tube is formed. In this mouth, therefore, all the parts, except the maxillæ, would seem at first sight to be wanting; but they may be detected by a careful examination, and the rudiments of the upper lip, of the mandibles, and of the lower lip, as well as of the *palpi* (organs to be presently described), may be distinctly demonstrated.

Different parts of the mouth of a beetle.*

* A, upper side; B, under side; C, parts separated; *a a*, antennæ; *e e*, eyes; *l 1*, upper lip; *m m*, mandibles; *m x*, maxillæ; *m p*, maxillary palpi; *l 2*, labium; *l p*, labial palpi; *c 2*, chin or mentum.

529. How do the mouths of insects vary?

530. What of the first group?

531. Describe the variety of structure, and their use.

532. What modification in butterflies?

484. In other instances, an entirely different modification of the same parts may be observed. Thus, in the Diptera, to which the gnat, horse-fly, and other blood-sucking insects belong, we find a sort of proboscis formed by a prolongation of the lower lip; and between its base and the upper lip, there are five lancets, with sharp cutting points or edges, of which the upper pair represents the mandibles, the lower ones the maxillæ, while the middle one is the tongue.

485. The head of the perfect insect is usually furnished with three pairs of jointed appendages, all of which are probably instruments of sensation. The first of these are termed *antennæ*; they are affixed to the sides of the head, and usually between the eyes and the mouth. The number of joints in them, and the forms they present, vary in the different tribes of insects; as also does their size, within very wide limits. Sometimes they are three or four times as long as the whole body, and sometimes they are scarcely to be perceived. Sometimes they are simple thread-like organs, gradually tapering from the base to the point; sometimes they swell out towards the extremity, and often possess side branches or appendages of various forms. These different characters are extremely useful in classification. The *palpi*, or feelers, are organs which are not dissimilar in general character, but are usually of much smaller size, consisting of seldom more than six joints; of these, one pair is attached to the *maxillæ*, and the other to the *labium*, and they are called *maxillary* and *labial palpi* respectively.

Variously formed Antennæ.

486. The uses of these organs are involved in some

533. What of the proboscis of blood-sucking insects?

534. What appendages of the head are mentioned?

obscurity. There is good reason to believe that all of them are organs of touch ; and this sense is probably sometimes most acute in the antennæ and sometimes in the palpi. When the antennæ are long, they may take cognisance of objects at a distance from the animal ; whilst the palpi may be employed in examining its food or other bodies in closer proximity to the mouth. There is also reason to believe, that the sense of hearing is in some way connected with the antennæ ; and a curious modification of the joint at the base seems to be particularly appropriated to this function. It has also been thought that the antennæ minister to the sense of smell. There is no doubt that many insects are guided by this sense in the selection of their food, and in the choice of the position for their eggs ; but where the olfactory organ is lodged is still doubtful.

487. The *wings* of insects are the organs most peculiar to them ; nothing at all analogous being developed in other Articulated animals. They consist of a double layer of membrane, prolonged from the skin which covers the body, and partaking of its characters. This membrane is supported by a framework of harder structure, composed of ribs, which go by the name of *veins* or *nerves*. These terms must not be supposed to imply any analogy of structure with the organs they designate in higher animals ; they are rather drawn from the analogous parts in the leaves of plants. The veins contain air-tubes, which are continuous with those of the interior of the body, and it is, in fact, by the injection of air into these tubes, that they are extended in the first instance ; for when the imago emerges from its pupa sheath, they are closely folded up, and the insect has no power of moving them until they have been thus distended. In the young state they also contain blood-vessels ; and a circulation of blood can be distinctly seen in them, during their growth in the pupa state, and (in some insects which enlarge after their last metamorphosis) during the early part of the perfect con-

535. Describe their various functions.

536. Describe the peculiar structure of the wings.

dition also. But the vessels soon become dried up, and the circulation ceases; and no further nutrition of the wings then takes place—injuries to these organs not being repaired.

488. There is scarcely any organized substance upon which insects are not adapted to prey. The growing vegetable and the living animal are alike subject to their attacks; their dead bodies supply many tribes with abundant nutriment; and even when these are in an advanced stage of decay, they supply wholesome food to particular species. Thus, although man sustains great damage by the injury or destruction of his cultivated plants or trees, he receives a still greater benefit by the removal of decomposing substances, whose noxious exhalations would poison the air, of which the purity is so important to his health and comfort. As an instance of the rapidity with which they effect this object—a consequence of their individual voracity and their speedy multiplication—may be mentioned a calculation made by Linnæus, that three flesh-flies and their immediate progeny would devour the carcass of a horse sooner than a lion would do.

489. In regard to the food of individual tribes of insects, it may here be stated generally, that some are purely carnivorous, devouring only prey which they have themselves killed. Others eat carrion, and even keep it until its decomposition is advanced. Others are herbivorous; some feeding only upon particular species of plants, whilst others are not restricted, but feed upon almost any vegetable substance. Others, again, are omnivorous, and will attack almost any thing that falls in their way. The excessive multiplication of insects, which would result from the enormous number of their eggs, and from their rapid growth, is prevented by the influence of other tribes of animals, as well as by the wars of their own tribes against each other. The destruction of the larvæ of some insects by those of others is often enormous, and far exceeds in proportion the diminution in their numbers effected by

537. What of their variety and multiplication?

538. What of the variety of their food?

higher tribes. There are no classes of animals formed to exist on land, however, of which part do not derive a great proportion of their food from insects; and thus, if man does not interfere with the economy of nature, a balance is maintained which is rarely disturbed. But if these higher tribes be destroyed (as for example, if a rookery be dispersed), insects will then multiply inordinately, and will become a pest to the country.

490. Insects are distributed abundantly over all the portions of the globe yet trodden by man. Even in the coldest regions which he has yet explored, they present themselves to his notice during the brief summer; and no severity of the winter appears capable of destroying their vitality, although it reduces them to a state of complete torpidity. It is in tropical regions, however, that the largest and most brilliant species are usually found. Different tribes have peculiar geographical limits; and the globe might be mapped out into several regions, of which each should contain many species peculiar to it, and few that exist in others. The common house-fly has the most extensive range of all. Further, the insects of each region have a peculiar character; so that a practised entomologist, to whom a small collection from any particular country might be shown, would be able to state the locality from which they came, even though every one of the species might be new to him.

491. With these general remarks, we are now prepared to consider the principal subdivisions of this important class in more detail. These subdivisions are principally formed upon the character of the wings; since it is found that the structure of these organs affords a good index of that of the body in general. But it cannot be trusted to alone. For, whilst certain orders may be included under the general designation *Aptera* or wingless, and another is termed *Diptera* or two-winged, we find the wingless and two-winged insects in all the other orders.

492. Winged insects may be distributed amongst the eight

539. What prevents the excessive multiplication of insects?

540. What of their distribution and range?

following orders, of which the first four are MANDIBULATE, whilst the rest possess a mouth formed for suction, and are termed HAUSTELLATE.

493. (I.) COLEOPTERA (*Beetles*). In these the two anterior wings are converted into a horny or leathery substance, and enclose the posterior when folded.

494. (II.) ORTHOPTERA (*Grasshopper, Cockroach*). In these the anterior pair of wings is composed of a substance more resembling membrane.

495. (III.) NEUROPTERA (*Dragon-Fly, White-Ant*). Both pairs of wings are membranous, and the nerves form a close network by their interlacement.

496. (IV.) HYMENOPTERA (*Bee, Wasp, Saw-Fly*). Both pairs of wings are here also membranous; but the veins have larger areas between them. The tail is possessed of a sting.

497. (V.) HOMOPTERA (*Cicada, Lantern-Fly*). In this order the four wings are of the same consistence, often somewhat parchmenty; and, when folded, they incline at an angle like the roof of a house.

498. (VI.) HETEROPTERA (*Bugs*). The anterior pair of wings is horny or leathery, but generally tipped with membrane; both pairs are horizontal or but slightly inclined.

499. (VII.) LEPIDOPTERA (*Butterflies and Moths*). These have four membranous wings, covered with minute scales.

500. (VIII.) DIPTERA (*Gnat, Fly*). These have but two wings, and are in many respects parallel to the Hymenoptera.

501. Besides these, there are some small orders intermediate between the principal groups. Thus a separate order, TRICHOPTERA, has been formed to include the *Case-worm-Flies*, which are intermediate between LEPIDOPTERA and NEUROPTERA. The order STREPSIPTERA, again, comprehends a small group termed *Wasp-Flies*, intermediate between the LEPIDOPTERA and DIPTERA.

541. How are insects divided and sub-divided?

542. Describe the eight orders of winged insects.

502. The APHANIPTERA, the order to which the flea belongs, are entirely *apterous* or wingless, and parasitic : but undergo a metamorphosis, by which they show an alliance with the Diptera.

503. The Wingless Insects, which do not undergo any metamorphosis, may be distributed into two classes—1. PARASITA (*Louse*) ; and, 2. THYSANOURA (*Sugar-Louse*, *Spring-tail*). These connect true Insects with the Myriapoda.

504. These orders will now be considered more in detail.

Order I.—Coleoptera.

505. The order Coleoptera includes the extensive tribes of *Beetles* of all descriptions ; and, in regard to the number of species, and the size which some of them attain, it may be considered as holding the foremost rank amongst insects. There are probably between 40,000 and 50,000 different kinds existing in collections at the present time ; and there is little doubt that, when the species of other quarters of the globe shall be as attentively examined as those of Europe have been, the number will be doubled or even trebled. In this surprising number we find the most brilliant colours and singular forms, with a variation in size from the most bulky to the most minute of insects. Scarcely any branch of Natural History—certainly no department of Entomology—has been investigated with the same attention as this order has received. This is due to the causes already mentioned, and also the solid texture of their integuments, which renders their preservation easy.

506. This order comprehends all insects which have the anterior pair of wings converted into wing-cases, or *elytra*, and which undergo a complete metamorphosis. These wing-cases are of horny consistence, and are opaque, or nearly so. When expanded, they are of little or no use in flight ; and, when closed, they meet along the back, in a straight line, which is called the suture. The second

543. What of those which are wingless ?

544. What of the variety of beetles ?

pair of wings constitute the true organs of flight; they are of large size, and of membranous texture; and, when unemployed, they are shut up in several transverse folds, and are entirely concealed beneath the elytra. The mouth is formed for mastication, and possesses two horny mandibles. The head is provided with two antennæ, of variable form, and of which the number of joints is usually eleven; these often differ considerably in the two sexes. The eyes are large and protuberant, especially in the carnivorous species, and in those the slowness of whose habits makes them need quick powers of sight for the purpose of avoiding their enemies.

507. The body exhibits a well-marked division into thorax and abdomen. The former consists, as usual, of three segments; but the first of these is so largely developed at the expense of the rest, as to appear almost to constitute the thorax in itself. The abdomen usually consists of only six or seven segments; the remainder of the nine which properly form this part being consolidated in the last. The colour of the body varies according to the habits of the species, which may be stated in a general way almost with certainty from them alone. Thus, the dull-brown and black beetles for the most part frequent the earth; those of a green colour are principally found among the leaves of plants; those of a red or bright metallic hue, which abound in tropical climates, rather frequent the flowers; others, again, of an aspect like decaying wood, live principally upon or within timber.

508. Although the characters already mentioned are applicable to by far the greatest number of insects included in this order, nearly all of them are subject to exceptions. Thus, there are some species in which the organs of flight are altogether wanting, as in the female of the glow-worm; others which have elytra, but no wings; others, again, in which the elytra adhere together along the suture; others, in which they overlap; others, in which they do not meet; and others, in which the wings

545. Describe their structure.

546. What variety of colour is found?

are longitudinally folded. It is well for the student to be aware that such exceptions exist in almost every large natural group, however definite its characters may generally be. In none of these instances is there an exception as to more than one or two of the characters; the remainder conform to the usual type. The most universal is that of the metamorphosis, which, being *complete*, distinguishes this order from others approaching it in the structure of the mouth or in the character of the wings.

50.). The *larvæ* are worm-like in their aspect; the head is usually horny, and the rest of the body soft. There is generally a pair of short jointed legs attached to each of the three first segments, representing those of the perfect insect. Those which possess legs are usually active in their habits; but there are others which, leading a re-

Rose-beetle, in its different shapes.

tired life, and being born in the midst of their food (such as the nut weevil), are destitute of legs. The larvæ of the carnivorous species have in general the most robust

legs; and in some of the herbivorous species these are replaced by fleshy prominences, or pro-legs. A pair of these generally exists on the last segment of the abdomen. Previously to undergoing its change, the larva often forms a case for itself of bits of earth or chips of wood, united by silken threads or gluey matter. The *pupa*, or chrysalis, is inactive, sometimes even for years, and takes no nourishment; but the form of the future beetle is plainly perceived, the different parts being encased in distinct sheaths.

510. There is much difficulty in forming a simple natural classification of this immense tribe, on account of the great number of distinct species it includes, and their strong general resemblance to one another. Hence it is often necessary to resort to characters of great minuteness as the groundwork of the system; and it sometimes happens that, by the adoption of such a plan, tribes which are in reality closely allied in general structure, are placed in different groups, and others are brought together which are generally dissimilar. No better system has yet been proposed, however, than that of Latreille, who took as the basis of his classification the number of joints in the *tarsi*, or divisions of the foot. He thus formed the four following sections:—

511. (I.) *PENTAMREA* (or five-parted), in which the tarsi of all the feet are five-jointed, the fourth being of ordinary size.

512. (II.) *HETEROMERA* (or differently parted), in which the four anterior tarsi are five-jointed, and the two posterior four-jointed.

513. (III.) *TETRAMERA* (or four-parted), in which all the tarsi have four distinct joints. It has lately been observed, however, that the fifth joint exists in these, although it is very minute, and concealed in one of the others.

514. (IV.) *TRIMERA* (or three-parted), in which only three ordinary-sized joints exist in the tarsi—a fourth of

548. What is peculiar in the larvæ?

549. What is made the basis of classification?

550. Into what sections are they divided?

small size, however, being also present. Hence these two last sections may be more correctly denominated Pseudo-Tetramera and Pseudo-Trimera.

515. Each of these sections contains several families, of which the most important will now be noticed.

516. Section I. PENTEMARA.—(1.) The first family of this section is composed of beetles exclusively carnivorous, hunting after and devouring other insects, and carnivorous even in the larva state. These *Carnivora* are characterized by the possession of six palpi; and by the termination of the jaws in a sort of claw or hook. Some of them are aquatic; others terrestrial. In many species there are no wings under the elytra. The terrestrial carnivora have legs fit only for running; their body is elongated, and their eyes are prominent. Amongst these may be mentioned the *Cicindelæ*, which have usually a brilliant or even metallic colour, and frequent dry places which are exposed to the sun. They run very quickly, fly off when approached, and alight at a short distance. If again disturbed, they have recourse to the same means of defence. The larvæ burrow in the earth, and lie in ambush in their holes, of which the mouth is exactly stopped by the flat plate on the back of the head. They are extremely voracious; feeding upon other larvæ, of their own kind, if in their neighbourhood. A common English species is the *C. campestris*, a beetle of about half an inch in length, and of an obscure green colour, with five white dots on each of the elytra; this is most abundant in the spring. From their savage propensities this group has received the name of *tiger-beetles*.

517. To this division belongs the tribe of *Carabidæ*, which is of very great extent, above two thousand species having been brought together by a single collector. Their bodies are of very firm consistence, whereby they are enabled to creep under stones, and through fissures, and are also prevented from being injured by the insects they attack. They prowl about on the surface of the ground, under stones, &c., beneath the bark of trees, or in the moss grow-

ing at their roots, in search of their insect prey, which principally consists of the herbivorous species. Some of them are nocturnal in their habits, feeding upon cockchafers and other species of herbivorous beetles that fly abroad by night. The habits of the family are not exclusively carnivorous, however; for some species generally found in corn fields are clearly ascertained to feed upon growing grain. Many larger species of this tribe are provided with a very curious means of defence; being enabled to exhale a very fetid odour, and to discharge from the abdomen, to a considerable distance, an acrid fluid capable of producing considerable irritation. In the *Brachinus* this fluid is so highly volatile that, immediately on coming in contact with the air, it becomes a bluish vapour of very pungent scent, and makes a sort of explosion; hence the species possessed of this power have been termed Bombardier Beetles. They mostly live in societies.

Carabus Clathratus.

518. There is a group of the Carabidæ which has received the name of *Grandipalpi*, from the size of the palpi, and which is remarkable for the brilliant colours of the beetles contained in it. This group contains the genus *Carabus*, of which one of the largest and best characterized species is here figured. Nearly allied to this is the *calosoma*, a beetle of about three-fourths of an inch long, of a velvet black, with the elytra golden green or brilliant copper. Its larva lives in the nests of the processionary caterpillars, upon which it feeds, devouring many in the course of the day; and other larvæ of its own species, smaller and younger, attack and devour it when inactive in consequence of satiety. These larvæ are black; and are sometimes found running upon the ground

552. What varieties of beetles in this family?

553. Name the various species here cited.

or upon trees, especially the oak, the leaves of which are frequented by the caterpillars.

519. The *aquatic* Carnivora form a tribe far less numerous than the terrestrial species, and are characterized by the peculiar modification of the legs, which adapts them for swimming; these members being flattened and fringed with bristles, so as to serve as oars. They pass their larva and perfect states in water; quitting it, however, in order to undergo their metamorphosis into pupæ. The larvæ have the body long and narrow, with a strong head armed with powerful mandibles; and they are of very active carnivorous habits. They breathe by organs adapted for aquatic respiration; but the perfect insect can only breathe air, and it is obliged to come to the surface occasionally for that purpose. The *dytiscus*, the principal

Dytiscus Marginalis—Larva and Imago.

genus of this tribe, is common in fresh and placid waters, such as lakes, pools, or ditches. Its larva feeds upon other aquatic larvæ, such as those of dragon-flies, gnats, &c., and moves quickly through the water, striking it by its expanded tail. The pupæ may be found buried in the adjoining banks. The genus *Gyrinus* includes a smaller race, known in this country by the name of whirligigs, which may be often seen in large numbers on the surface of quiet waters and even on that of the sea, moving with great agility, and describing all kinds of circular or tortuous paths; whence their common name. Sometimes

they remain stationary without the slightest motion; but when approached, they dart beneath the surface, carrying down a bubble of air which appears like a silvery ball attached to the body.

520. (II.) The next family is that of BRACHELYTRA, which possess but four palpi, and are distinguished, as their name imports, by the shortness of the wing-cases. The family consists of only one genus, *Staphylinus*, of which one of the largest species is known by the name of devil's coach-horse, and is frequently to be seen running about garden walks. These insects run and fly with equal agility. They are very voracious, but do not feed upon living prey, deriving their nutriment from dead and decaying animal matters, especially fungi, &c., in which they chiefly reside. They are also found in profusion under heaps of putrescent plants. They all possess the faculty of emitting a powerful odour, which seems to serve as a means of defence; and this is, in some instances, of peculiarly fœtid character. The larvæ feed on the same substances, and frequent the same situations, as the perfect insect. This group leads, in many respects, towards the Earwig tribe, with which the next order commences.

521. (III.) The family SERRICORNES is distinguished by the toothed or serrated form of the antennæ. Like the last, it possesses four palpi; but the elytra completely cover the body. Some of this family, having the body of solid consistence, and oval in form, have the head buried, as it were in the thorax, which advances on its two sides nearly as far as the mouth. In this way are formed the *Buprestis*, distinguished for the splendour of its colours, many of its species having spots of golden hue upon an emerald ground, whilst in others azure glitters upon the gold. These brilliant species belong to tropical climates, which these insects appear especially formed to inhabit, our native species flying with the greatest activity in warm weather. They live among trees; and if an effort be made to seize them, they counterfeit death, and fall to the ground. The beetles belonging to the allied genus *Elater*,

are commonly called skip-jacks; for, when laid on their backs, being unable to raise themselves on account of the shortness of their feet, they spring perpendicularly into the air, so as to alight upon their feet. This is effected by a violent backward blow of the head, against the surface on which they are lying. On looking at the under surface of the body, a long projection backwards of the first segment of the thorax may be observed, which is received into a corresponding hollow of the second segment. It is by this that the violent action just mentioned is guided. These insects are often found upon flowers, and fall to the ground when alarmed, applying the feet to the outside of the body, which has hollows for their reception. The larva of an English species is known to the farmer as the wire-worm, which does much injury by devouring the roots of the corn. A species of elater inhabiting the West Indies and South America has two brilliantly luminous spots upon the front of the thorax; and a portion of its abdomen, which is uncovered during flight, is also illuminated.

522. Another interesting genus of this family is the *Lampyrus*, to which belong the glow-worm of this country, and some of the fire-flies of warmer regions. The body of these insects is very soft, especially the abdomen; and it is from the two or three last segments of this part of the body that the phosphorescent light, for which they are so remarkable, is emitted. Its intensity is evidently dependent in a great degree upon the state of the animal: if the insect be irritated, it is increased; but if its powers are depressed or exhausted, it is lessened. It seems to be sometimes withdrawn simply at the will of the animal. In the glow-worm (*L. noctiluca*) it is only the female that is luminous; and she is destitute of wings and elytra, which the male possesses. They are only active by night; and as the male is known to be attracted, like moths, by lights in houses, it is probable that the phosphorescence of the female is given for the purpose of signalizing her position to him. In most of the tropical

species, both sexes are furnished with wings. In another genus of this family, the *anobium*, a different mode of communication between the sexes exists. The insects belonging to it burrow in the wood of the interior of houses, to which they do much injury, and they signalize their presence to each other by beating with their jaws on the wood-work on which they are stationed. This sound, resembling the quickened ticking of a watch, has received the superstitious name of *Death-watch*. One species is peculiarly remarkable for the pertinacity with which it feigns death, preferring to be consumed by a slow fire, rather than give any sign of life.

523. (iv.) The next family of Pentamerous Coleoptera is that of CLAVICORNES, characterized by the club-shaped form of the extremities of the antennæ. These are partly terrestrial and partly aquatic; they feed for the most part on animal matter, at least in the larva state. The terrestrial ones seem to prefer substances which are in a state of decay; they creep slowly, and are mostly of a dark colour, black or bronzed. One of the most interesting genera is the *necrophorus*, or burying beetle, so named from its habit of excavating the ground beneath the dead bodies of small quadrupeds, such as mice or moles. When they have interred the carcass, they deposit their eggs in it, and the larvæ, when hatched, feed upon the flesh. Another genus, *Silpha*, resides in and feeds upon carcasses, and thus diminishes the quantity of obnoxious vapour which they emit. They also feed upon small snails and caterpillars; to pursue which, the larvæ, as well as the perfect insects, climb trees and plants. Some other allied genera derive their chief food from decaying vegetable matter, but seems to prefer the fungi, which most nearly approach animal tissues in chemical constitution. The aquatic tribes of this family approach the next in their general characters.

524. (v.) The PALPICORNES also possess antennæ with

557. What of the luminous varieties?

558. How do they make themselves audible?

559. What of the habits of the fourth family?

560. Describe the burying-beetle?

a club-like termination; but these are never longer, and usually shorter, than one of the pairs of palpi. Nearly all of these are aquatic, and have their legs formed for swimming. The most remarkable genus is the *hydrophilus*, of which a large species, *H. piceus*, an inch and a half long, oval, of a brown black colour, and highly polished, is common in the ponds and ditches of this country. It swims and flies well, but walks badly. The eggs are laid in a sort of cocoon, spun by the female, and coated with a gummy matter which is impervious to the water on which it floats. The larvæ, which have a worm-like body, with six feet, the head armed with strong mandibles, are very voracious, feeding upon tadpoles and the young fry in fish-ponds, and upon small fresh-water mollusca. When the growth of the larva is terminated, it quits the water, and excavates a sort of burrow in which its metamorphosis into the pupa state takes place; and it remains in this even after it has arrived at the perfect condition. The perfect insect feeds upon little but decomposing vegetable matter; and the intestinal canal undergoes very important changes during the metamorphosis. Other species of this family are terrestrial, though many of these frequent the margins of water, inhabiting and feeding upon cow-dung and other excrementitious matter.

525. (VI.) The last family of the Pentamerous section, the LAMELLICORNES, is of very great extent, and one of the most striking of the whole Beetle tribe, in respect to the size of the body, and the variety in the form of the head and thorax in the different sexes; and often, also, in those species which, in their perfect state, live upon vegetable substances, in respect to the brilliancy of the metallic colours with which they are ornamented. But the majority of the other species which subsist on decomposing vegetable matter, are of a uniform brown or black colour, though some are not inferior in brilliancy to the preceding. All have wings, and they crawl but slowly along the ground. None of them are aquatic. The larvæ have a long soft body, with a scaly head and strong jaws,

and six feet. The back is arched, and not capable of being extended in a straight line; so that these grubs, of which that of the common cockchafer affords a good example, walk but badly on a smooth surface, tumbling over at every step. Some species do not change to pupæ until they have passed three or four years as larvæ. They form for themselves a sort of oval casing, in their retreats, with earth or the debris of the materials they have gnawed, of which the particles are united together by a glutinous secretion. Their food consists of dung, manure, tan, and particularly (in some species) of the roots of vegetables; whence these insects, especially in their larva state, often occasion great loss to the cultivator. This family receives its name from the peculiar conformation of the antennæ, which terminate in a mass formed of the three last joints; these are flattened into plates or lamella; and sometimes arranged like a fan or the leaves of a book, sometimes in the manner of a comb, and sometimes enclosing each other. The family is distributed into two principal sections, the *Scarabæi* and the *Lucani*.

526. Of the *Scarabæi*, one subdivision, including the sacred beetle of the Egyptians, feed principally upon the excrements of various animals; and they enclose their eggs in balls of the same (whence they have been called *Pilularii*), which they roll along with their hind feet (several often being in company), until they reach the hole in which they are to be deposited. To this group also belongs the *geotrupes stercorarius*, the common dor or shardborne beetle, which is one of the commonest British insects. A most remarkably-formed species is the *dynas-*

Ateuchus (Scarabæus)
Ægyptiorum.

562. How is the sixth family characterized?

563. What of their various habits?

564. Name the varieties of this family.

tes hercules, a native of Brazil, which attains the length of five inches, and of which the male possesses an enormous horn, projecting from the head, which is opposed by a corresponding protuberance from the thorax. To this group also belongs the *melolontha vulgaris*, or common cockchafer, which is most destructive to vegetation both in its larva and perfect condition; feeding on the roots in the one case, and on the leaves and young shoots in the other. The larva lives for three or four years beneath the ground, becoming lethargic in winter, but actively voracious in summer. Their excessive multiplication is usually pre-

Dynastes Hercules.

vented by birds; but if these be kept away, they increase very rapidly, and become a complete pest to the cultivator. The perfect insect sometimes makes its appearance in such swarms as to devastate an entire forest. The *goliath* beetle may also be mentioned as belonging to the same group. This genus is composed of large and splendid species, principally from Africa and the East Indies.

527. The *Lucani*, or *Stag-Beetles*, derive their common name from the peculiar form of their mandibles, which are very large, curved, and toothed, like stag-horns. The *L. cerves* is one of the largest British insects, the males being two inches or more in length. This species flies about in the evening in the middle of the summer, especially round the oaks, upon the wood of which the larva feeds, remaining in that state for several years before undergoing its final transformation. Some of the

exotic species of this group are very large and splendidly coloured.

528. Section II. HETEROMERA.—The Coleoptera of the second section entirely feed on vegetable substances; they are all terrestrial, and most of them frequent dark places. In the first family, the *MELASOMA*, the body is of an ashy brown or black colour; and, for the most part, the wings are absent, the elytra being united along the suture. They almost invariably live in the ground, beneath stones, or in the sand; often, also, in low and dark parts of buildings, such as cellars, stables, &c.

Blaps mortisaga.

This tribe of insects is very tenacious of life; individuals have been known to remain alive for six months without food, and stuck on a pin. To this family belong the *blaps mortisaga*, a beetle often found in dark and dirty places about houses; and the *tenebrio molitor*, of which the larva is known under the name of the meal-worm, living in corn and flour; and the perfect insect frequents bake-houses, corn-mills, &c., where it may often be found in the evening.

529. The next family, the *Taxicornes*, requires but little notice, being a small and comparatively unimportant one. It differs from the last principally in the presence of wings, and is remarkable for the square shape of the body; the antennæ are short, and thickened towards their extremities. The majority of these beetles are found in fungi growing on trees, or beneath the bark; others live in the ground under stones.

530. The insects of the next family, the *Stenelytra*, have antennæ destitute of the thickened tip which characterizes the last; they are also more active in their habits. Some are found under the bark of old trees; but many frequent the leaves and flowers.

531. In the family *Trachelides*, the head is triangular

566. What of the first family in the second section?

567. What other families are named?

or heart-shaped, and carried on a kind of neck, which separates it from the thorax. The body is soft, the elytra being flexible, and sometimes very short. The majority live in the perfect state upon different vegetables, devouring the leaves, or sucking the honey of the flowers. Many, when seized, depress the head and contract the feet, as if they were dead. Their colours are often very brilliant. This is well seen in the *cantharis vesicatoria*, or blistering-fly, which is of a shining green metallic hue; this insect is most abundant in Spain, but appears about midsummer in France and is found most frequently on the ash and lilac, of which it consumes the leaves. Its larvæ lives in the earth, and feeds upon the roots of vegetables. The *Meloe* is an allied genus, in which the wings are wanting. It also possesses blistering properties, and is commonly mixed with the cantharides in Spain. In several genera of this family the eggs are laid, and the larvæ produced, in the nest of wild-bees; and the grubs subsist upon the store of nourishment laid up by these, which they consequently often starve.

532. Section III. TETRAMERA.—All the insects of this section are likewise vegetable-feeders. The perfect insect is found upon the flowers and leaves of plants; the larvæ are often produced in their interior; and, when thus hatched in the midst of their food, their legs are commonly very imperfect. Very often the true legs are almost entirely absent, and their place supplied by fleshy tubercles. The first family, that of RHYNCHOPHORÆ, or the *Weevil* tribe, is distinguished by the prolongation of the anterior part of the head into a kind of muzzle. Their larvæ have an oblong body, like a soft white worm; many live entirely enclosed in fruits or seeds, making their way out only when they have devoured the whole interior, or have arrived at their perfect condition. The egg of the common nut weevil, for example, is deposited in the fruit when immature; and by the time the latter has ripened, the egg is hatched. The larva grows within it; and, in autumn, when the nut has fallen

to the ground, it bores a hole with its jaws through the shell, and makes its way out through this aperture ; it then descends into the ground, and passes the winter in its pupa condition. The number of species in this family is very great ; nearly 4000 have been reckoned. Many of them are extremely destructive ; especially the *calandra granaria*, or corn-weevil, which commits great havoc in granaries. To this tribe belongs one of the most splendid of all beetles, the *curculio imperialis*, well known as the diamond beetle, a native of South America, in some parts of which it abounds. There are small species belonging to our own climate which are scarcely less brilliant when magnified in a good light.

533. The second family of the Tetramerous Coleoptera has received the name of XYLOPHAGI (Wood-eaters) on account of the peculiar habits of the beetles composing it. They usually live in wood, which their larvæ pierce in every direction : and when abundant in forests, especially those of pines and firs, they destroy the trees in a few years, and sometimes in enormous numbers. They are destitute of the prolonged muzzle of the last order, and have short antennæ, thickened towards the tips. One of the most important species is the *bostrichus typographus*, so named from the figure of its burrows, which has at different times ravaged the forests of Germany. It devours the soft wood beneath the bark, which is most essential to the vegetative processes, both in the larva and perfect states ; and thus causes the death of the tree. It was reckoned that a million and a half of pines were killed by this species alone in the Hartz Forest in 1783 ; and that as many as 80,000 insects were ordinarily engaged in the destruction of each tree.

534. The beetles of the family *Longicornes* are distinguished by the great development of the antennæ, which are always at least as long as the body, and often longer. The larvæ mostly reside in the interior of trees or under the bark, and are destitute of feet, or have them

569. Name their peculiarities and species.

570. What of the second family in this section ?

very small. They are furnished with robust mandibles, and do much injury to trees, especially those of large size, by burrowing deeply into them. They are vegetable-feeders in their perfect state also, and do great injury to plants, some attacking the leaves, and others the roots. Many of them produce a slight creaking sound, by the friction of the joint which unites the thorax to the abdomen. Many of these are brilliantly coloured, especially the tropical species. Some of them are remarkable for exhaling an agreeable musky odour. This is the case with an English species, the *callichroma moschata*, which is about an inch long, entirely green or shaded with blue,

Callichroma Moschata.

and is very common upon willows. Others are remarkable for the curious spines which project from the body, as shown in the figure. Some species are destitute of wings.

535. The insects of the next family, EUPODA, have a strong general resemblance to those of the last. They are distinguished, however, by the thickening of the hind legs. These beetles are usually of small or but moderate size, and in general are brightly coloured. They are found, both in their larva and perfect states, on plants and shrubs, upon the leaves and tender portions of which they feed :

571. Describe the different species.

572. What variety is presented in the diagram ?

and as some species are prone to great multiplication, they occasionally do much injury to the farmer and horticulturist. Some of them especially frequent water-plants. To this group belongs the *oriocerus asparagi*, or asparagus beetle, which occasionally does great damage to the cultivators of that vegetable.

536. Nearly allied to these are the beetles of the family of *CYCLICA*, so termed from the rounded form of their bodies. Like the last, they feed upon vegetables both in the larva and perfect condition. The larvæ are furnished with six feet, and, as well as the pupæ, are often coloured. These beetles are of small size, often ornamented with metallic and brilliant colours; they are generally slow in their motions, timid, and fall to the ground when apprehensive of being seized. Many species leap well. The habits of the larvæ are often very remarkable. Some cover themselves with their own excrement, as a sort of protection. Others live in tubes, which they carry about with them. Others, again, have no protection; living in the interior of leaves, and feeding on their soft tissue. The *Cassidorixæ*, or Helmet-Beetles, are so named from the thorax being prolonged forwards, so as to cover the head. Some of the foreign species are of the most singular forms, and their colours are generally diversified agreeably. Some bear so strong an analogy in general form to the Tortoise tribe, that they have received the name of Tortoise Beetles. The *Chrysomelidæ*, or Golden Beetles, are often ornamented with colours as brilliant as any of the order; amongst these, blue, green and gold, are pre-eminently conspicuous. Their motions are very slow, but they hold firmly on the leaves upon which they reside. To this group belongs the genus *Timarcha*, which contains the largest vegetable-feeding beetles found in this country, and in which the wings are absent. These insects are known by the name of bloody-nose beetles, from their habit of emitting a reddish fluid from their mouths and joints of the legs when alarmed. The larvæ are found amidst moss and low herbage; they are thick, fleshy, and

wrinkled, of a greenish black colour; and, when alarmed, they roll themselves up, somewhat in the manner of a wood-louse. They pass the pupa state beneath the ground. The *Galerucidæ* are of usually much more obscure colours than the *Chrysomelidæ*, but are, like them, herbivorous in both states. To this group belongs the genus *Halitica*, of which several species make very destructive attacks upon turnips, devouring the leaves as soon as they come above ground. The larvæ seem to devour the soft interior tissue of the leaves, and undergo their transformations in that situation. Another species has attacked the vines of the south of France, and done such great damage to them, that in the year 1837 religious processions were instituted for the purpose of exorcising the insects.

537. The Tetramerous Coleoptera contain another family denominated CLAVIPALPI, so named from the thickening of the last joint of the palpi. The species included in it are not numerous, and are of small size; they are principally found in fungi growing on the trunks of trees, beneath the bark, &c.

538. Section IV. TRIMERA.—The beetles of this last section are mostly of small size; and they are not very common. Their habits are various; a portion feeding upon fungi, and the remainder chiefly upon aphides. To the latter section belongs the genus *Coccinella*, of which several species are known in this country under the name of lady-birds, or lady-cows. They sometimes appear in great profusion, and have created much alarm. It is erroneous to suppose, however, that they do any injury to vegetation; for, on the contrary, they are of great benefit to plants by feeding on the aphides which infest them, and this they do both in the larva and perfect states.

Order II.—Orthoptera.

539. The order Orthoptera comprehends all insects that have the mouth armed with jaws fitted for mastication, and two pairs of wings; of which the anterior encase the

574. Name the different species and their peculiarities.

575. What of the fourth section and its characteristics?

others, the posterior being membranous, and folding longitudinally during repose. In many respects they resemble the Coleoptera; and they are closely connected with that order by the FORFICULIDÆ, or *Earwig* tribe, which partake of the characters of both. But they differ from the beetles in the softer covering of their bodies; in the partially membranous character of the anterior pair of wings, which seem intermediate between the horny elytra of beetles, and the membranous wings of other insects, and which do not meet along the back when closed; and in the fan-like manner in which the posterior wings are folded up beneath them, which is permitted by the straight direction of their veins. They differ also in their metamorphosis; for, whilst that of the beetles is complete, that of the Orthoptera is only partially so; for the larva and pupa closely resemble the perfect insect in form, walking and feeding in the same manner, and differing in but little else than the absence of the wings and wing-covers, which are gradually developed in the latter.

540. This order comprises numerous well-known insects, often of large size and splendid colours; such as grasshoppers, locusts, walking leaves, as well as cockroaches and earwigs. Some of the largest of known insects belong to it; a few species attaining a length of eight or nine inches, and an equal expansion of wings. Comparatively few of this order are inhabitants of temperate regions; it attains by far its greatest development, both in number, size, and colour, between the tropics. All the known Orthoptera are terrestrial, both in their perfect and two previous states. Some are purely carnivorous, and others are adapted to a mixed diet—the cockroaches, for example, being capable of feeding on almost any organized matter, whilst the great majority feed upon plants. Hence, from their large size, and the quantity which each individual can devour, they are among the most destructive of all the insect tribes, when they appear in large numbers. This is particularly the case with the locusts in warm

576. How is the next order described?

577. What various species belong to it?

countries, the ravages of which not unfrequently cause famine and pestilence, both among men and beasts.

541. The Orthoptera are divided into two principal families. In the first, that of CURSORIA, the legs are all alike, and adapted for running. They have generally the wing-covers and wings resting horizontally on the body. In the second, the *Saltatoria*, the thighs of the hind legs are much larger than the rest, by which they obtain great powers of leaping. In some of these, the wings meet at an angle when folded, like the two sides of a roof. The males have the power of making a sharp creaking noise, which is very loud in some species.

542. (1.) The CURSORIA contain three well-known forms—the *earwig*, *cockroach*, and *mantis*. Of these, the first approaches more closely than the rest to the Coleoptera, for the wing-covers are of firm consistence, and they meet when closed, along the whole of the back. In some species, too, the wings are folded transversely instead of longitudinally. They have a peculiar character of their own, however, in the forceps with which the posterior part of the body is provided; these are used as weapons of offence and defence. These insects frequent dark and damp situations; they do much injury to the flowers and fruits of our gardens, and sometimes multiply to such an extent as to destroy them; they also devour the dead bodies of their own species. The popular notion of their creeping into the ear is quite unfounded. The *Blattæ*, or Cockroaches, are intermediate between them and other Orthoptera. These well-known insects are now pretty generally diffused over temperate climates, although most of the species are believed to have been originally natives of tropical regions. Their wings are small in proportion to the weight of their bodies; and in cold climates are seldom enough developed to lift them from the ground. The females are generally almost destitute of these organs.

543. The MANTIDÆ are purely carnivorous insects, of

578. How are they divided and subdivided?

579. Describe the several species.

which none are natives of this country. They differ much from the *Blattæ* in the form of the body, which, instead of being flattened and oval, is narrow and elongated. The first pair of legs is enormously enlarged, and forms a very powerful organ of attack. They frequent trees and plants; and the forms and colours of their wings and bodies are often so adapted to those of the leaves and twigs which surround them, as to give them remarkable power of eluding observation: hence, these have been called walking-leaves. One species, the *mantis religiosa*, is regarded by the natives of the countries it inhabits with

Mantis Religiosa.

superstitious reverence, on account of its occasionally assuming the attitude of prayer. This is, however, the position in which it lies in wait for its prey; the front of the thorax being elevated, and the two fore-legs held up together like a pair of arms, prepared to seize any animal that may fall within their reach. They are extremely voracious insects, and if kept together without food, will fight, the victor devouring its conquered adversary. Allied to the mantis is a very singular genus, the *Phasma*, of which the different species have received the names of walking-

stick, spectre insects, &c. Their bodies are extremely prolonged, and rounded; and in their colour they much resemble dried sticks, previously to the development of the wings, which are usually green and leaf-like. The legs are all equal, so that they are distinguished from the Mantidæ on one hand, and from the Saltatoria on the other. But they are not able to move rapidly either in the larva or perfect state; and their want of activity is compensated by their powers of concealment. They are mostly, if not entirely, vegetable feeders.

544. (II.) The family SALTATORIA consists of numerous species allied to the well-known *crickets*, *grasshoppers*, *locusts*, &c. Besides the peculiarities already mentioned, they are remarkable for the deposition of their eggs in the ground, which is generally accomplished by means of a long horny ovipositor. The mode in which the sound is produced varies in different species. In the locusts it is caused by the friction of the posterior thighs, like the bow of a violin, against the wing-covers. In others, it is occasioned by the friction of two talc-like spots, on the inner sides of the wing-covers, against each other.

545. The first division of the Saltatoria, termed *Achetidæ*, includes the species known as *Crickets*. These are essentially inhabitants of the ground, in which many of them burrow; few have any power of active flight. The greater number of them, like the common house-cricket, are nocturnal. One of the most remarkable species is the *grylloptalpa vulgaris*, or mole-cricket, which derives its name from the analogy it presents, both in structure and habits, to the common mole. Its fore-legs are rather short, but remarkably strong and broad; and by means of these, the larva (which resembles the perfect insect except in the want of wings) burrows under ground, raising a ridge as it proceeds, but seldom throwing up hillocks. In its progress it does great injury by cutting or detaching the roots of plants. It has been stated that it does this only to get

581. What species are included in the next family?

582. What of crickets and their variety?

at the worms and insects among them, but there is no doubt that it actually devours the vegetable substances which comes in its way. A species of mole-cricket, inhabiting the West Indies, is thus extremely injurious to the plantations of young sugar-canes.

546. The next subdivision of the Saltatoria, the *Gryllidæ*, is distinguished by the roof-like position of the wing-covers, when they are closed; they also possess very long thread-like antennæ. The group contains the *Grasshoppers* and their allies, which, although bearing a general resemblance to locusts, differ from them in the inferior robustness of the body, and the delicacy and slenderness of the appendages. These insects are entirely herbivorous, and are formed to exist upon the plants and trees from which they derive their support. They do not assemble in swarms, like the locusts, and consequently do not become such formidable enemies. They will attack and devour each other, however, if confined together; and one which had accidentally jerked off its leg has been known to eat it, when enclosed with it in a box. The great green grasshopper, found in Britain, is one of our largest native insects, being about two inches long, and measuring three inches and a half across its wings. Some species of large size, inhabiting the south of Europe and Africa, are remarkable for the total absence of wings; and some of these are most hideous-looking insects.

547. The last section consists of the various species of migratory locusts forming the tribe *Locustidæ*. These are formed for a more active life than the preceding, being able to leap much farther, and to sustain a longer flight. Their powers of devastation, also, are enormous; for they are produced in vast numbers, and live in societies, so as speedily to destroy the vegetation of the spot on which they have settled. Thence they take their flight in great swarms to adjoining districts; and so great is the number of which these swarms consist, that it is not speaking figuratively to say that the sky is darkened by their passage.

583. Describe the structure and habits of Grasshoppers.

584. What of the Locust tribes?

Even their destruction, which is sometimes the result of starvation, and is sometimes effected by tempests, is a fresh source of danger, the air being filled for miles with the effluvia of their putrefying carcasses. Several species of them exist, of which some have occasionally visited Britain, and done much damage; but it is in warmer climates that they most abound.

548. In various parts of Africa and Asia, the inhabitants use locusts as food, pulling off their wings and legs, and frying them in butter or oil, or drying them in a mass. Hence it is not necessary to resort to the supposition, which some have entertained, that the food of John the Baptist was derived from the locust-tree. The species which regularly inhabit Britain are small, and are commonly known as grasshoppers. These, however, bear more resemblance to locusts than to the large green grasshopper already mentioned.

Order III.—Neuroptera.

549. The Neuroptera resemble the Coleoptera and Orthoptera in the structure of the mouth, but differ from them in the conformation of the wings. The anterior, as well as the posterior pair, are here membranous and transparent. In both, the veins form a very beautiful and minute network, subdividing and uniting again, so as to divide the whole surface into a large number of cells, which very much exceed in number those of the wings of any other tribe of insects. The posterior wings are usually as large as the superior, or sometimes even larger; if narrower, they are generally longer. The order is one of comparatively small extent, being far inferior in the number of species to many others; but the varieties of structure it presents are very considerable, and are often very perplexing to those who seek to form a natural arrangement of the different groups. There is also a great dissimilarity in their habits and economy; the majority, however, are carnivorous. In their larva state, their abodes are very

585. What of their being used as food?

586. How is the third order described?

diversified ; some residing in water, some in damp earth, and others living exposed upon plants.

550. The body of the insects of this tribe, which contains the well-known *Dragon-flies*, *May-flies*, *Ant-lions*, and *White Ants*, or *Termites*, is generally prolonged, and destitute of any very hard integument. They are of intermediate size, none exceeding in dimensions the largest dragon-flies of this country, and none exhibiting the minuteness of some Hymenoptera and Coleoptera. They differ in the character of their metamorphosis, as well as in their adult structure ; for in some the metamorphosis is complete, the larvæ undergoing a marked change of form ; in others there is not much difference, except in the absence of wings, between the larvæ and the perfect insect. By these differences, the order may be subdivided into two groups, in the first of which the pupa is active, whilst in the second it is quiescent, except just before the assumption of the perfect state. The first of these groups may be further divided into those which have terrestrial larvæ, such as the TERMITIDÆ, and those which are aquatic in their preparatory states, such as the LIBELLULIDÆ, or Dragon-flies, and the EPHEMERÆ, or Day-flies. These pass the first two stages of their lives in water, respiring by means of peculiar organs placed at the sides or extremity of the abdomen. In other respects, their larvæ and pupæ nearly resemble the perfect insect. They creep out of the water to undergo the final metamorphosis.

551. (1.) The LIBELLULIDÆ are well-known insects ; being easily distinguished by the slender form of their bodies, their varied colours, their large gauze-like wings, and the rapidity of flight with which they pursue other insects upon which they feed. They have a large head of rounded form, furnished at its sides with two very large eyes. The eggs are deposited upon aquatic plants, and the larvæ are produced in water. The head, in the early state, is remarkable for the singular form of the piece

587. What various species are here named ?

588. Name the peculiarities of the first family.

which occupies the lower lip, covering all the under side of the head like a mask; and this is furnished with a pair of long claws, which serve as pincers for seizing the prey. The breathing apparatus of the larva is partly situated within the posterior extremity of the intestine; and into this cavity the animal draws water, which it expels again with a sudden jerk, that drives it forward. When arrived at the period of their final change, the pupæ quit the water, crawl up some adjacent stem, where they fix themselves by their claws and throw off their skin. At first, however, the wings are soft and moist; and it is not until they are dry that the insect can maintain itself in the air by their means.

552. (II.) The EPHEMERIDÆ derive their name from the short duration of their lives in the perfect state. In the larva condition they exist for two or three years; in this

Ephemera Vulgata—Larva, Pupa, and Imago.

and the pupa state they reside in the water, burrowing in the banks. In this condition, the abdomen is furnished on each side with a row of plates, which appear to serve as gills for respiration, and also to act as paddles. The pupa differs from the larva in possessing rudiments of wings, which are covered over with scales. At the moment of their last change they quit the water, and appear, after casting their skin, in a new form; but, by a singular

589. What family are exhibited in the diagram?

exception to what is elsewhere observed, they have to undergo another moult before they are fit for propagation. They generally appear at sunset in the fine days of summer and autumn, along the margin of the streams, &c., in which they have been developed. They take no food after their final change; and as the propagation of the race is then their only object, they die almost as soon as it has been performed, often in a few hours after their exit from the water. Sometimes they come forth in such numbers that the ground is covered by their bodies when they die, to such a thickness as to make it worth while to cart them away as manure. Those which fall into the water are greedily seized by fishes; and fishermen give them the name of manna. The swarms of one species with white wings have been so abundant as to resemble a fall of snow.

553. (III.) The TERMITIDÆ, or White Ants, are terrestrial, active, carnivorous or omnivorous, in all their stages. In several points of their structure they approach the Orthoptera; whilst in their habit of living in societies they resemble the Hymenoptera. Unlike the social tribes among the former, however, the neuters or sexless individuals in these communities officiate only as soldiers; and those which are here denominated workers are in reality the larvæ, which closely resemble the perfect insect, except in the absence of wings. These insects commit the most extraordinary ravages, the numbers in each colony being almost incalculable, and their voracity extreme. Their nests are sometimes concealed below the surface of the earth, or in the interior of trees, timbers, &c.; and through these they bore galleries in such a manner that though the outer surface is left untouched, they fall to pieces on the slightest violence. Sometimes the nests are elevated to several feet above the surface of the ground, and have a pyramidal roof. When arrived at their perfect state, the termites quit their habitation, and fly abroad during the evening or night in great numbers; they lose their wings before the

590. What of their habits and structure?

591. How is the third family described?

morning, and some of them falling to the ground, become the prey of birds, reptiles, &c. The females, however, are sought by the workers, who imprison them in royal chambers (as they have been termed) in the centre of the nest. Their abdomen subsequently attains an enormous

Queen in the winged state, and when filled with eggs.

size, from the quantity of eggs it contains; and these, when laid, are carefully tended by the workers and defended by the soldiers. Some small species inhabit the south of France, living in trees; but it is only in tropical climates that their extraordinary economy excites attention.

554. (iv.) Of the division of Neuroptera, in which a more complete metamorphosis occurs, the family of MYRMELEONIDÆ is one of the most remarkable. Their larvæ have received from their peculiar habits the name of *ant-lions*; the perfect insects are large and handsome. None of them are natives of this country, though one species is common on the continent of Europe; and it is in tropical climates that they attain their greatest size and brilliancy, vying with the dragon-flies in the delicate reticulation and beautiful colours of their wings. The larvæ excavate conical pit-falls in fine sand, and bury themselves at the bottom, their long mandibles only appearing above the surface; and by these any luckless insect that happens to

592. What is said of their nests?

593. Describe the diagram on this page.

fall down the hole is immediately seized and killed. The larva sucks the juices of its victim, and then throws the dry carcass by a sudden jerk, out of its hollow. If the insect chances to escape the murderous jaws of its enemy, the latter immediately commences throwing up the sand, by which the hole is at the same time made deeper and its sides steeper; and at the same time the escaping insect is struck by the shower, and made to roll down into the trap.

555. (v.) The *HEMEROBIIDÆ* have a considerable resemblance to the last family, but are mostly known by the brilliantly golden colour of the eyes. The larvæ do not construct traps to obtain their prey by stratagem, but wander about in search of it like lions. They feed chiefly upon Aphides, which they seize with their mandibles; and they then, within half a minute, suck the juices of their victim. In default of other prey, they will even attack and devour one another. Some of these larvæ cover themselves with the carcasses of their victims, in such a manner as to render their own bodies almost invisible.

556. The remaining families of this order need not be here particularized, as they contain but comparatively few species, and these little known.

Order IV.—Hymenoptera.

557. In the membranous character of their four wings, the insects of this order resemble the Neuroptera; but they cannot well be mistaken for them. The anterior wings are usually much larger than the posterior; the veins or nervures are much fewer in number than in the Neuroptera, and do not form a close network by their ramifications, as in that order. In some of the minute species the wings are almost, or even entirely, destitute of nerves. Another character, furnished by the wings, consists in the connection of the anterior and posterior during flight, by

594. What of the family of Ant-lions?

595. Describe the fifth family.

596. What is peculiar in the fourth order?

means of a series of minute hooks along the front edge of the latter, which catch the hinder margin of the former, so as to produce one continuous margin on each side.

558. The principal character of this order, however, is derived from the structure of the mouth; for, although considered as mandibulate insects, the Hymenoptera are much better fitted for imbibing their nourishment by suction, than for obtaining it by mastication; their maxillæ being much prolonged and channelled, and even uniting at their base into a tube, so as to form a kind of proboscis. This is well seen in the bee. The Hymenoptera are also peculiarly distinguished by a prolongation of the last segment of the body in the females, into an organ which is in one division of the order a *sting*, and in the other an *ovipositor*, or instrument for depositing the eggs, usually possessing the power of boring a hollow for their reception.

559. The Hymenoptera are further remarkable for the great development of their instinctive faculties, and of their locomotive powers. It is in this order that we find the most remarkable examples of contrivance and skilful adaptation of means to ends; but this adaptation results, it would appear, not from an exercise of *intelligence* on the part of the animals themselves (as in man and the higher vertebrata), but from their blindly following out a plan laid down for them by the Almighty Designer. This inference may be deduced from the *invariability* of the operations performed by different individuals among the same species, so that a history of the life of one is equally applicable to all. The adjustment of instinctive actions to each other is nowhere more remarkable than in the case of the *social* insects, which are chiefly restricted to this order. The bees, the wasps, the ants, the saw-flies, the ichneumons, the gall-flies, have attracted the attention of the observer of nature from the earliest period.

597. What is said of their females?

598. What of their intelligence, and how shown?

560. The insects of this order undergo a complete metamorphosis, the larvæ being amongst the most imperfect of those of any tribe. In the great proportion of the order they are destitute of feet, and resemble little worms. These are dependent upon the instinctive care of the parent for support; which is either provided for by the deposition of the eggs in situations where the future grub will be certain of an ample supply of food, or by the active exertions of the parents, which convey to the young the food they have themselves collected for them, or by similar exertions on the part of a race destitute of peculiar sex (hence termed *neuters*), on whom this charge more especially devolves. When arrived at their full growth, and after undergoing several previous moultings, the larvæ are transformed into inactive pupæ, in which all the limbs of the future insect are visible, encased in distinct sheaths, and folded on the under surface of the thorax. During this part of their existence they take no food. In their perfect state, these insects for the most part take but little nourishment; and this almost exclusively consists of the nectar of flowers. Many of them however, such as the wasps, attack and destroy other insects; but these are often destined, not for their own support, but for the nourishment of the young. This order is of considerable extent, being inferior only to the Coleoptera; and it has been estimated as containing one-fourth of the whole insect population. It attains its greatest development in warm climates; for of the numerous species inhabiting this country, the greater part are of very small size. None of the species, however, attain any great dimensions; very few exceeding or attaining two inches in length, or three in the expansion of the wings. The duration of their lives, from the hatching of the egg to the final change, is believed never to exceed a year.

561. This order may be primarily divided into two sections, the TEREBRANTIA, in which the female is furnished with a saw or borer for the deposition of the eggs; and the ACULEATA, in which the abdomen of the females

(and neuters) is armed with a sting connected with a poison reservoir. In the former, the antennæ vary considerably in the number of their joints; in the latter, there are always twelve in the female, and thirteen in the male. The Trebrantia may again be divided into the PHYTIPHAGA, in which the larvæ feed upon vegetable matter; and the ENTOMOPHAGA, in which they (in general) feed parasitically upon living insects. The Aculeata are in like manner divided into the PRÆDONES, or predacious tribes, which do not collect pollen, and in which the larvæ feed upon other insects stored up for them, or upon fluids provided by the neuters; and the MELLIFERA, in which the larvæ feed upon honey or pollen paste stored up for them. The adult forms of all these are distinguished by certain technical peculiarities, which it would be tedious here to specify.

562. Section I. TEREBRANTIA.—(I.) The principal family of the Phytophagous Terebrantia is that of TENTHREDINIDÆ, or *Saw-Flies*, so named from the saw-like character and action of the ovipositor. With this instrument, they make a succession of small holes in the branches or other parts of trees, in each of which an egg and a drop of frothy fluid are discharged, the latter of which closes the hole. The larvæ greatly resemble the caterpillars of Lepidoptera, but have either only six feet, or from eighteen to twenty-two; they are thus distinguished from caterpillars, which have from ten to sixteen feet. Some of them live within the wood in which they have been deposited, and a sort of *gall*, or swelling, is then formed, by a process resembling inflammation, in the surrounding parts of the vegetable; from this the perfect insect eats its way out by a circular aperture. In general, however, the larvæ soon come forth from the aperture in which they were deposited; and feed upon the neighbouring leaves. In order to undergo their change, they spin, either on the earth, or on the plants upon which they feed, a cocoon, in which they remain unchanged for many months, changing to pupæ only a few days before they become perfect saw-flies

The structure of the mouth in this family approaches more to the general type of that of mandibulate insects than in any other Hymenoptera.

563. (II.) The family of CYNIPIDÆ, or *Gall-flies*, placed on account of its structure in the Entomophagous division of the Terebrantia, is nearly allied in habits to some among the last group. The ovipositor does not seem capable of boring a hole by itself, but, being armed with teeth at its extremity, it can enlarge slits already existing,

Pimpla Manifestor engaged in oviposition.

for the deposition of its eggs. The fluid accumulating in the wounded parts forms excrescences or tumours, which are commonly termed *galls*, *nut-galls*, or *gall-apples*. Their form and solidity vary according to the parts of the plants which have been attacked, and the species of the insect, of which each is restricted to a particular kind of plant. The eggs enclosed in these galls are sometimes single, and sometimes very numerous; as many as 1100 have been obtained from a single oak-gall. They devour the interior without stopping its growth; and remain five or six months in that state. They at last make their escape, in some species before, and in others after, the me-

tamorphosis, by perforating it with a small round hole. The hard galls formed on a particular species of oak, and by a particular species of *Cynips* inhabiting the Levant, constitute one of the principal ingredients in the manufacture of writing-ink, owing to the quantity they contain of a particular acid, which forms a blackish-blue compound with iron. An insect of this family deposits its eggs in the seeds of the most forward wild figs in the Levant; and the fig cultivators take advantage of this circumstance by hanging some of these figs among the later ones, so that the insects which escape from the former covered with pollen may fertilize the flowers contained in the latter.

564. (III.) The family of *ICHNEUMONIDÆ* may be regarded as peculiarly characteristic of the Entomophagous division. The female deposits her eggs, by means of her sharp-pointed ovipositor, only in the bodies of other insects, chiefly the larvæ of caterpillars, on which the young may feed when hatched. Some of them have a very long ovipositor, which is used to insert the eggs into the bodies of caterpillars that live beneath the bark or in the crevices of trees; whilst those which have this instrument short, place their eggs in or upon the bodies of caterpillars or pupæ, to which they can obtain easier access. They do not confine themselves to these situations, however, but employ for the same purpose the eggs or pupæ, still preferring the larvæ when they can find them. The young ichneumons, when hatched as footless grubs, sometimes in considerable numbers in the body of one larvæ, devour only the fatty parts, which are not absolutely necessary to life; but when ready to undergo their metamorphosis, they either pierce through the skin and escape, or else kill their victim, and perform their changes within its body. Of those which escape, some species form a cocoon; and of these several are sometimes united into a kind of cottony mass, which is attached to the stems of plants. This

602. What of gall-flies and their products?

603. Describe their structure and habits.

604. Of what use is the product of these insects?

605. Describe the peculiarities of the third family.

family is extremely numerous in species, above 3000 probably existing in Europe alone.

565. (iv.) The family CHALCIDIDÆ consists of very small insects, usually ornamented with brilliant metallic colours, and generally possessing the power of leaping. Their habits much resemble those of the Ichneumons; some of the smallest feeding on the eggs of insects which are scarcely perceptible from their minuteness, and others living in the larvæ and pupæ of Lepidoptera. Some of the species deposit their eggs in the galls occasioned by the puncture of the Cynipidæ, where their larvæ devour those of the original inhabitants.

566. (v.) The CHRYSIDIDÆ approach the Aculeata in several points of structure, and especially in having the ovipositor terminated by a small sting. In the richness of their colours they vie with the humming-birds; and they are commonly known as golden-tailed flies. They may often be observed walking, in constant agitation, and with great agility, upon walls and palings exposed to the sun. They deposit their eggs in the nests of solitary mason-bees, or other Hymenoptera, their larvæ destroying those of these insects.

567. Section II. ACULEATA.—The Hymenoptera of this division may usually be distinguished from the Terebrantia by the mode in which the abdomen is united to the thorax. In the *Borers*, it is in general closely jointed to it—a structure which is evidently necessary for providing the ovipositor with the requisite strength; whilst in the stinging Hymenoptera, it is usually connected by means of a peduncle or footstalk, which is often, as in some of the Wasp tribe, of great length, and extremely slender. The predaceous division of this section contains several families, of which the most important only will be noticed in detail.

568. (vi.) The CRABRONIDÆ, LARRIDÆ, BEMBECIDÆ, SPHEGIDÆ, SCOLIIDÆ, and MUTILLIDÆ, may all be considered under one general description. They form a group which may be termed that of *Fossores* or Diggers, from

606. What other families are here named?

607. What of the structure of the next section?

their peculiar habits, and they are commonly known as *Sand* and *Wood Wasps*. They are solitary in their mode of life, and consequently no neuters exist among them. In general, the females excavate cells in the ground, or in posts, timbers, &c., in which they deposit, together with their eggs, various larvæ, or perfect insects, and (in some species) even spiders, which are destined for the support of their progeny when hatched. Occasionally the insects composing this store are first stung to death; but sometimes they are only slightly stung, and are finally killed by the larvæ when hatched. In this manner they are rendered powerless, whilst their bodies are prevented from decomposing. The perfect insects are generally very active, and fond of the nectar of flowers, especially those of the umbelliferous tribe. They delight in the hottest sunshine, flying and running over sand-banks exposed to the mid-day sun, and keeping their wings in constant agitation; some of the tropical species are among the largest of the order, and their sting is very severe. The sand-burrowers excavate their nests by means of powerful brushes with which their legs are furnished; while the wood-burrowers use for the purpose their strong broad mandibles, which are provided with tooth-like projections. One species, common in sandy districts, has been observed to use its jaws, in the first instance, to loosen the material, and then throws away the sand, by a peculiar movement of the body, to several inches' distance. These families differ in their geographical distribution, the *Bembecidæ* being altogether confined to warm climates, whilst others are more widely diffused.

569. (VII.) The next family, that of *FORMICIDÆ*, is composed of the well-known and singularly interesting tribes of Ants; it must not, however, be confounded with the *Termitidæ*, or white ants, belonging to another order. The Ants are distinguished from all the Hymenoptera previously described, by their habit of residing underground in numerous societies, and by the existence of *neuters* among them, by which class the labours of the

community are chiefly performed. The males and females, which constitute but a small proportion of each community, are alone furnished with wings; the former are the smallest. The neuters are somewhat smaller than the males, and mostly resemble the females in conformation; but the thorax is much narrower, and contracted in the middle, not having to give attachment to wings. The nests of Ants are differently constructed in the different species, but in all are very curiously and regularly arranged. The males and females leave them as soon as they have acquired their wings, and go forth together into the air. The males soon die, without entering their former abode; of the females, some return, and deposit their eggs in the original nest, whilst others go off to a distance and become the foundresses of new colonies. They lose their wings at this period, sometimes stripping them off with their own feet, in other instances being deprived of them by the neuters.

570. The neuters not only construct the nest, but most carefully tend the young grubs; supplying them with food, moving them on fine days to the outer surface of the nest to give them heat, and carrying them back again at the approach of night or bad weather, and defending them when attacked by enemies. The winged Ants having all perished at the commencement of the cold weather, the neuters only survive the winter. In the species of this climate they remain torpid, and lay up no store of food (what have been supposed to be grains being in reality the pupæ); but in tropical species this is otherwise, the Ants being active the whole year, and "gathering their food in the harvest;" to these, therefore, the description of the sacred writer (Proverbs vi. 6, 7, 8) strictly applies. Some of the neuters are larger and rather differently formed from the rest, and appear to be the chief defenders or soldiers of the community. A most remarkable instinct is observed in some species, that of making war upon colonies of smaller ants, carrying captive the larvæ and pupæ of the neuters, and keeping them in slavery

when hatched. Ants are well known to be extremely fond of saccharine matters, and they seem greatly to relish the fluid which exudes from the bodies of Aphides, and Coccidæ. Some species of ants collect Aphides, and keep them, as it were, in pastures, which they connect with their nests by means of galleries excavated along the stems and branches of trees; and they protect the eggs of these insects in their own nests, especially in bad seasons.

571. The foregoing are a few of the chief facts relating to the economy of this tribe, on which many volumes have been written; and it may be safely asserted that there is none whose habits are calculated to afford more of interest and entertainment to those who seek acquaintance with them, either by the recorded observations of others or by their own.

572. (VIII.) The family of VESPIDÆ, or Wasps, is distinguished from the other Hymenoptera by their wings being folded, when at rest, throughout their entire length. In general these insects are social; the communities, however, being small. In such cases there are neuters, which are not destitute of wings. There are also some solitary species (whose habits resemble those of the Fossors, whilst their general structure is more conformable to that of the social wasps), among whom no neuters exist. The nests of the solitary species are formed of earth; they are sometimes concealed in holes of walls, in the earth, or old wood, and sometimes they are fixed to plants. The parents store them with caterpillars or spiders, which they have previously wounded with their stings. These nests contain a succession of cells, in each of which a single egg is deposited.

573. The best known of the social wasps, such as the common species of this country, construct their nests with bits of wood, bark, &c., which they separate with their jaws, and reduce to a pulp; and this, when expanded and dried, forms a paper-like substance. With this are built layers of hexagonal cells, one row being joined to the

610. Describe the variety of ants, and their habits.

611. What of the Wasp family?

under side of another. The top row is attached, in some species, merely to the under side of the branch, or to the top of a slight hollow, by which it may be in some degree protected; but in others, the whole comb is enveloped in a covering formed by several layers of the same paper-like substance, with one or more apertures. This nest is begun in the spring by the females; and they deposit eggs, which produce neuters or workers; by these the nest is enlarged, and the subsequent broods are tended, until the beginning of autumn. The young males and females then appear; and all the larvæ which do not undergo their final change before November are destroyed by the neuters. These likewise perish, as do also the males, when the cold weather commences; and a few females alone remain, which become the foundresses of new colonies in the following spring. Wasps feed, in their perfect state, upon insects, meat, fruit, &c., and nourish their young with the juices of these substances. A Brazilian species stores up an abundant provision of honey.

574. The Hymenoptera belonging to the *melliferous* or honey-collecting division of the Aculeata, are known by the peculiar conformation of the hind feet, of which the first joint is compressed and extended into the form of a square plate, and provided on its inside with brush-like tufts; these organs are employed for the purpose of collecting and carrying the pollen of flowers, which is employed for the nourishment of the young. All of these insects are commonly known by the name of Bees; but the tribe contains two families; in one of which, the *ANDRENIDÆ*, all the species are solitary, and are of only two kinds—males and females; whilst in the other, the *APIDÆ*, or true Bees, they mostly live in societies, but are chiefly distinguished from the former by certain peculiarities in the structure of the mouth.

575. (IX.) Of the *ANDRENIDÆ* some species seem nearly allied to the solitary Wasps. They burrow in the ground, often to considerable depths, in situations exposed to the

612. Describe their nests and habits.

613. What of the structure of Bees?

an. In these burrows they deposit their eggs, placing with each a supply of pollen, mixed up into a paste with honey, for the nourishment of the future progeny. Each of these deposits is covered up, and another then laid over it; so that the entire burrow consists, when filled, of a series of cells. The hole at the top is closed up with earth, chiefly to prevent the attacks of parasites, which, however, often succeed in entering the hole.

576. (x.) Among the APIDÆ there are some solitary species, which approach the last family; and there are some which are parasitic, depositing their eggs in the nests of other bees, upon whose store of food the larvæ are sustained, the parents not having themselves the power of collecting pollen. Of those which construct nests for themselves, there are many curious varieties, some of which go under the names of Mason, Carpenter, and Upholsterer Bees, from the material with which they work—the first agglutinating bits of sand or gravel, the next excavating wood by means of their powerful jaws, and the last constructing their cells of portions of leaves. The habits of all of these may be studied in detail with extreme interest.

577. Of the social species there are two principal groups, the Humble-Bees, or Wild-Bees, and the Hive-Bees. The common Humble-Bees of this country live in curious underground habitations, in societies usually of fifty or sixty, but sometimes of two or three hundred individuals; which are broken up, however, at the approach of winter, like those of the wasps. The females are the largest of the two sexes; but besides these, each community contains many neuters, which are intermediate in size between the two others. The females which survive the winter commence the construction of the nest in the ground, often at the depth of one or two feet, early in the spring. The cavity is lined with moss, which the bees card with their hind legs. Within this excavation, cells are constructed with wax, in which the eggs are laid;

614. Describe the solitary variety.

615. What varieties of bees are here described?

and the larvæ, when hatched, are fed with pollen paste. After undergoing their changes, they issue forth, usually in the months of May or June, and assist in the labours of the hive. The males and females are chiefly produced, however, towards the end of the summer.

Queen Bee.

Drone.

578. It is in the Hive-Bees that the arts of construction are exhibited in the most elaborate degree. Their societies consist of but one female, commonly termed the queen, several hundred males, which are known as drones, and about twenty thousand working-bees or neuters. It is by the latter that all the labours of the hive, the construction of the combs, the collection of food, both honey for the adults and pollen for the larvæ, and the nourishment of the grubs, are performed. The accompanying figures exhibit the

Neuter Bee.

relative sizes and aspects of these three orders. The wax of which the comb is constructed is secreted by the insects themselves in little scales, which work out from between the segments of the abdomen. These are taken up and kneaded by the jaws, and applied in the proper place. The hexagonal form of the cells is that which gives the nearest approach to the circular form, with the least expenditure of material, and at the same time the greatest strength. The bottom of each cell on one side abuts against three on the other, and is supported by the divi-

616. What of the Humble-Bees and their social habits?

617. Describe the Hive-Bees and their societies.

618. What of their cells and their construction?

sions between them. It is formed of three plates meeting at an angle, and this angle has been ascertained,* by a very intricate mathematical calculation, to be *precisely* that which enables the greatest strength to be attained with the least material. Some of the cells thus formed are employed as store-rooms for honey and pollen, and in others the eggs are laid. The eggs from which perfect females or queens are to be produced, are laid in cells much larger than the rest, and of different form; but if, from any cause, these should not afford a sufficient number, the bees have the power of rearing a female or queen from a neuter grub, by feeding it with an aliment more stimulating than the pollen. The drones are killed at the end of summer, but the queen and great part of the workers remain; and when, in the summer, they increase so much as to overpeople the hive, colonies are sent forth with young queens, in search of another habitation.

Order V.—Homoptera.

579. The insects contained in this order present many curious anomalies of structure and habit, and depart more widely from the general type, than is the case in almost any other division of the class. Hence it is difficult to assign any general characters which shall include them all. It is in the structure of the mouth that there is the greatest agreement. This is adapted for suction, the tongue being elongated and channelled into a gutter, and being surrounded by delicate lancet-like organs, which pierce the tissues of plants. All the insects of this group subsist on vegetable juices; and some of them, from the amount of damage they commit, are very injurious to the cultivator. Some

* This question was long ago treated by the celebrated mathematician Maraldi, who brought the results of his calculation to agree with the observed angle within two minutes of a degree. This near approximation has been generally considered quite close enough to establish the fact: but Lord Brougham has recently investigated the subject afresh, and shown that the bees were perfectly right and the mathematician wrong.

619. What is said of the angle observed in their cells?

620. Describe the use of the cells, and the habits of bees.

of the females are furnished with an ovipositor, provided with several toothed saws, and with this they make incisions into the leaves or stems of plants, into which they introduce their eggs. The anterior pair of wings is usually similar to the posterior in consistence, both being composed of a firm membrane; that which chiefly distinguishes the Homoptera, however, from the Heteroptera is, that the substance of the anterior pair, whatever be its nature, is the same throughout; and that, when folded, they are roof-like.

580. This order may be divided, like the Coleoptera, into sections, according to the number of joints in the tarsi. These sections are only three in number: in the first, TRIMERA, the tarsi are three-jointed; and in the second, DIMERA, they are but two-jointed; and in the third, MONOMERA, they have but one joint.

581. Section I. TRIMERA.—The three-jointed division of the Homoptera includes three families, of which two, the CICADIDÆ and FULGORIDÆ, are very interesting. The CICADIDÆ are the largest of the order; one species measuring between six and seven inches in the expanse of its wings. Their peculiar characteristic consists in their musical powers. By a peculiar apparatus situated beneath the abdomen, they are enabled to produce a continued sound, nearly monotonous, but of considerable power. In some species the sound is so loud and shrill as to be heard at the distance of a mile. The song of the cicada was a favourite theme in the verse of the Grecian poets; and one of them thus notices the fact of the males alone being possessed of vocal powers—

“Happy the cicada lives,
Since they all have voiceless wives.”

582. The female cicada deposits several hundred eggs in excavations which she makes in dried branches. The larvæ have six feet, by means of which they speedily descend into the earth, where they increase in size and are

621. How is the next order described?

622. How are they divided and sub-divided?

623. What is peculiar in the largest species?

converted into pupæ, which are active, and differ but little from the larvæ, except in having the rudimentary wings visible at the sides of the body. During the winter, they burrow to the depth of two or three feet into the earth, and derive their subsistence from the roots of plants. In this pupa state they were eaten by the ancients. This family is almost entirely confined to tropical regions, where alone the largest species exist; and it is most numerous in America. Only one small species inhabits this country.

583. The FULGORIDÆ are destitute of the power of producing sound, but are distinguished by a curious prolongation of the forehead, which sometimes equals the rest of the body in size. The shape of this projection differs extremely in the various species, which are very numerous. It is in it that the luminous property of the *lantern-fly* is said to exist; but the luminosity of this insect, of which one species is a native of Brazil and Guiana, whilst another inhabits China, is doubted by many naturalists. If it real-

Fulgora Laternaria.

ly exists, it probably only shows itself at particular seasons. Some species of this family produce a considerable amount of a white waxy secretion, which is collected by the Chinese, who make from it a fine white wax, which is greatly esteemed in the East Indies. Another species is sometimes extremely injurious in the West Indian islands, from its attacking the sugar-canes in vast numbers, and destroying their vitality by devouring the leaves and young shoots.

584. The family of CERCOPIDÆ, also belonging to this

624. How are the sexes dissimilar?

625. What of the other variety?

section, consists of insects of small size, but which are remarkable for the grotesqueness of the forms which many of them assume. Some inhabit this country, and are known by the names of cuckoo-spits and frog-hoppers; but the most singular species are confined to the tropics. The curious appendages represented in the accompanying figures of a Brazilian species, result from an extraordinary

Bocydiium Globulare. *Bocydiium Cruciatum.*

development of the first segment of the thorax. The insects of this family are often beautifully varied in their colours; they are constantly found amongst plants and on trees, upon the juices of which they subsist in all their stages. Of the best known species of this country, the larva and pupa invest themselves with a frothy secretion, whence the vulgar name is derived. Some of this tribe are employed by certain species of ants for the same purpose as the Aphides, having the power of supplying them with a saccharine fluid.

585. Section II. DIMERA.—Of the Dimerous Homoptera, the most remarkable family is that of *APHIDÆ*, commonly known as *Plant-lice*, which is extremely obnoxious on account of the injuries committed by its members against almost every kind of vegetable. The Aphides live in great numbers upon the surface of the plant, and suck the juices, by means of their proboscis, from the young shoots, leaves, stems, and even roots. They thus greatly weaken its vigour, and often distort young shoots and leaves; some species cause little gall-like excrescences by the irritation they produce. From two horn-like processes

626. What of the variety in the next family?

627. Describe the diagrams.

at the posterior part of the body, a saccharine secretion exudes, of which ants are very fond; and it is either this fluid dropped on the adjacent leaves, or the extravasated sap flowing from the wounds made by the insects, which is known under the name of honey-dew. In many of the species of this family, a large proportion of the individuals never acquire wings; in which case the pupa is not to be distinguished from the mature larva or imago states; whilst at certain parts of the year, other individuals of the same species, and of both sexes, acquire wings. The wingless Aphides, which may be seen in the spring and early summer, are all females, capable of producing fertile eggs; and from these are reared the winged males and females which are seen later in the season. Their rapidity of production is enormous; nine generations having been obtained within three months. The young are sometimes produced alive, whilst in other cases (according to the season and other circumstances) eggs are deposited. Many of the *blights*, so injurious to the gardener and the agriculturist, consist really of Aphides, although, from the minuteness of the insects themselves, they often escape observation.

586. Section III. MONOMERA.—The third section contains but one family, that of COCCIDÆ, sometimes called *Scale Insects*. These, although ordinarily of very small size, are amongst the most injurious to vegetation of any tribe. Their powers of propagation are excessive; and when they once gain possession of a plant or young tree, its death is almost certain, the minute size of the larva rendering it impossible to exterminate them. They find their way into hot-houses, and are even more destructive to the exotics they infest than to out-door vegetation. This is perhaps because they are not then kept in check by their natural enemies, such as exist in the regions of which they are natives. They furnish, however, some very important products. The bodies of many species are very deeply coloured through their whole substance, and yield dyes of great value, the richness of which seems to de-

pend upon the nature of the plant on which they feed. The species employed by the ancients was a native of the Levant; but that which furnishes the *cochineal* so highly valued at the present time, was originally confined to Mexico, where it feeds on the cacti; it has, however, been introduced, along with its proper food, into Spain and Algiers, and also into the hot-houses of this country. About 800,000 lbs. weight of cochineal are annually brought to Europe, each pound of which contains about 70,000 insects. The *lac* of the East Indies, which is extensively used in the composition of varnishes, the making of sealing-wax, &c., is the product of another species of *Coccus*.

587. The transformations of these insects are among the most curious which we anywhere encounter. In their early stages, both sexes are much alike, and are possessed of some degree of activity, having much the appearance of minute red tortoises, and feeding by means of the sharp weapons with which their mouths are furnished, and which enable them to puncture the young shoots on which they crawl. After a time, however, this small amount of activity ceases; the males no longer increase in size, and if one of them be opened, the larva skin will be found to contain a small and elegant chrysalis; but the females continue to grow until they are many times larger than the other sex—the margins of the body are as it were glued down to the plant—and the abdomen being distended by a great number of eggs, until scarcely any thing but the upper and under skins appear to remain. The male coccus is of very elegant form, but his life is short, being unable to take food in the perfect state. The female seems among the least organized of insects, having neither legs nor antennæ, and presenting to the sight nothing but an inert, scale-like mass. The eggs are deposited beneath the body of the female, who then dies; they are covered with both the upper and under folds of her skin, which protect them until they are hatched, and then the larvæ make their way out from beneath the envelope, to

629. Describe the insects of the third section.

630. What valuable dye is furnished by them?

go through a like succession of changes. This is one of the very rare cases in which a living being appears to lose in advancing life that which *seems* to be the perfection of its structure. It would appear as if, in this instance, the whole force were concentrated in the function of reproduction, of the amazing power of which some idea may be formed by the enormous and undiminishing supply just stated as being drawn from one species alone.

Order VI.—Heteroptera.

588. These insects bear a close general resemblance to those of the last order; as in them, the structure of the mouth, which is wholly adapted for suction, indicates that their nourishment consists solely of the juices of plants or animals; but they are at once known from them by the character of the anterior pair of wings, which are coriaceous at the base, and membranous towards their point, and which fold nearly horizontally, partly lapping over each other. By far the greater number of them feed upon the juices of plants, but some of them prey upon other and weaker insects; and a few species (of which the numbers, however, sometimes multiply to a great extent) suck the juices of larger animals. The majority of this order are found in tropical climates; and the species which inhabit these regions are mostly ornamented with a great variety of beautiful colours and markings, often vying in brilliancy with the most splendid of the beetle tribes. Many species, however, are of aquatic habits; and they are all of an obscure black colour. Nearly all the terrestrial species have the power of emitting, when suddenly alarmed or touched, a powerful odour, which is of a pleasing character in some species, but in others (as the common bed-bug) very disgusting. Others seem to inject a poisonous fluid into the wound they make for the purpose of suction. In some species the wings are altogether undeveloped, or the upper pair is wanting. The insects of this order continue active, and require food, during all the stages of their existence. They may be

631. What singular transformations are cited?

632. How is this order distinguished, and how divided?

divided into two sections, distinguished by their residence—the *Geocoris*, or Land-Bugs, and the *Hydrocorisa*, or Water-Bugs.

589. The first section contains a large number of families, nearly all of which bear a considerable resemblance to that which includes the common Bugs; the *Cimicidæ*. Some of the tropical species attain considerable size, being described as of the bulk of a cockchafer, and they are much dreaded by the inhabitants of the regions they infest. The expression of the Psalmist (Psalm xci. 5) is considered by many learned commentators as referring to them. Many of the *Geocoris*, however, are vegetable feeders, and it is among these that the most brilliant colours exhibit themselves. Some of them, belonging to the family *Hydrometridæ*, are distinguished by their power of moving on the surface of standing or running waters. The body is long, narrow, and generally covered on the under surface with a fine layer of plush, which is evidently serviceable in repelling the fluid. The most active species have the body shaped like a London wherry, and they are rapidly propelled along the surface by the oar-like action of the two middle feet, which do not, however, dip into the water, but merely brush along it; the hind legs, brought together, serve the purpose of a rudder. In some of the species, however, there is less power of swimming; the insect creeping along aquatic plants, with its body elevated above the surface. In this tribe, as well as in the Land-Bugs more strictly so called, wingless individuals are not unfrequently seen.

590. Of the true Water-Bugs, there are two families only; and both these deserve notice. The *Notonectidæ* live almost entirely in the water, where they feed upon other aquatic insects; these they seize by means of their fore legs, which are formed as claws. The two hinder pairs have a fringe of bristles along their edge, by which the surface with which they strike the water in swimming is greatly increased. Their general form is extremely

633. What variety of Land-bugs is described?

634. What family are aquatic in their habits?

well adapted for rapid progression in water; and, from the peculiar aspect of the body, they have received the name of *boat-flies*. The insects of this family swim on their backs, a peculiarity to which their name refers; and the arrangements of all their organs has reference to this position. When stationary at the surface of water, as is much their custom in hot weather, they very quickly obtain intelligence of the approach of danger, by means of their eyes, which are so placed as to be able to see both above and below; and then, by a single stroke of their paddles, which are ordinarily stretched out at full length, they descend out of sight. Their motions are very quick in the element they chiefly inhabit, whilst on land they are scarcely able to walk. They fly well. The larvæ and pupæ differ from the imago only in their smaller size, and in the deficiency of wings. The Notonectidæ carry down a supply of air for respiration beneath the wings.

591. The NEPIDÆ are in most respects similar in structure and habits to the insects of the last family. Their motions, however, are much slower. They are very predacious, feeding upon other insects, and especially on the larvæ of Ephemeræ. They breathe, when in the water, by two tubular appendages at the extremity of the body, which, when projected above the surface, admit the air into the system of respiratory vessels contained within. The *Nepa Cinerea* is a common British species; it is of a dirty ash-colour, with the upper surface of the abdomen bright red. Like the rest of the family, it is able, when so disposed, to leave the water, and take wing.

Order VII.—Lepidoptera.

592. The order Lepidoptera, characterized, as formerly stated, by the downy covering of the wings (which is composed of minute scales, arranged with great regularity upon the membrane itself), contains some of the most beautiful forms of the whole class, as well as some of the largest. The number of species it comprehends is pro-

635. Describe the water-bugs and their variety.

636. How is the seventh order characterized?

bably as great as that of any other order except the Coleoptera, and may probably rank as about one-fifth or one-sixth of the whole class.

593. All the insects of this order belong to the well-known forms of *Butterflies* and *Moths*; and there is so much general resemblance among them, that the difficulty of classifying them is often considerable. The possession of scales upon the wings is not altogether peculiar to them; for they are found on the wings and bodies of other insects. But it is only in these that the wings are covered with such complete layers of them. The scales are generally of somewhat oval form, terminating at one end in a kind of stalk, by which they are attached to the membrane of the wing; and on this they are arranged in rows, overlapping each other like tiles in a roof. They may be easily rubbed off with the finger; and the bare membrane is left, which is then seen to correspond with the wings of other insects. The number of scales covering the wings of the silk-worm has been estimated at about 400,000. It is entirely to the scales that the colours of the wings are due; and sometimes these are so brilliant as to be almost painful to look upon, if a strong sunlight is reflected from the surface. In some species the wings are partially, or even almost entirely, destitute of scales.

594. The Lepidoptera, in their perfect state, are formed to exist entirely upon fluid nutriment, which they suck up by means of a long trunk, which is usually coiled up spirally under the head. This trunk is not an organ altogether peculiar to them, however, for it is constructed out of the lower pair of jaws, or *maxillæ*, which are very much prolonged; each is channelled on the side nearest the other, and furnished with very closely set teeth along its whole edge. When the edges are brought together, and the teeth lock into one another, a perfect tube is formed by the junction of the channels in the two, and through this canal these beautiful insects suck up the juices of flowers, to which they seem, in the brilliancy of their

637. To what forms do these insects belong?

638. What is peculiar to this family?

639. What is remarkable in their structure and habit?

colours, and the softness yet liveliness of their aspect, the most appropriate companions. In the language of the poet,

“They flutter round the jasmine stems,
Like winged flowers or flying gems.”

All the other parts of the mouth usually possessed by insects, may be detected in that of the Lepidoptera, but in a different state of development. The antennæ are variable in size, and always composed of a great number of joints. The eyes are usually large, and contain a considerable number of facets.

595. The thorax of the Lepidoptera is less distinctly separated from the other divisions than in most insects. The first pair of legs is often small, folded beneath the body, and concealed by the hair, so that the butterfly seems to have but four legs. The wings are generally of large size, simply veined, and incapable of being folded together; two pairs exist in almost every instance, and these are often held together during flight by a peculiar contrivance. This consists of a strong bristle on one wing, which plays in a loop on the other. The abdomen is cylindrical in form, and possesses no sting at its extremity. All the Lepidoptera are either males or females, neuters having no existence in this order. There is often a considerable difference in the colouring of the two sexes, so that they might have been supposed to belong to different species; the females are generally the largest, and most dully coloured. They are occasionally almost destitute of wings, and much resemble full-grown larvæ in their aspect.

596. The curious phenomena of the metamorphosis are presented to our notice more remarkably, perhaps, in this order than in any other. “Were a naturalist,” it has been strikingly remarked, “to announce to the world the discovery of an animal which, for the first five years of its life, existed in the form of a serpent, which then penetrating into the earth, and weaving a shroud of pure silk of the finest texture, contracted itself within this covering into a body without external mouths or limbs, and re-

sembling more than any thing else an Egyptian mummy ; and which, lastly, after remaining in this state without food and without motion for three years longer, should, at the end of that period, burst its silken cerements, struggle through its earthly covering, and start into day a winged bird—what would be the sensation excited by this piece of intelligence ?” This is one of the many instances in which the real phenomena of nature are passed over with inattention, solely because they are common ; but by which, taken alone, as much of wonder might be raised as by the fabulous metamorphosis of Ovid, or the magical transformations of the East.

597. All the beings commonly known as *caterpillars* are the larvæ of Lepidoptera. They are produced from eggs of various forms and curious markings (sometimes almost resembling Echini), which have been deposited by the parent upon the leaves that are to serve as the food of the larvæ when hatched. The body of the caterpillar is generally cylindrical, and divided into twelve segments, besides that which represents the head. Nine stigmata may be seen on each side ; and the surface of the skin is sometimes smooth, sometimes covered with hairs, and sometimes beset at intervals with strong spines.

598. The three first segments of the body have each a pair of simple, short, and jointed feet, which are the rudiments of those of the perfect insect. Behind these are a variable number of temporary appendages, called pro-legs, which are thick, short, fleshy limbs, armed at their extremity with a great number of minute hooks, and furnished with powerful muscles. There are usually five pairs of these—four of them succeeding the true legs, and another arising from the last segment of the body. Those possessing pro-legs on nearly every segment, crawl upon all the feet at once, after the manner of the Myriapoda ; but those which have only a small number of pro-legs, adopt a different method. They seize fast hold of the ob-

641. What of their metamorphosis ?

642. What of caterpillars ?

643. Describe their peculiar structure.

jects on which they are stationed with the six true legs at the fore part of the body, and then elevate the intermediate segments into an arch, until they bring the pro-

Caterpillar and Chrysalis of the Magpie Moth.

legs behind close to the others; they then disengage the true feet, and retaining hold with the pro-legs, thrust the body to its full length, and then recommence the same manœuvre. These are called Loopers or Geometers. Many of them resemble, in their forms and colours, as well as in their mode of standing fixed for a great length of time by their hind legs only to twigs, small pieces of stick.

599. The greater number of caterpillars are vegetable feeders, and are mostly confined to the leaves; and the correspondence between the development of the leaves and flowers of plants on the one hand, with that of the caterpillars and butterflies which are respectively to feed upon them, cannot but strike every one as a beautiful instance of creative foresight. But there are some caterpillars adapted to feed on flowers (such as come forth early in the year), and others attack seeds, roots, and even the woody portion of the stem. Moreover, there are a few which live in this state upon animal matter, such as wool,

644. What of the diagram?

645. What instance of Divine Wisdom is cited?

hides, leather, and fat. Many can digest a considerable variety of alimentary materials; whilst there are others that can only find support on some one kind—the leaves of a particular species of plant, for example.

600. The habits of caterpillars are extremely various. Some burrow into the substance of leaves, in which they excavate galleries; others envelop themselves in the membrane of the leaf itself. Many construct cases or sheaths, either fixed or portable, by agglutinating various substances together; and there are some which live in societies, living together under a tent of silk which they spin in common, and which serves to defend them from the inclemency of the weather. They usually throw off their skin four times, before undergoing the transformation into the chrysalis state. For this they prepare by spinning a *cocoon*, in which they are enclosed during the greater part of that epoch. Some construct this entirely of silk; others attach together portions of leaves or particles of earth by silken threads. These threads are formed by a glutinous secretion from glands which seem analogous to the salivary glands of other animals; and this being forced out through a small opening at the end of the lip, hardens as it dries in the air. There are some caterpillars which form no cocoon, but which are contented with suspending themselves by the attachment of the hinder part of the body to some solid support, or by a silken thread coiled around them.

601. The *chrysalis*, or nymph, has the whole body enclosed in a tough envelope, under which, however, the form of the parts of the future insect may be discerned. At the moment of the final transformation, it discharges from its intestine a red liquid, which softens one end of the cocoon, and allows the exit of the moth. Generally, one end of it is weaker, or even fitted by the arrangement of the threads for the escape of the insect.

602. The *butterfly*, when it throws off its last envelope, and comes forth into the air, of which it is henceforth to be one of the gayest inhabitants, is not altogether

646. What is remarkable in their habits?

647. What of the cocoon, chrysalis and butterfly?

perfect, although capable of very soon becoming so. The wings appear at first very slightly developed, and hang loosely by the sides; and it is not until the animal has injected their tubes with air, by taking several full inspirations, that they become expanded so as to serve for flight. From that period, the body is supported by them during by far the greatest proportion of the active state.

603. The order of *Lepidoptera* is usually divided into three sections, which are different alike in their conformation and habits. These are—(I.) The *DIURNA*, or *Butterflies*, which may be at once recognised by the vertical position of the wings during repose; (II.) The *CREPUSCULARIA*, or *Twilight-Moths*, commonly known as *Hawk-Moths*, in which the wings are horizontal in repose, and the antennæ thick or club-shaped; (III.) The *NOCTURNA*, or true *Moths*, whose wings are also horizontal or inclined in repose, but whose antennæ are more slender, tapering gradually from the base to the point.

604. Section I. *DIURNA*.—The first section corresponds with the Linnæan genus *Papilio*, which is now, however, very much subdivided. The Butterflies are distinguished from other *Lepidoptera* by the brilliancy of their colouring, and by the beauty of the under as well as of the upper side of the wings. Their caterpillars have generally sixteen feet; and their pupæ are nearly always destitute of any silken envelope, and are attached by the tail. The antennæ of Butterflies are sometimes knobbed at their extremities, sometimes of the same thickness throughout, and sometimes tapering gradually from base to point. This section may be divided into three families, according to peculiarities in the metamorphosis.

605. (I.) In the first family, the chrysalis is attached by a cord around the body, as well as by the tail. This includes many well-known forms. The *Papilionidæ* have six pairs of legs fitted for walking; and the two sexes are nearly alike. They are remarkable for their size and the variety of their colours, especially in the equatorial regions

648. How is this order divided?

649. What division is made of the first section?

of both hemispheres. Many have the hind wings prolonged into a kind of tail, as the common *papilio machaon*, or swallow-tailed butterfly. In some other tribes of this section, the first pair of legs is very short.

606. (11.) In the second family of the Diurnal Lepidoptera, the chrysalis is suspended simply by the tail; and in all of these the males, and generally the females, have the first pair of legs very small, and folded against the thorax. In this tribe we find the genus *Vanessa*, which is distinguished by the form of the antennæ, these terminating suddenly in a short knob. This genus contains many of the most common and beautiful butterflies of Great Britain; as, for instance, the *Vanessa antiopa*, or Camberwell beauty; the *V. io*, the peacock; *V. cardui*, the painted lady; *V. atalanta*, the red admiral; *V. polychloros*, the large tortoise-shell; and *V. urticæ*, the small tortoise-shell. These names will sufficiently indicate the general aspect of the Butterflies of this genus. The *Argynnis*, an allied genus, has pearly spots on the under side of the wings, and the club of the antennæ is oblong. The accompanying figure gives a good representation of the general as-

Argynnis Paphia.

pect of the Diurnal Lepidoptera. The *Nymphalis* is another allied genus, remarkable for the brilliancy of its colouring and its high and rapid flight. The males of some species have changeable reflections in their hues, as in the *N. iris*, or purple emperor.

607. (III.) The last subdivision of the Diurna, composed of those species in which the caterpillars enclose themselves, instead of merely suspending their bodies, is a very small one. When about to undergo their transformation, they roll up leaves, and spin a thin web of silk within. The principal genus of this tribe is that of *Hesperia*, of which the species are numerous, and are known to collectors under the name of Skipper Butterflies, on account of their peculiar flight. One species, of which the caterpillar lives on the mallow, is a common example. In this group the wings are often inclined, or even horizontal, when in repose; thus conducting us towards the next family.

608. Section II. CREPUSCULARIA.—The section of Crepuscularia, or *Hawk-Moths*, corresponds with the Linnaean genus *Sphinx*, which derived its name from the peculiar attitudes (resembling that of the sculptured sphinx of antiquity) into which the larva sometimes throws itself. Although the Lepidoptera arranged under this division, on account of their similarity of structure, are mostly twilight fliers, it is not the case with all; for there are some which come abroad in open daylight, and suck the juices of flowers with their long trunks, whilst the sun is brightly illuminating their wings. These species are observed to be more brilliantly coloured than the rest. In most of the Sphinges the body and wings have a dull brownish-gray aspect, like that of many owls, whose habits are similar. The wings are more downy in appearance than those of the Butterflies, as if the scales did not lie so closely upon each other. The larvæ of the Crepuscularia have always sixteen feet; and their pupæ are either enclosed in a cocoon, or bury themselves in the earth. The Hawk-Moths make a loud humming noise in their flight.

609. (IV.) The first family, HESPERI-SPHINGES, evidently connects, as its name imports, the true Sphinges with the last group of the Diurna. The genera it includes are principally exotic.

651. What of the third subdivision?

652. Describe the second section.

610. (v.) The second family, the true SPHINGES, contains some of the largest species of the order. They may be known by the peculiar brush of scales in which the antennæ terminate. The majority of their caterpillars have the body destitute of hairs, but furnished with a kind of horn on the back, near its extremity. They feed on leaves, and undergo their changes in the earth, without weaving a web. They fly with great swiftness, hovering over flowers, from which they pump up the juices by means of their long trunks, and make a loud humming noise. One of the most remarkable of this group is the death's-head moth (*acherontia atropos*), recognised by the skull-like patch

Acherontia Atropos.

on the back of the thorax. This emits a squeaking kind of sound, sometimes rather loud, but upon the mode in which it is produced entomologists are not agreed. In consequence of the peculiar aspect of its body, the sudden appearance of this insect, in large numbers, has been popularly regarded as ominous of evil. It is a great enemy to bees, and enters their hives undefended, alarming the inhabitants so that they seem to keep aloof from it, and devouring the honey.

611. In some species of Sphinges, the larvæ have the power of thrusting out the anterior part of the body to a great length, like the trunk of an elephant, whence they have been called elephant hawk-moths. A very beautiful British species of sphinx is the *S. stellatarum*, or hum-

653. How are the Sphinges divided ?

654. Describe each species.

655. What of the diagram ?

ming-bird hawk-moth, commonly called the bee-bird. This is remarkable for flying during the hottest sunshine, and for keeping itself poised over flowers during a long period, whilst imbibing their juices; the movement of the wings emitting a sound, "deep, full, lulling and musical." This species is not so restricted as to the time of its production as are most others; it being found in the perfect as well as the larva state from the spring until the first frosts of winter.

612. (VI.) The tribe of *SESIADÆ*, constituting the third sub-division of the *Crepuscularia*, is small and little known. The insects composing it, however, are remarkable for the strong resemblance they bear to wasps and other *Hymenoptera*, to *Diptera*, &c. The caterpillars feed on the internal part of the stems and roots of plants, and they construct their cocoons in these stems with the debris of the substance on which they have fed.

613. (VII.) The last section of this group consists of the *ZYGENIDÆ*; a tribe of which most of the members frequent the open daylight, and even prefer the strong rays of the sun. Their larvæ live, without any protection, on the leguminous plants which serve as their food, and they form a silken cocoon, which they attach to the stems of those plants. The perfect insects are of small size, but generally remarkable for the brilliancy of their colours, and some of the exotic species are exceedingly beautiful. Their flight is usually slow.

614. Section III. *NOCTURNA*.—The group of nocturnal *Lepidoptera* is by far the largest of the order. In general aspect, Moths and *Sphinges* are somewhat alike, but they may be at once distinguished by the form of the antennæ, which, in the latter, gradually taper from the base to the point. Many of them have no distinct trunk, and in some species the females are almost or altogether destitute of wings. In general, these organs assume a horizontal or inclined position, and are connected in the same manner as in the *Sphinges*. Sometimes they can be rolled around the body, and in a few instances they fold longitudinally

like a fan. The greater part of these Lepidoptera fly by night, and their colours are usually dull. Their caterpillars vary as to the number of legs from ten to sixteen, and their pupæ are of rounded form, without those angular projections usually seen in those of other families, and almost always spin a cocoon. The large number of species belonging to this section, and the general similarity of their form, make their classification a matter of much difficulty. They have been divided into ten families, of which only the most important will now be noticed.

615. (VIII.) The tribe of *HEPIALIDÆ* feed in their larva state upon the interior of plants, in the substance of which the caterpillar buries itself. One species devours the roots of the hop, and is very injurious where that plant is cultivated. In its perfect state it is known by the name of the ghost moth, from the peculiar habit observed in the male, of hovering with a pendulum-like motion for a great length of time in one situation (often in churchyards), where the female is concealed in the grass, and its white colour renders it very conspicuous. The *cossus ligniperda*, or great moth, is one of the largest British Lepidoptera. In its larva state it feeds upon the wood of willow trees, which it perforates in every direction, so that they are blown down by the first strong wind. It was this caterpillar, to the anatomy of which the celebrated Lyonnet devoted twenty years of study. He found in it 4041 muscles. It is not confined to the willow, but burrows also in the oak, and more frequently in the elm.

616. (IX.) The next tribe, the *BOMBYCIDÆ*, consists of moths allied to that of the common silk-worm. Their proboscis is very short, and not spirally folded. The pupæ are enclosed in cocoons of pure silk, frequently of very firm texture, and are rarely subterranean. The prevailing hues of these moths are gray, or fawn colour, and many of the larger species have the wings ornamented with eye-like spots. This tribe contains the largest species of Lepidoptera, which are mostly included in the

657. What of the nocturnal variety?

658. Describe the eighth tribe, and its varieties.

genus *Saturnia*; this is distinguished from the true *Bombyx* by the horizontal position of both wings, the anterior pair in the latter being inclined. The *S. atlas*, a native of China, sometimes measures twelve inches across the wings. The *S. pavonia major*, found in France, has been seen to attain the breadth of five inches; and the *S. pavonia minor*, or emperor moth, attains in this country the breadth of three inches and a half. It is believed that the silk formerly obtained from China and India proceeded from the caterpillars of this genus. Many of them are remarkable for the contrivances they adopt for security in the chrysalis state; and among the most so is the *S. promethea*, an American species, which, previously to spinning, draws together the sides of a leaf (within which it afterwards forms its cocoon), and fastens its stalk to the stem by a strong silken web.

617. The genus *Bombyx* is an extremely important and interesting one, as it is by the caterpillar of the *B. mori* that all the silk now employed in Europe is produced. The larva feeds especially upon the mulberry, although it may be grown upon other plants; but as the silk produced by the former is preferable, that tree is grown to a great extent in Italy and the south of France, where the breeding of silk-worms is carried on. The quantity of nutriment they require is enormous in proportion to their original size, but probably not greater than that consumed by other caterpillars. The care bestowed upon them, however, draws attention to the fact. The larva is reckoned to weigh, when first hatched, about one-hundredth of a grain; previously to its metamorphosis it increases to ninety-five grains, or 9500 times its original weight. It is reckoned that, for the larvæ proceeding from *an ounce* of eggs, nearly *two thousand pounds* of leaves are requisite. The caterpillars of another species of *Bombyx* are very remarkable for their curious habits. They live in societies on the leaves of the oak; and spin, when young, a kind of silken tent, divided within into cells. They may be seen to issue from it in the evening in procession.

One of them advances at the head, and seems to act as a guide; two then follow; next three; then four, and so on, each rank containing one more than the preceding one. Hence they have been called processionary caterpillars. Each spins a separate cocoon; but they are united in regular opposition, laid side by side against each other.

618. (x.) The tribe of NOCTUIDÆ includes a large proportion of the whole family of Moths, as many as 400 British species being known. They have a spirally-rolled trunk, which is generally long, and possess considerable powers of flight. Their colours are very sombre, and their habits, as their name imports, almost exclusively nocturnal. The common Moths which flutter about our candles mostly belong to this group. Their larvæ ordinarily undergo their transformations underground, in cocoons, in which particles of earth are often mixed with the silk.

619. (xi.) The tribe of GEOMETRIDÆ may be noticed, on account of the peculiar mode of progression of their caterpillars, already alluded to. They often escape observation by remaining in one position for a long period, even several days; the dull colour and knotted aspect of the body making it resemble a twig of the stem on which it is. Some species have the instinct, when alarmed, of dropping down from the leaves, and suspending themselves by a thread, which enables them to remount when the danger is past. Small caterpillars possessing this power may be very commonly noticed.

620. (xii.) The TORTRICIDÆ are a tribe of Moths whose larvæ are peculiarly destructive to our fruit and forest trees. Some twist and roll up the leaves, connecting them together by a silken web, forming a kind of tube, in which they live. Others tie several of the young leaves together, consuming the inner layers, and preventing their development; others particularly attack the flowers, destroying them whilst yet in bud. A species of this group is one

660. What of the *Bombyx* genus?

661. Describe this variety, and its habits.

662. What other tribes are here named?

of the most destructive enemies to the apple crops of this country, laying its eggs in the eyes of the newly-formed fruit, within which the larva feeds, its presence being only indicated by the premature falling of the fruit. Another feeds upon the leaves of the oak, which it has been known to strip of its entire foliage; and the vines of the south of France have recently suffered much from the ravages of another species, which rolls up and fastens together the young leaves.

621. (XIII.) The family of *TINEIDÆ* contains those little Moths which are so injurious to woollen stuffs of every kind, as well as to furs, skins, feathers, and other objects of natural history, upon which their voracious larvæ feed. They use the material also for the construction of their movable cases or sheaths, which they enlarge with the increasing size of their bodies, both by adding to their extremities, and by slitting them along and inserting a new piece, so as to increase their diameter. In these tubes they undergo their metamorphosis, after closing the orifice with silk. The *Pseudo-Tineæ*, as they have been termed, burrow in leaves, and construct sheaths for themselves; but these are fixed, and not carried about on their bodies. The caterpillars of an allied genus, the *Hydrocampe*, are remarkable for their aquatic habits. They are furnished with appendages resembling long hairs, inside of which are breathing-tubes. In the habits of this family, we have an evident approach to those of the order Trichoptera.

622. (XIV.) The *TISIPENNÆ* are distinguished from all other Lepidoptera by the division of the membrane of the wings into branches or rays, of which each pair has from two to six. These are most beautifully fringed at their edges, and much resemble the feathers of birds. The rays are composed of the nerves, without any of the usual intervening membrane, which seems to be transformed into the fringe. These insects (commonly known by the name of Plumed Moths) are of small size; some of them are diurnal, and brightly coloured; others are twilight-fliers.

663. What of the thirteenth family of moths?

664. How is the last family described?

and of a duller aspect. Some species have the power of folding up their wings, one ray against another, somewhat like a fan; so that, when closed, they present the appearance of a single broad ray.

Order VIII.—Diptera.

623. The two-winged insects constitute one of the most extensive orders of the whole class, not only in regard to the number of distinct species, but also from the swarms of individuals of the same species. Many of them, also, have been constant attendants upon man in all ages. They do not attract attention from their size, however, for there are few that exceed an inch in length; nor is it on account of their beauty, for the majority of them are of dull colours; their forms, too, are rarely elegant, and the transformations of many are unknown. They owe the notice they have attracted chiefly to their habits, and especially to those which affect man and the domestic animals, both in their perfect and early states. However annoying these are, it must not be forgotten that other Diptera are of extreme service, by cleansing the surface of the earth of vegetable and animal impurities: the carcass that is full of maggots would be much more prejudicial in its decomposition than if it were not principally eaten up by these voracious creatures.

624. The mouth of these insects is formed only for imbibing fluid matter, and in many tribes is furnished (as formerly stated) with lancets for puncturing the flesh from which they suck the juices; both the channels through which they draw the fluid, and these accessory organs, consisting only of the usual parts of the mouth, altered in form and arrangement. The development of the portions of the thorax bears a relation to that of the wings. The first segment is very minute, as is also the third; whilst the second, from which arises the single pair of wings, that corresponds with the anterior wings of other insects, is greatly extended. The wings are membranous, and

665. How is the next order described?

666. What of their structure?

destitute of any covering, except at the base in some species, where there are few hair-like scales. Behind the base of these wings, there is a pair of small membranous appendages, termed *winglets*, which are usually regarded as the rudiments of the second pair of wings possessed by other insects, but which are probably to be really considered as appendages of the first. The true analogues of the second pair are the curious organs termed *halteres*, or poisers, which are very characteristic of this order, being present, even when the wings are wanting. These are two slender spiny organs, sometimes terminating in a little enlargement, like the head of a pin. They are generally kept in constant vibration, but nothing is known regarding their use. Their size is usually in inverse proportion to that of the winglets.

625. The Diptera all undergo a complete metamorphosis as far as the structure of the larvæ is concerned; these being generally cylindrical footless grubs, no representatives of legs being found except in a few species. But in many there is no proper transformation into the pupa state—the skin of the larva, which hardens, contracts, and shortens, becoming (as it were) the cocoon for the chrysalis. The body is detached from its interior, leaving the organs peculiar to the larva, such as the parts of the mouth, adherent to the inside of the skin. Shortly afterwards, the enclosed being assumes the form of a soft and gelatinous mass, without any of the parts of the future insect being visible; some days after,

Stratiomys Chameleon—Larva, Pupa, and Imago.

667. Describe their metamorphosis.

668. What of the diagram?

however, these organs become distinct, and the insect has then assumed the real state of pupa, though without having yet thrown off its larva skin. When ready to escape, it scales off the anterior end of its case like a cap. Many larvæ, however, throw off their skins, when assuming the pupa state, and some spin a regular cocoon. The duration of life in the perfect state is usually very short.

626. In subdividing the order, we first separate from it a small but remarkable group which forms the transition to the more aberrant orders of the class, especially the Aphaniptera. Some of them are entirely destitute of wings, and yet in their general structure correspond with the Diptera. They are distinguished from all other insects by their curious mode of reproduction. Not only are the eggs hatched within the body of the parent, but the larvæ are retained there until they have been transformed into pupæ, in which state they come forth into the world. Hence the group has received the name of PUPIPARA.

627. The remaining Diptera, constituting by far the largest proportion of the class, may be divided into four sections. In the first, NEMOCERA, the antennæ are composed of more than six joints, whilst in all the remainder the antennæ are short, not having apparently more than three distinct joints. In the second, NOTACANTHA, the last division of the antennæ is really composed of two; the proboscis does not project much from the mouth, and is furnished with only two lancets. In the third, TANYSTOMA, the antennæ have really only three joints, the last being usually terminated by a *se'a*, or bustle. And in the fourth, the ATHERICERA, the antennæ are only two or three-jointed, and the proboscis is withdrawn into the mouth.

628. Section I. NEMOCERA.—To the Nemocera belong the two families of CULICIDÆ and TIPLUIDÆ; the former known as the *Gnat* tribe, the latter as the *Harry-long-legs*. The former are distinguished by their beautifully tufted antennæ. Gnats are well known to abound chiefly in damp situations; the reason being, that their larvæ are inhabitants of the water. In this state they are very ac

tive, swimming with great agility, and often descending, but coming to the surface to breathe, which they do head downwards, the respiratory orifice being at the end of the tail. The head is furnished with a pair of ciliated organs, by means of which are produced currents in the water, that serve to bring them food. After undergoing several moultings, they become transformed into pupæ, which continue to swim by the action of their tails and two oar-like pieces at their extremity, but respire by openings in the thorax. When the final transformation occurs, the skin of the pupa, which is being cast, serves as a kind of raft, which prevents the perfect insect from being immersed in water. The penetration of the skin by gnats is accomplished by their delicate lancets, and the blood is then sucked up by the proboscis, a venomous fluid being discharged into the wound. Man is only attacked by female gnats, the organs of the mouth in males being fewer and weaker. The females deposit their eggs in the water, uniting them in a mass, which resembles a small boat. All the changes are effected, during warm weather, in the course of three or four weeks; so that many generations may be produced in the course of a year. The mosquitoes which infest many countries, especially in warm latitudes, differ but little from the common gnats. They sometimes appear in such swarms, especially in marshy districts, as to be kept off only by fire.

629. Of the *TIPULIDÆ*, the larvæ of some live in water, and resemble those of gnats, whilst those of others live in the earth, in the rotten parts of trees, fungi, &c. The former are known as midges; the ~~the~~ ne-flies, tailors, Harry-long-legs, &c., belong to the latter. Some species of this tribe are extremely injurious to the wheat crops, both in Europe and America. The eggs are deposited by the females in the centre of the corolla, and the formation of the seed is prevented by the voracity of the larvæ produced from them. The most destructive of the Ame-

670. What two families belong to the first section?

671. Describe each of these.

672. How is the next section divided?

rican species is known under the name of the Hessian fly.

630. Section II. NOTACANTHA.—The second section of the Diptera contains three families, STRATIOMIDÆ, BERIDÆ, and CÆNOMYIDÆ, which do not attract much attention, although some of the insects contained in them are very abundant. They are generally small but gaily coloured insects, and are most numerous in moist situations, in which the larvæ are generally produced. They mostly feed upon vegetable rather than animal juices.

631. Section III. TANYSTOMA.—The insects composing the third division have usually a more perfect mouth than those of the other sections; and they are also remarkable for the structure of the head of the larva, which possesses two claw-like appendages, by which they attach themselves to the substances from which they derive their support. Many of the perfect insects are eminently carnivorous or insectivorous, as are also some of the larvæ. To this group belongs the family of TABANIDÆ, the Gad-Fly tribe, to which belong the largest Dipterous Insects, pre-eminently distinguished for the tormenting powers which the different species possess, by piercing the skins and sucking the blood of various quadrupeds, and even of man himself. So noxious is one species of these insects to the cattle in some parts of Africa, that, according to Bruce, unless they are driven to the sandy regions when attacked by it, they forsake their food, and run wildly about the plains, dreading even its very sound, until they die, worn out with fatigue, fright, and hunger; even the lion is said to be afraid of them. Gad-flies are sometimes so numerous, that cattle are covered with the blood that flows from their punctures. It is remarkable, however, that as in the Culicidæ, only the females of these insects are blood-suckers, the males subsisting on the juices of flowers.

632. The family of BOMBYLIDÆ is remarkable for the bee-like form and habits of the insects composing it. They fly with astonishing rapidity, hovering at times over flow-

ers without settling, and extracting the nectar by means of their long proboscis, making at the same time a considerable humming with their wings. Their larvæ are stated, however, to be carnivorous; some of the tropical species feeding on the larvæ of the very bees they so strikingly represent.

633. Several other families, containing a very large number of genera and species, belong to this section; but as they closely resemble each other in structure and habits, and present little that is very peculiar in either, they need not be here particularized. They are mostly very active insects, some of them pursuing other insects on the wing and sucking their juices; others, like the Bombylidæ, chiefly deriving their subsistence from flowers. The tropical species are often brightly coloured; and all of them seem to prefer warm situations.

634. Section IV. *ATHERICERA*.—The insects of the fourth tribe of Diptera are principally vegetable feeders in their perfect state, only a few being carnivorous, or feeding on other insects; but their larvæ are generally extremely voracious, and will devour almost any kind of soft animal matter. This section includes the flies strictly so called, the bot-flies, and many other tribes.

635. The first family, that of *SYRPHIDÆ*, bears an extremely close resemblance to the humble-bees and wasps, in the nests of which some species of them deposit their eggs; others lay them amongst Aphides, which fall an easy prey to the larva when it is hatched. The perfect insects are very partial to flowers preferring the *Compositæ*; and they delight to hover immovably over certain spots, to which they will return, if disturbed, a considerable number of times. Above a hundred species inhabit Britain. In a few species, the larvæ are aquatic, and the posterior part of the body is prolonged into a respiratory tube, whence they have received the name of rat-tailed larvæ. The imago of one of these closely resembles in size and colour the male of the hive-bee.

636. The form and habits of the family *MUSCIDÆ*, or

Fly tribe, are generally known; the family is an extremely numerous one, above 1700 species having been recorded as existing in Europe, of which about half are indigenous to Great Britain; and there are probably at least as many more which have not been described. The strong general resemblance which exists among all the species, makes it very difficult (especially when their small size is considered) to discriminate them readily. The larvæ of these insects, commonly known as *maggots*, are soft, vermiform, footless grubs, possessing on the head a couple of retractile hooks, by which they can cling to the substances on which they feed. They devour various substances, both animal and vegetable, living, recently dead, or far advanced in putrefaction. They are extremely voracious, and multiply rapidly. The eggs are deposited by the female, as in other instances, in the neighbourhood, or in the very substance, of the food which is adapted for the support of the larva, however little to its own liking. The common meat-fly seems to be attracted to this by the smell; for it has been noticed to deposit its eggs in the flower of a species of arum, which exhales an odour like that of tainted meat. The larvæ of many species exist only in the dung of various animals, of which they are thus very useful in cleansing the ground. Those of others are very injurious to agriculturists, mining the interior of vegetables, especially the roots of corn. The larvæ of the *Rophila*, commonly known as *Cheese-hoppers*, are remarkable for their leaping powers. Their movement is effected by first bending together the head and tail, and then suddenly straightening the body. In this way, a larva, whose length was only a quarter of an inch, has been known to spring six inches, or twenty-four times its length.

637. The *ÆSTRIDÆ*, or *Bot-Flies*, are a family very remarkable in regard to their structure and habits. The perfect insects resemble large meat-flies in form, are very hairy, and generally have these hairs coloured in rings, like humble-bees; but they are seldom seen, the duration of their lives being very short in this condition. Their

chief peculiarity consists in the absence of any proper mouth in the imago (in which respect there is an analogy with the Strepsiptera), and in the peculiar habitation of the larva. This is always found in living animals; its situation, however, varying with the species of which almost every herbivorous mammal has one or more peculiar to it. The egg is deposited by some in situations where the larva may burrow into the flesh, and occasions there inflammatory tumours, the fluids contained in which afford it nourishment. In other cases, the eggs or larvæ, existing upon spots which the animal is in the habit of licking, are conveyed by the tongue into the mouth, whence they pass into the stomach. There they remain until full grown, and then they quit the body (as do also those that inhabit the flesh) and fall to the ground, beneath the surface of which they undergo their transformations. The larvæ of one species, which inhabits the sheep, are found in the cavities in the front of the bones of the skull, and higher parts of the nose. Man is subject to the attacks of one or more species, which do not, however, infest this country.

638. The Pupiparous division of the Diptera contains two families, the HIPPOBOSCIDÆ and NYCTERIBIDÆ, the habits of all the species of which are parasitic. The former, sometimes termed *Forest-Flies*, are of small size, covered with bristles, and sometimes destitute of wings. They are known to the French under the name of Spider-Flies. They reside upon quadrupeds and birds, running with great agility, and often sideways, burying themselves amongst the hair or feathers. That which is parasitic on sheep is known as the *tick*. One minute species infests the hive-bee; and this is remarkable, not only for being destitute of wings, but of eyes also. All of this order possess the *hatteres*, even when the wings are absent. In the other family, that of NYCTERIBIDÆ, both wings and balancers are entirely absent, and the general form more nearly approaches that of spiders. It contains but few species, all of which are parasitic upon bats, and are com

monly termed *bat-lie*. The head seems attached to the upper part, instead of the front, of the thorax, and the legs arise from the margin in such a peculiar manner, that what seems the upper side is really the lower. Notwithstanding the absence of wings, these insects move with such agility as almost to appear to fly.

Order IX.—Trichoptera.

639. This order is a very small one, and consists but of one tribe, the *PHRYGANEIDÆ*, which have been commonly associated with the Neuroptera. But there seems good reason for ranking them as a separate order, connecting the Neuroptera with the Lepidoptera, for they resemble the latter in the distribution of the nerves of the wings, and in the hairy covering with which both the wings and bodies are beset, as well as in many other characters.

640. The larvæ, well known under the name of *caddice-worms*, reside in cylindrical cases, open at each end, to which they attach various matters, as bits of stick, weeds, pebbles, or even small living shells, by the assistance of silken threads which they spin from the mouth in the same manner as caterpillars. These cases they bear about with them, protruding the three first segments, with their legs, when they creep forwards, and withdrawing these upon the slightest alarm; they never quit the cases of their own accord. Different species appear to prefer different materials for the construction of their cases, but they have the power of employing almost any which fall in their way, when those they prefer are deficient. The food of some of the larvæ is vegetable, but others prey upon smaller aquatic larvæ, such as those of Neuroptera. Some of the larvæ are furnished with external organs of respiration; others breathe by spiracles.

641. When about to assume the pupa state, the larvæ fix their cases to some solid substance beneath the water, and close the two extremities with a kind of grating, that

677. What other families are here described?

678. Describe the third order

679. What of their larvæ and pupæ?

admits of the passage of water through the tube, which is necessary for respiration. When nearly arrived at their perfect form, they make their way out by the pair of hooked jaws with which they are then furnished, and swim about with great activity by means of the two hind legs, crawling also upon the four first. The pupæ of the larger species creep out of the water, crawling up the stems of plants, &c., and undergoing their final change in the air; but the smaller ones merely come to the surface, where they shed their pupa skin in the same manner as gnats, the old envelope serving them as a raft. The perfect insects are of moderate size, seldom reaching a couple of

Phryganea Grandis;
A, Larva in its case; B, Grating; C, Imago.

inches in the expanse of their wings. They run with great activity, but their flight is generally awkward. They are most active in the evening or at night, and are not unfrequently attracted by the light into houses; they emit a disagreeable smell when touched. They live but a short time in the perfect state, taking no nourishment, and engaged only in propagating the race.

Order X.—Strepsiptera.

642. This is a small order, containing only a single group of insects, but these are so anomalous in structure,

that it is not merely impossible to associate them with any other order, but it is even difficult to assign their proper place in the class. They are all of small size, none being known to exceed a quarter of an inch in length; and they are all parasitic, in the larva state, upon the bodies of wasps and bees. The chief peculiarity of the adult insect consists in the very great development of the posterior segment of the thorax, which constitutes the greatest part of the trunk, the anterior segments being mere rings, and the abdomen very small. From this segment there proceeds a pair of wings, which are large, membranous, divided by longitudinal nerves, and folded lengthwise like a fan. Of the anterior wings, usually proceeding from the middle segments of the thorax, there are no traces, except a pair of curious organs which have been termed *pre-balancers*. These in form and substance might be compared to very small elytra, narrow, and somewhat club-shaped. This is the only instance in which, where one pair of wings only is present, it is the anterior pair that is undeveloped.

643. From the arrangement of the parts of the mouth, these insects are usually placed among the Mandibulata; but no oral aperture has been discovered, nor have they been ascertained to take any nourishment during their imago state, which is of very short duration. The larvæ, which are destitute of feet, are found in no other situation than beneath the scales of the abdomen of some species of the bee and wasp tribe. No mouth has been discovered in them; and it is believed that they obtain their nourishment by absorption of the juices that surround them, through the skin—a mode of alimentation to which nothing correspondent is known in animals so high in the scale. The larvæ undergo both changes in the same situation; so that after the perfect insect has escaped, the larva-skin remains in its original place, and the pupa-case is found crumpled up at the bottom of it. No distinction of sex has yet been detected; and it is uncertain when and how the eggs are deposited in the bodies of the animals on

which the larvæ prey. This singular group is one, therefore, particularly open to investigation. It seems pretty universally diffused, but has hitherto been chiefly studied in Britain.

WINGLESS INSECTS.

644. Besides the foregoing orders, which constitute the true Insects, three others must be included in the class on account of the correspondence in their general structure, although they present only one or neither of the two characters which have been stated to distinguish it—the presence of wings in the perfect state, and the metamorphosis. These three orders are—the APHANIPTERA, or *Flea* tribe, which have their rudiments of wings, and undergo a metamorphosis; the PARASITA, or *Louse* tribe, which is entirely destitute of wings, and undergoes no metamorphosis, but agrees with the true Insect in having only six legs; and the THYSANOURA, including the *Spring-tails*, in which there are appendages to the abdomen, representing the legs of the posterior segments, so that these may be regarded as approaching the Myriapoda.

Order IX.—Aphaniptera.

645. This order contains only one family, the PULICIDÆ, or *Flea* tribe, all of which are insects of minute size, and, like the Diptera (to which they are perhaps most nearly allied), of suctorial habits. Their larvæ come forth from the egg in the form of minute worms, possessing considerable activity, and feeding upon animal matter, a provision of which seems to be formed for them by the parent. They afterwards enclose themselves in a small cocoon of silk, which is often covered with dust, and in this they undergo their change into the pupa state. In their perfect state, the rudiments only of wings are visible, in the form of little scales, attached to the second and third segments of the body, in which there is no proper distinction of the thorax and abdomen. The habits of the common fleas of this

country are well known; but there is a West Indian species, which, though of minuter size, is still more obnoxious. This is the *pulex penetrans*, commonly known as the chigoe, or jigger. It chiefly attacks the naked feet, buries itself deeply in the skin, and then deposits there an immense number of eggs. The larvæ of these, when hatched, produce great irritation; and severe sores, from which death has sometimes resulted, often follow. These can only be prevented by extracting the animal, with its bag of eggs (consisting of the enormously distended abdomen), as soon as a slight but peculiar itching gives notice of its presence.

Order XII.—Parasita.

646. The insects of this order, the *Louse* and its allies, are regarded with the greatest disgust, by the common consent of civilized man, because their presence on the body is an indication of a gross want of cleanliness of habit. Most of the lower animals, however, are infested with one or more species, from the attacks of which they are unable to defend themselves; and man is subject to a peculiar disease, which seems very much to favour their production. Their generations succeed each other very rapidly. So constantly are the different species, which are very numerous, restricted to particular animals, that they are named from the species they infest; and it has been even proposed to employ the identity of difference of species in the louse appearing on two animals, the identity or difference of whose species might be doubtful (as the dog and wolf, or the different races of men), as a test of the latter. But this is straining the general law too far, since there are several animals which support more than one species. The Parasita are almost entirely destitute of eyes.

Order XIII.—Thysanoura.

647. In the insects of this order there is a remarkable diversity of structure, especially in regard to the mouth.

683. Describe the flea tribe.

684. Describe the twelfth order.

Some of them possess as complex an oral apparatus as the mandibulate insects; whilst in others there is scarcely a perceptible opening. The same is the case with regard to the eyes, these organs being fully developed in some, and almost rudimentary in others. The order contains two families. In the first, the LEPISMIDÆ, the abdomen is furnished on each side with a row of movable appendages like false legs, and is terminated by long-jointed bristles, of which three are more remarkable. These little insects leap very well; some frequent stony places, whilst another is found in sugar, and is known as the *sugar-louse*. In the PODURIDÆ, the appendages to the sides of the abdomen are wanting; but the extremity of it is prolonged into a forked tail, by which these insects can execute very surprising leaps; this, when in inaction, is applied against the belly. From this conformation they are popularly known under the name of *Spring-tails*. Some species are found upon trees and plants, others beneath stones, and some have been seen on the snow itself at the time of a thaw. Many, residing upon the earth or in sandy places, unite into numerous societies, and resemble at a distance a small quantity of gunpowder. The scales of the insects of both these families are extremely beautiful microscopic objects; those of the latter require a very high power and good adjustment to exhibit their delicate markings; and hence are employed as test-objects.

Podura Villosa.

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685. What of the next and last order?
 686. What different species are named?
 687. Describe this distinct class.
 688. How are they distinguished from insects?

CLASS VII.—ARACHNIDA.

648. The class of Arachnidæ, including the *Spiders* and their allies, was for a long time confounded with that of Insects, and has been only recently separated. The characters which they present are perfectly distinct from those either of Insects on the one hand or of Crustacea on the other; nevertheless they present numerous relations with both those groups. In regard to their general complexity of structure, they are probably to be considered superior to either; but in the development of those locomotive and instinctive powers, which are so peculiarly characteristic of the Articulated series of animals, they are decidedly inferior to Insects, to which, in this point of view, the highest rank must be accorded.

649. The Arachnida may be distinguished from Insects by the absence of any division between the head and thorax; and the compound mass thus formed is termed the cephalo-thorax. Again, Insects in their mature state are always provided with six legs and no more: the Arachnida have eight of these members. Moreover, their eyes are not compound, but more resemble those of higher animals. From Crustacea they are separated by the softness of their bodies (in which respect, however, they are approached by certain Macrourous Decapods termed Spider-Crabs), but still more completely by their exclusively atmospheric respiration. The organs by which this function is performed vary in different tribes. In the *Acari*, or Mites, and their allies, they resemble the tracheæ of Insects, and are distributed through the body, whilst in the *Spiders*, *Scorpions*, &c., they consist of rounded cavities, or air-sacs, into which the air is admitted by spiracles situated in the abdomen, and which are lined by a membrane plaited into numerous folds, which resemble gills, and lie in opposition like the leaves of a book. On this

689. How are they subdivided?

690. What are their habits?

character is founded the subdivision of the class into *pulmonary* and *tracheary* Arachnida.

650. The majority of the Arachnidæ feed upon insects, which they seize alive, or upon which they fix themselves, and from which they suck the juices. Others live as parasites upon the bodies of vertebrated animals. There are some, however, which are only found in flour, cheese, and upon various vegetables. These last, which mostly belong to the tracheary order, exhibit an affinity to insects, not only in their structure, but in their metamorphosis; for they undergo great changes after they come out of the egg, an additional pair of legs being often developed, whilst in the others nothing else than a moult, or casting of the skin, occurs.

Order I.—Trachearia.

651. The Trachearia, being the most nearly allied to Insects, are naturally the first to be considered. This order contains several remarkable forms, of which the one best known is that of ACARIDÆ, or Mites, the majority of the species of which, however, are very minute, or almost microscopical. They are very extensively distributed; some being wanderers under stones, leaves, the bark of trees, in the ground, or upon articles of food; whilst others subsist as parasites upon the skin and in the flesh of different animals, often greatly weakening them by their excessive multiplication. There are some species which infest insects, especially the carrion beetles. Some of this tribe much resemble spiders in form and habits, as, for instance, the *acarus telarius*, the red spider of hothouses, which forms upon the leaves of various vegetables, especially lime-trees, webs which injure them greatly. The *Ixodes*, of which the various species, known under the name of Ticks, are so annoying to some animals, also belong to this group. Although naturally much flattened in form, they acquire by suction a very large size, swelling out like a blown bladder; and they bury their suckers so completely in the flesh, that they cannot be detached

Acarus Domesticus
(Mite) magnified.

without great difficulty. Some interesting aquatic species of this tribe exist. The legs are of a form adapted for swimming, and are fringed with hairs to increase the resistance; the body is oval or round. In some instances, these Water-Mites appear to pass through an inactive or pupa condition during the progress of their metamorphosis; attaching themselves, in this state, to the bodies of aquatic insects.

a, *Hydrachna Globulus*; *b*, magnified; *c*, young larva; *d*, pupa.

652. Besides the *Acari*, which form the principal part of this order, there is a curious group which has received the name of *Pseudo-Scorpions*, owing to their possession of a pair of large claws terminating in forceps, which, like those of the true Scorpions, are formed by an excessive development of the organs which in insects are termed palpi. There is also a very curious family, which some naturalists have separated into a distinct order, the *Pycnogonides*; these are distinguished by the absence of all special respiratory organs, and in their aquatic habits bear a strong resemblance to Crustacea. They are found amongst marine plants, and under stones on the sea-beach. Their motions are remarkably slow, and they are said to live chiefly upon the animals of Bivalve Mollusca.

Order II.—Pulmonaria.

653. In this order the respiration is performed by means of air-sacs contained on the under side of the body, and opening externally by stigmata; sometimes these apertures are eight in number, four on each side, but sometimes four, or even only two. This diminution appears to indicate a gradual elevation in the character of the apparatus; leading us from the diffused condition in which it exists in Insects, to the more concentrated form it presents in higher animals. The Scorpions possess eight

breathing pores; and thus approach nearer to the Tracheary Arachnida than do the Spiders. They offer themselves next, therefore, to our consideration.

654. The family of PEDIPALPI is distinguished from that of Araneidæ, principally by the great development of the palpi, which form extended arms, terminated by a pincer or claw. The entire body is clothed with a hard skin. In the *Scorpions*, which constitute the principal part of this family, the abdomen is very much prolonged, forming a sort of tail, which is terminated by a sting, furnished with a venomous secretion. The wound of this sting, although very painful, does not seem to be ordinarily dan-

Scorpio Occitanus.

gerous. A small species inhabits this country; but it is between the tropics that the Scorpions attain their greatest development. They usually live on the ground, hiding themselves under stones or other bodies, among ruins, where such exist, and dark and cool places generally, even the interior of houses. They run quickly, and curve the tail over the back. They can turn it as an arm of offence or defence. They seize wood-lice and ground insects, upon which they feed, by means of their pincers; they then prick them with their stings, and convey them to the mouth. They seem particularly fond of the eggs of spiders and insects.

655. Besides the Scorpions, there is included in this family the tribe of *Tarantula** Spiders, which seem inter-

* These are not the animals known in the south of Europe under the name of Tarentula, receiving their designation from the city of Tarentum; the latter are true Spiders.

692. What various species are named?

693. How is the next order characterized?

694. What of the Scorpion family?

mediate in several respects to the Scorpions and true Spiders. They also possess the enlarged palpi, but the body has the general form of that of Spiders, and the spiracles are only four in number. These Arachnida inhabit only the hottest parts of Asia and America. They are unpossessed of a sting, and hence it may be supposed that their prey is of such a kind as not to require such a weapon for the mastery of it; but scarcely any thing is known of their habits. In one species the body is prolonged almost like that of the scorpion.

656. The other family of the pulmonary Arachnida consists only of the Spiders of various kinds, and is designated ARANEIDÆ. In these the palpi are not developed to any thing like the same degree as in the Scorpion tribe; they rather resemble feet; but the jaws are armed with sharp and hooked fangs, and are perforated near the points for the emission of a poisonous secretion provided for the destruction of their prey. Nearly all of them are furnished with organs, situated at the hinder part of the body, for spinning a very delicate silken thread; but the use to which it is to be applied varies in different species. In some it forms webs in which are entangled the insects on which they feed; in others, it is employed to make a delicate silken tube, which lines their habitation; and in others, it is chiefly used for the fabrication of a sort of cocoon with which the eggs are surrounded. The instruments by which this thread is produced are little teat-like protuberances, termed *spinnerets*, of which four usually exist at the posterior extremity of the abdomen. Each of these, when highly magnified, is found to be perforated at its extremity by innumerable orifices of extreme minuteness, through which is forced out a glutinous fluid, secreted by glands within. This fluid soon hardens by exposure to the air; and thus each thread, delicate as it may seem, is composed of several hundred, of extreme minuteness, coiled together, so that it possesses great strength in proportion to its diameter.

695. What other species is described?

696. What of the structure and habits of the Spider family?

657. No animals fall more universally under observation than Spiders. We see them everywhere, fabricating their snares, or lying in wait for their prey, in our houses, in the fields, on trees, shrubs, flowers, grass, and in the earth; and if we watch their proceedings, we may sometimes see them, without the aid of wings, ascend into the air, where, carried by their web as by an air-balloon, they can elevate themselves to a great height. Sometimes they assemble in very large numbers. The river Tagus was observed, in 1811, to be covered for more than half an hour by their webs; and spiders have been sometimes carried by a light breeze to a considerable distance from land. Mr. Darwin, in his recent voyage round the globe, noticed many thousands on the rigging of his ship, when sixty leagues from any shore.

658. The Spiders are all extremely voracious in their habits, feeding only upon prey which they have themselves killed. When they have got an insect between their claws, either by entrapping it in their web, or by their stealthy mode of pursuit, they plunge their poisoned mandibles into its body, and the bite is usually soon fatal. Sometimes, however, the insect has strength enough to resist its enemy, and to prevent the infliction of the fatal wound; and as a prolonged struggle might be very injurious to the spider, on account of the softness of its body, it generally retires from the contest if not speedily successful. Where its prey has been entangled in its web, however, the spider still further encloses it by a silken thread, and then retires until the insect has lost its strength by ineffectual struggles, when it soon despatches its victim. This family may be divided into two great groups, characterized by the number of pulmonary sacs and spiracles in each.

659. In the first group, possessing two pairs of these organs, we find but one genus, *Mygale*; but this is a very extensive and important one. The Spiders of this genus

697. What is said of their powers of locomotion?

698. What of their food?

699. How are they divided?

do not form webs to entrap their prey, but they construct with their silk a sort of tube, which serves as their habitation, and in which they lie in wait for such animals as may come within their reach. It is asserted that the largest species, which is a native of South America, feeds not only upon insects, but even upon the young of humming birds and other small animals. This, the *M. avicularia*, fixes its tube in the slits of trees, or amongst the leaves; when their legs are spread out, they occupy a circular space of seven or eight inches. The web is white, of a very fine texture, semi-transparent like muslin. Other species of *Mygale* burrow in the ground, and go under the name of Mining Spiders; of these some are found in the south of Europe. They construct in dry shelving situations exposed to the sun, subterranean cylindrical galleries, often two feet deep, and so tortuous that the traces of them are lost. These they line with a silken tube, forming at its entrance a movable lid, composed of silk and earth, attached to the silken lining by a sort of hinge; and this is adapted, by its size, situation, and weight, to close the opening so precisely as scarcely to allow its entrance to be distinguished from the neighbouring soil. When the spider enters its retreat, or passes out of it, the door shuts of itself. The mygale spins a sort of cocoon round its eggs, enclosing a hundred or more; they are hatched within it, and the young undergo their first changes before quitting it.

Mygale Fodiens.

660. The Spiders possessing only two respiratory sacs and apertures belong to the genus *Aranea*, which contains a very large number of species of very dissimilar habits, and has been much subdivided. The first section com-

700. Describe the first group, and its species.

701. What of the other genus and its divisions?

prehends the *Sedentary* Spiders, which construct webs, or at last throw out webs, for the capture of their prey, and generally station themselves upon or near their webs, as well as near their eggs; whilst the *Wanderers*, of which the second section is composed, do not spin webs, but lie in wait for their prey, or seize it by running. These are distinguished by differences in the arrangement of the eyes, which are placed close together on the front of the cephalo-thorax of the former; but in the latter are extended lengthwise upon it, the space occupied by them being as long as it is broad.

661. Each of these sections has been formed into numerous subdivisions, which it is not necessary to describe minutely. Amongst the spiders of the former, the *clotho* is remarkable for the curious habitation which it constructs for its young. It spins a kind of circular cocoon or tent, which it attaches to the under side of stones, or to crevices in rocks, by seven or eight points, leaving festoons between these, the edges of which are free. At first, this consists of only two folds, but others are gradually added; and, beneath them all, a lining of peculiarly soft texture is constructed for the reception of the eggs. The young remain in this for some time after they are hatched, and are supplied by the parent with food. The *argyroneta* forms a winter retreat for itself beneath the water. It spins an oval silken chamber, open at the bottom like a diving-bell, which it attaches by cords to water-plants. It then carries down successive bubbles of air beneath its body, by crawling down their stems; and these bubbles it transfers to its bell until it has filled it. It then takes up its abode in this cell, where it remains for the winter, first closing the mouth of the bell. The *Epeiræ* are among the most remarkable for the strength of their webs; some of the exotic species, which are celebrated for the variety of their forms, colours, and habits, spinning nets which are sufficiently strong to catch small birds, and even to annoy man when he happens to come in the way of many

702. What is said of the *clotho* and its web?

703. What other species is described?

together. Some species make a sort of cell in the vicinity of the web, which is sometimes composed of leaves brought

Epeira Diadema.

together and attached by threads, and is sometimes a silken tube.

602. The *Wanderers*, or Hunting Spiders, often display great cunning in the pursuit of their prey. There is a species, the *aranea scenica*, common in this country in summer, frequenting walls and windows exposed to the sun. It takes short leaps, stopping suddenly after a few steps, and raising itself upon its legs. When it discerns a fly, or especially a gnat, it approaches cautiously within leaping distance, when it darts upon it. It sometimes leaps perpendicularly from a great height, suspending itself by a thread, by which it can return. Many species construct silken nests among leaves, under stones, &c., into which they retire to take rest, to moult, and for protection against the inclemency of the weather. To this group belongs the *tarentula* of Italy and the south of France, the bite of which is said to produce severe and sometimes fatal symptoms, but which may be cured by music. It is certain, however, that these symptoms have been greatly aggravated by the imagination, and that it is only over the latter that music has any control.

704. Describe the *Wanderers*, and their varieties.

CLASS VIII.—CRUSTACEA.

663. The animals composing this group may be regarded as representing in the sea the Insects and Spiders of the land. Indeed, they were associated with those classes by Linnæus, in his class of Insects ; but they are separated from both by very important characters. Their chief distinction is in the breathing apparatus, which is adapted to aquatic and not to aerial respiration. Instead of the system of branching tubes which we find in Insects, or the lung-like cavities, which are a more concentrated form of the same structure, in the Arachnida, the Crustacea are furnished with fringes of gills like those of the Mollusca or Fishes, into which the blood is sent, as it were, out of the body, to meet the small quantity of air contained in the surrounding water. In the highest order of this class, the gills do not hang loosely from the body, but they are enclosed in a cavity having two orifices, through one of which a constant stream of water is introduced, that is ejected through the other by a curious mechanical contrivance. And in a few species of this order, there is a special provision for keeping the gills moist when the animal leaves the water, out of which it can live for a considerable period. The best known of these are the land-crabs of the West Indian islands.

664. It is not only by their aquatic respiration, however, that the Crustacea are distinguished, but also by the calcareous nature of their integument. The shell, as it is commonly termed, is a secretion from the surface of the true skin, just as are the shells of Mollusca from their mantle. There is this important difference, however, between the two, that whilst the latter is merely adapted to enclose loosely and to protect the general mass of the body, so that the locomotive appendages, when put in action, must be made to project beyond it, these being themselves unsupported by any hard skeleton, the former accurately

fits not only the trunk but the extremities also, and, as in the other Articulata, is composed of a number of rings, more or less regular in form, and accurately jointed together by an intervening membrane.

665. As no addition to the edges of these rings would increase their diameter, some other means must be provided for enabling the size of the shell to keep pace with the increasing bulk of the body. This is effected by the periodical *exuviation*, or throwing-off, of the old shell, and the formation of a new one. This change is preceded by evident illness on the part of the animal, which retires to its hiding-place at the time. The part of the shell enclosing the trunk splits usually at its under part, in such a manner as to allow the body to escape; but the shell of the legs and claws remains entire, though the fleshy parts are entirely withdrawn from their interior. This is the more remarkable, as the bulk of the claw is much greater than the diameter of the joint through which it is thus made to pass, and often the disproportion is extreme. When the shell has been thus thrown off, the animal is entirely unprotected, and it carefully conceals itself from its enemies. Its soft skin is soon covered, however, with a sort of mucous exudation, which contains a large quantity of calcareous matter, and speedily hardens. The reformation of the shell is facilitated by a store of carbonate of lime previously laid up in the stomach, where it forms the concretions commonly known as *crabs' eyes*; these disappear at this period, being absorbed, and then excreted on the surface of the skin.

666. The power possessed by the Crustacea of repairing injuries, is very remarkable in beings of such high organization. In the process of exuviation, it is not uncommon for a part of a claw to be lost, and this is very speedily replaced. The second joint from the body is that at which the fracture most commonly occurs, and it is probably the only one from which the new growth can issue; for, if the claw be broken off below that point, the animal itself

706. What other peculiarity is named?

707. What of exuviation, and its use?

effects the removal of the upper portion, either simply casting it off by violent muscular contraction, or striking it against some hard body. The same is the case when the claw has been accidentally lost in some other way; and, accordingly, it is by no means uncommon to witness a great disproportion in the size of the two members, one being much smaller than natural, from its having been only recently produced.

667. The number of legs possessed by the Crustacea is greater than that of perfect Insects, being never less than four pairs, besides the pair of claws, which may be considered as metamorphosed legs. It is in the crab, lobster, crayfish, &c., that we find this small number; and these belong to the highest order, the Decapoda, or ten-footed Crustacea. In front of these are some curious organs termed feet jaws, being intermediate in structure between these two kinds of appendages; in some of the lower Crustacea these become true legs. And from the posterior part of the body there hang down certain appendages, which are also true legs in the lower orders. In fact, the lowest Crustacea approach very closely to the Myriapoda in their general form and structure, differing chiefly in their aquatic mode of life; the segments of the body are nearly equal, and are each furnished with a pair of legs. On the other hand, among the Decapods we find an approximation to the form both of Insects and Spiders—the lobster representing the one, and the crab the other. In the lobster we have a regular division into *head*, *thorax*, and *abdomen*, as in Insects; and it is to the thorax alone that the locomotive appendages are attached, as in the perfect state of the insect. There is no rudiment, however, of wings. As in the insect, we find that, where the force is concentrated in one part of the body, and the general movement is effected chiefly by the members, the segments of that part are consolidated; and, accordingly, the thorax of the lobster seems, until carefully examined, as if composed of a single piece. The segments of the abdomen, however, are movable on each other; and their

motions assist in progression, the flattened tail serving as a fin by which the water is struck. In the crab, the head, thorax, and abdomen, are all consolidated into one mass ; but the division into segments is still evident on the under side.

668. The Crustacea, in general, at the time of their first emersion from the egg, differ considerably from their adult forms, especially in the number of their legs. The changes which subsequently take place can scarcely be regarded as amounting to a metamorphosis like that of Insects, although in some instances they approach very near to it. In general, they principally consist in the modification which the appendages of the anterior segments undergo, these being sometimes converted into true jaws, sometimes into legs, and sometimes retaining their mixed character. In other cases, especially among the Decapods (as in the common ditch-prawn), we find an absolute change of members—those which the animal possessed, on its emersion from the egg, combining the characters of legs and respiratory organs, like the permanent members of the lower orders ; and these being replaced, after the skin has been several times thrown off, by true legs and separate respiratory appendages. Thus, the members of the different orders of Crustacea have a much greater resemblance to each other in their young state than subsequently ; for it is only in the progress of their growth that the characters which distinguish species and genera, and even orders, evolve themselves ; and hence there has been much confusion among naturalists regarding them.

669. As in all other Articulata, the eyes of the Crustacea are compound. Their external coating is thrown off with the shell ; and this, when examined with the microscope, is seen to exhibit the division into minute lenses with beautiful distinctness. By its transparency the cast shell may be at once distinguished from one in which the animal has died. It is interesting to find this structure preserved in great perfection in a curious fossil tribe of this

709. What of their variety of structure ?

710. What changes do they undergo ?

class, the *Trilobites*, the compound structure of whose eyes, mounted as they are upon short footstalks, is at once distinguishable with a magnifying glass, proving them to have been articulated animals, even if no other evidence existed to that effect. The Crustacea also possess organs of hearing, and perhaps also of smell. Their senses do not seem, however, to be acute; and that of touch, which probably exists chiefly in the antennæ, must be especially dull, in consequence of the hard casing which encloses the whole body. Their movements are ordinarily slow, and some are almost inert.

670. In these respects, then, the Crustacea appear to partake in the characters of the Mollusca, to which they approximate in some degree through the *Trilobites* and their existing allies, which have an affinity with the Chitons. They also resemble the Mollusca in the high development of the nutritive system. The stomach is furnished with a very complex apparatus of teeth, adapted to bruise and tear in pieces the alimentary matter submitted to their action; and the liver, and other glands furnishing products which assist in digestion, are of large size, and of much greater complexity of structure than the corresponding parts in Insects. The heart is muscular; and the circulation of the blood takes place through a regular series of vessels, which convey it to the gills after it has been rendered impure by passing through the body, very much as in the Mollusca. The structure is greatly simplified, however, in the lower forms of this class, which includes a greater variety, in regard to degree of organization, than most others. There is also a vast variety in size; some are by far the largest of the sub-kingdom to which they belong, whilst others are very minute. The largest size is usually attained by those of inactive habits, which may be regarded as leading a *vegetative* kind of life, like that of the Mollusca; whilst the most active species, such as the shrimp, are almost invariably small, like other Articulata.

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711. What of the organs of the senses?
 712. What fossil tribe is named?
 713. What of their digestive apparatus?

671. The attentive study of the geographical distribution of this class by a distinguished naturalist, M. Milne-Edwards, has enabled him to attain certain general principles, which will probably apply, with some modifications, to many other classes. The following are the most important:—1. Each species appears to have had its own central origin and limited distribution. Very few species are found to inhabit regions at a distance from one another; and those which are, are generally the best adapted for locomotion. 2. Though the number of *individuals* does not seem less in the northern than in tropical regions, it appears that the different forms and modes of organization tend to become more numerous as we approach the equator. 3. These differences become not only more numerous but more important. The number of natural groups increases with the temperature; and it is only in tropical regions that we meet with the extremes of dissimilarity of structure. 4. The species most elevated in the scale are deficient in polar regions, and their proportional number augments as we approach the equator. 5. The hottest regions are those in which we see the peculiarities of structure, characteristic of particular groups, carried to the highest degree. 6. Certain general forms are found to prevail in different regions, although the species are different; thus, although the Crustacea of the tropical seas of India and of America are distinct as to their species, they have a great general analogy in their relations to each other, and in their differences from those inhabiting particular localities in colder regions.

672. Owing to the great varieties of structure which this class includes, its division into orders appears very complex. Thirteen are established by M. Milne-Edwards; the characters of which will now be generally stated. As many of them, however, contain but a few species, of which little is known, a more detailed account will be given of those only which possess more universal interest.

673. The class Crustacea may be separated, in the first instance, into two divisions. In one of these, including

the great bulk of the class, the mouth is furnished with organs specially destined for the prehension or division of the food. In the other, there are no special organs for the purpose, the bases of the neighbouring legs serving the purpose of jaws. This *second* division contains but one order, the *XYPHOSURA*, and this contains but one genus, the *Limulus*, or King-Crab, which will hereafter be noticed in detail. The *first* division is then separated into two groups—one, the *MAXILLOSA*, having the mouth furnished with jaws; the other, the *EDENTATA*, having the mouth prolonged in the shape of a sucker. These two groups are precisely analogous to those of *Mandibulata* and *Haustelata* among insects. The *EDENTATA* are divided into three orders, according to the form of the extremities.

674. *ARANEIFORMES*, in which the extremities are rod-like, long, and adapted for walking.

675. *SYPHONOSTOMATA*, in which the extremities are not adapted for walking, are partly formed into plates, and partly adapted for prehension.

676. *LERNÆIFORMES*, in which the extremities are but little developed, and the body presents great variety of form. Most of these are parasitic upon other animals, especially fishes, to which they cling by means of hooks in which their rudimentary extremities terminate.

677. The *MAXILLOSA*, containing by far the larger proportion, as well as the most highly organized forms, of the class, are again distributed into four sections. (I.) *PODOPHTHALMIA*, in which the eyes are mounted upon footstalks and are movable. These have almost always branchiæ, properly so called; their feet are partly ambulatory, partly prehensile; and the thorax is covered with a *carapace* or shield (like the upper shell of the turtles), which is formed by the great development of one of the rings, overlapping the rest. (II.) *EDRIOPHTHALMIA*, in which the eyes are *sessile*, or not mounted on a pedicle. The branchiæ are not separate organs, being united with the extremities; these are almost always seven on each side, and adapted for

walking. There is no carapace. (III.) BRANCHIOPODA, in which there are no gills, but the anterior pairs of legs are flattened into plates, which are subservient to respiration. (IV.) ENTOMOSTRACA, in which there are no branchiæ, or any apparent organs to supply their place. The eyes are sessile, and commonly united into a single mass.

These groups are again subdivided into nine orders, as follows :

678. (I.) The Podophthalmia consist of the DECAPODA, in which there are five pairs of thoracic extremities, and which have the gills enclosed in a special respiratory cavity ; and the STOMAPODA, which have six or eight pairs of thoracic extremities and external branchiæ.

679. (II.) The Edriophthalmia contain three orders—the AMPHIPODA, in which the thoracic members are subservient to respiration, and the abdomen well developed, and furnished with six pairs of limbs ; the LÆMODIPODA, in which the abdomen is not developed ; and the ISOPODA, in which the abdomen is well developed, and its members, which are similar in form to the rest, subservient to respiration. It is this order which most resembles the Myriapoda.

680. (III.) The Branchiopoda contain two orders—of which one, the CLADOCERA, has a carapace in the form of a bivalve shell, with five pairs of thoracic members ; whilst in the other, the PHYLLOPODA, there is no carapace, and the extremities, which are formed for swimming, are more numerous, varying from eight to twenty-two.

681. (IV.) The Entomostraca are also divided into two orders—the COLEPODA, which have the body divided into distinct rings, but without carapace, and the appendages to the mouth in considerable numbers ; and the OSTRACPODA, in which the body is without annular divisions, and entirely enclosed under a large shield having the form of a bivalve shell, the extremities being in very small number. In some members of this division we find a very close approximation to the higher Rotifera.

716. Into what four sections are the Maxillosoa divided ?

717. What of the variety in these groups ?

Order I.—Decapoda.

682. It is in this order that we find the highest general organization, the largest size, and the most varied habits ; it is the one most useful to man, and most interesting to the naturalist. The lobsters, crabs, cray-fish, prawns, shrimps—in fact, nearly all the species that are ever used as food, belong to it. Their growth is slow, but they ordinarily live a long time. Their habits are mostly aquatic ; but none of them are killed at once by being withdrawn from the water ; and some of them pass the greatest part of their lives in air. They are naturally voracious and carnivorous ; the first pair of legs is usually transformed into a pair of powerful claws, by which they seize their food, and convey it to the mouth. This order contains three families—the BRACHYOURA, or short-tailed Decapods, to which the name of *Crabs* is commonly given ; the MACROURA, or long-tailed, such as the lobster, cray-fish, &c. ; and the ANOMOURA, in which the abdomen is prolonged, but destitute of a shell, so that the tail is soft, and which inhabit the shells of Mollusca, in which they seek protection.

683. As illustrations of the structure and habits of the BRACHYOURA, the common *Crabs* will suffice ; but a peculiar tribe, that of the *Land-Crabs*, should be specially mentioned. These often live at a considerable distance from the sea, and even burrow under ground. Their gills are kept moist by a kind of spongy structure in the interior of the cavity which encloses them ; and from this a sufficient amount of fluid is secreted to prevent them from being dried up. Some species, though living on land, are confined to damp situations. Others, however, ordinarily inhabit elevated regions, and migrate towards the sea once a year to deposit their spawn. All the grass through the Deccan (in Hindostan) was noticed by Bishop Heber to swarm with a small land-crab, which burrows in the ground, and runs with swiftness, even when encum-

718. What of the first order and its species ?

719. Describe the families into which it is divided.

bered with a bundle of food as large as itself; this food consists of grass, or the green stalks of rice. The same species has been found on table-lands 4000 feet above the sea; and it is believed not to need migration for the purposes of reproduction. This migration is constantly noticed, however, in the West Indian species, which go down to the shore in large bodies, not allowing any obstacle to interfere with their progress. They are nocturnal in their usual habits, concealing themselves in their burrows during the day.

684. The *MACROURA* are distinguished not only by the length of their tail, but by having it expanded at the extremity into a pair of fin-like processes, which afford valuable assistance in swimming. This family is a very extensive one, and contains the largest species of the whole class. One of these is the *palinurus*, known in this country as the spiny lobster, which, when loaded with eggs, weighs twelve or fourteen pounds; and the tropical species attain a much greater size. The *cray-fish* may be regarded as a fresh-water lobster, the structure of the two being closely allied. It hides itself under stones or in burrows, on the banks of rivulets and streams, whence it only comes forth in search of its food, which consists of small mollusca and fishes, the larvæ of aquatic insects, and carcasses of animals floating in the water. The eggs, when laid, are attached under the abdomen of the female, where they are carried by her until hatched; and the young, which are very soft at birth, take refuge beneath the tail of the parent for some days. The *opossum-shrimp* carries this kind of protection still further, having a membranous pouch between the thorax and legs, in which the eggs, and the young for some time after they are hatched, are protected.

685. The Decapods of the family *ANOMOURA* are commonly known by the name of Hermit-Crabs, from their remarkable habit of seeking protection in the empty shells of molluscs. The shells they seem to prefer for this pur-

720. What of the tribe of Land-Crabs?

721. What of the second family, and its varieties?

pose are those belonging to the family Trochoidæ. The abdomen or tail is inserted into the upper part of the cavity, of which, after a time, it assumes the perfect form, so that, when withdrawn, it presents all the markings of it. The thorax and head occupy the lower part of the spire; and the mouth is closed by one of the claws, which is usually larger than the other, and serves as an operculum when the animal is withdrawn. When they outgrow the habitations they have selected, they quit them and go in search of others; and they try one shell after another, by slipping the tail into it, until they have found one whose size and form suit them. Those which ordinarily live on the shore feed on dead fish and other garbage; but there are some which ascend trees in search of vegetable food. There is one genus, *Birgus*, much larger than the rest, which hides itself in crevices of rocks, or forms burrows in the earth, instead of seeking a shell; and one species of this, which inhabits the islands of the Polynesian archipelago, ordinarily lives at the roots of coconut and other trees, which it climbs for the sake of their nuts, and from these it extracts the soft interior with great dexterity.

Order II.—Stomapoda.

686. This is a much less extensive order, and the species it contains are entirely marine, and mostly confined to tropical climates, on which account comparatively little is known of them. Some of them have powerful

Squilla Mantis.

claws, which they use for seizing their prey in the same manner as the Orthoptera among insects; so that these

have received the name of Sea Mantes. The accompanying figure shows one of the most characteristic forms of the order, which is abundant in the Mediterranean. The gills are there seen to be affixed, in separate tufts, to the abdominal appendages.

Order III.—Amphipoda.

687. This is an extensive order, in regard both to the number of species contained in it, and the amount of individuals which are sometimes seen collected together. The greater number of them are marine, but some are found in brooks and reservoirs; all, however, are more or less aquatic in their habits. They are of small size, and swim and leap with agility. The best known British species is the *sand-hopper*, which burrows in the sand, and which, unlike the greater part of the order, seldom enters the water. An animal not very dissimilar, called *pernys* by the French, is abundant on the coast of La Rochelle, where it forms extensive burrows in the sand. It keeps up a continual war with the nereids and other marine Annelida, which take up their abode in the same place. At the rising of the tide, they may be observed to assemble in myriads, beating the mud with their long antennæ in order to discover their prey. If they discover any Annelida, though often ten or twenty times larger than themselves, they unite together to attack and devour it. They also attack fishes, mollusca, and dead bodies on the shore; but they are themselves the prey of other fishes and of shore-birds.

Order IV.—Læmodipoda.

688. Of this small order, one of the most interesting and characteristic species is the *cyamus*, commonly called the whale-louse, from its infesting the Cetacea as a parasite. Sometimes these creatures are so abundant on the surface of whales, that the individuals they infest may be recognised at a distance by the white colour these parasites impart to them.

Cyamus Balænarum.

Order V.—Isopoda.

689. These Crustacea not only resemble Myriapoda in external form, but in many parts of their internal structure. The heart, for example, is not a short muscular cavity, but has the form of a long vessel lying upon the intestine. The females carry the eggs under the front of the body; and these are either defended by scales, or in a pouch or membranous sac, which is opened in order to allow the young ones to escape. The greater number live in water; but many species, such as the common wood-louse, are inhabitants of the land. Having no special apparatus, however, for keeping the respiratory surface moist, they can only exist in damp places. The *oniscus*, or wood-louse, frequents dark and concealed places, such as cellars, caves, chinks in walls, or hollows under stones. It feeds upon decaying vegetable and animal matter, and only comes forth from its retreat in damp weather. It has the power of rolling itself completely into a ball.

Order VI.—Cladocera.

690. The Crustacea composing this and the three following orders are of very small size, so that the details of their structure can only be examined with the microscope. They mostly inhabit fresh waters, and are in almost constant motion. A characteristic example of this order is the common *daphnia pulex*, or water-flea, which may be found during the summer in almost every pond, and is recognised by its very rapid and sudden movements, resembling the leaps of the animal after which it is named. These are principally executed by a pair of large branched antennæ, which serve as oars. They feed principally on vegetable matter, but also on animalcules. They are found at the surface in cloudy days, and in the mornings and evenings at other times; but when the middle of the day is hot, they seek the depths of the water. The eggs are hatched in a bag under the body of the parent.

724. What of the structure and habits of the fifth order?

725. Describe the sixth order.

Order VII.—Phyllopoda.

691. To this order, which is characterized by the prolonged form of the body, and the flattening of the extremities which adapts them for swimming, belongs a large

Branchipus Stagnalis.

number of species, whose movements are generally very regular and equable. The *branchipus*, one of the most characteristic examples, is found often in great numbers, in small puddles, and most abundantly after heavy rain. The eggs are capable of being dried up without injury, and are hatched soon after being moistened. To this order belongs the *artemia salina*, or brine-shrimp, which is found in salt-pans when the evaporation is considerably advanced. Its metamorphoses are very remarkable, and the aspect and movements of the perfect animal are very beautiful and interesting.

Order VIII.—Copepoda.

692. The animals of this and the next order are commonly termed *monoculous*, from the two eyes being united into one mass. In their general habits they agree with the former. The *cyclops* is an interesting species, very common in the ponds and ditches of this country. The female has an oval sac on each side of the tail, in which the eggs are carried. She is able to produce ten broods in the course of three months; and as these are speedily able to reproduce themselves, it

Cyclops Vulgaris, magnified

726. How is the seventh order distinguished?

727. What is remarkable in the eighth order?

has been calculated that, in a year, 4,442,189,120 young may be the progeny of one individual. The majority of the animals of this order swim with the back downwards, darting about with great agility and moving backwards or forwards with equal ease. In the absence of animal matter, on which they usually feed, they attack vegetable substances.

Order IX.—Ostrapoda.

693. In habit and general character, the animals of this order, of which the common *Cypris* of our ponds is an example, closely resemble those of the last; but their bodies are enveloped in a sort of bivalve shell. They swim, like the *Daphniæ*, by means of the prolonged antennæ, which spread at their extremities into tufts of filaments. The *Cyprides* appear to have been extremely abundant in former epochs of the earth's history, for their remains are now found in such numbers, as, in spite of their individual minuteness, to form extensive beds. A thin transparent section of the Sussex marble, for example, shows that almost the entire mass is composed of an aggregation of these minute animals, interspersed among the shells of the *Paludinæ* which it contains; and what appears to be the inorganic calcareous matter binding the whole together, is probably derived from the decomposition of a part of these delicate envelopes, which notwithstanding their transparency, contain a considerable amount of it.

694. The animals of the division *EDENTATA* are nearly all parasitic. In their general organization they are the most imperfect of all Crustacea; some of them approaching the higher Entozoa, whilst others have a resemblance to the lowest Arachnida. The various species of these orders, which need not be more minutely particularized, infest, more or less, almost all marine animals.

695. There now only remains the remarkable order,

728. Describe the ninth order, and their antiquity.

729. What distinguishes the division *Edentata*?

Xyphosura, separated from all the rest by the absence of any special organs for conveying food into the mouth. It receives its name from the sword-like prolongation of the carapace, which is used as a weapon by the natives of the regions in which the animals exist. The *Limuli*, or King-crabs as they are commonly termed, are peculiar to the East Indies (abounding in the neighbourhood of the Molluccas) and the coast of America. They sometimes attain the length of two feet. Their legs are very short, not extending beyond the margin of the shell. The anterior ones seem to assist in conveying food to the mouth, and the posterior are modified for respiration.

Limulus
Polyphemus.

696. Near the *Limuli* should probably be placed the remarkable group of *Trilobites*, which are at present only

Asaphus Expansus.

Same rolled up.

known in a fossil state, but which were very abundant in former epochs of the earth's history, especially at the *transition* epoch, intervening between the formation of the primary rocks and the deposition of the coal series. They are, therefore, among the most ancient animals whose remains are preserved to us. They abound in the Dudley

730. What of the King-crabs, and their species?

731. What of the fossils named?

limestone, along with Encrinites and Mollusca. In their external aspect there is a distinct evidence of their articulated character, in the division into regular segments ; and this evidence is confirmed by the character of the eyes already noticed. The body is divided along its whole length by two furrows, into three lobes ; whence the name given the group. There can be no doubt, from the character of the animals with whose remains it is found, that the trilobite was an inhabitant of the water ; and as its integument was evidently hard and articulated, it must have been a Crustaceous animal. But no remains, or only very slight rudiments, of feet can be detected ; whence it probably passed its life adhering to rocks, like limpets, or their allied species the chitons, which it resembles in the division of its shell and in the power of rolling itself up.

CLASS IX.—MYRIAPODA.

697. The class Myriapoda is the lowest, in the descending scale, in which we meet with articulated members, or distinct jointed legs, as well as with an articulated body. These are intermediate in their conformation between the more highly organized legs of Insects and the simple bristle-like appendages possessed by some of the Annelida ; and this is exactly the place to which we should refer the animals of this class, from a regard to their general structure. For, on looking at the form of their bodies, we observe that they are distinguished by an uniformity in the character of the segments, nearly as great as that which prevails in the Annelida ; so that an *iulus* might almost be likened to an earthworm provided with a stiffened integument and with slender legs. Whilst, on the other hand, the adaptation of the respiratory organs to breathe air with regularity and energy, the increasing complexity of the apparatus of mastication,

732. What is said of these fossil species ?

733. Describe the ninth class.

the possession of distinct eyes, and many other characters, indicate their affinity with Insects—in which class, indeed, some naturalists comprehend them.

698. Most persons are familiar with the common forms of this class—the *Centipedes* (hundred legs) and the *Millepedes* (thousand legs); and a minute description of them is therefore unnecessary. On examining any of these animals, the following points will be observed. The covering of the body is firm, and of a somewhat horny character, resembling that of many insects. The division into segments is very distinct; a flexible membrane being interposed between each pair of firm rings or plates. This is obviously required by the condensation of the skin; since, if it were otherwise, the body would not have the power of bending in any direction. The legs are covered by the same kind of integument, and are jointed in a similar manner; each terminates in a single claw or hook. No division of the body into distinct regions, like those which are so evident in the true Insects, can be observed; but, on the contrary, the segments are nearly equal along its whole length, and each is provided with one or two pairs of legs. The first segment, or head, is furnished with eyes formed upon the same general plan as those of insects; and also with a pair of long jointed appendages termed *antennæ*, which are probably organs of touch. On the side or under surface of the animal may be seen a row of minute pores, a pair usually existing on each segment, which are the apertures for the admission of air to the respiratory organs. The different parts of the nervous system are repeated in a similar manner, a pair of ganglia being found in every division of the body.

699. The Myriapoda may be divided into two orders, the IULIDÆ, or *Millepedes*, and the SCOLOPENDRIDÆ, or *Centipedes*.

Order 1.—Iulidæ.

700. The Iulidæ, consisting of animals bearing a general resemblance to the *iulus* or common millepede, are the

734. What familiar forms are cited?

735. How is this class divided?

most nearly allied to the Annelida, both in external form and in the arrangement of the several organs. The *iulus terrestris*, or gallyworm, is a species often found concealed under stones, or beneath the bark of decaying timber. Its body is long and cylindrical, and is composed of between forty and fifty hard rings, which, except at the head and tail, differ but little from one another. Each segment gives origin to two pairs of small legs, which arise close to the middle line along the under surface of the body.

These are scarcely large or strong enough to support its weight, so that the animal moves but slowly, and seems rather to glide or crawl than to walk. When at rest, the body

Iulus.

is rolled up in a spiral form; and the feet, being concealed in the concavity of the spire, are protected from injury; whilst the firmness of the rings of the body enables them to resist considerable pressure. These animals are furnished with another means of defence, for they are capable of emitting a fluid of very disagreeable odour from a series of orifices which may be seen on each side of the body. These orifices have been mistaken for the *spiracles* or respiratory pores, which are situated along the under surface. The annexed figure represents the *iulus*, with the body coiled up, the front of the body unrolled, and the antenna magnified.

701. The mouth of the *Iulidæ* is furnished with a pair of stout horny jaws, moving horizontally, and furnished with sharp toothed edges; and by means of these, they are enabled to divide with facility the portions of decaying vegetable matter upon which they usually feed. These animals are very harmless to man, not being possessed of any poisonous organs; and they may be regarded as positively benefiting him, by the removal of substances the decay of which would be noxious. The common *iulus* of this country seldom much exceeds an inch in length, but

there is a South American species (*I. maximus*) which attains the length of seven inches.

702. The *Iulidæ* deposit a large number of eggs in the ground. The young, when it comes forth, is nearly or altogether destitute of legs, resembling a short worm, of which the segments are few and indistinct. In a few days it changes its skin, and the division into segments then becomes apparent; in this change it acquires three pairs of legs, which are situated upon the three anterior segments of the body, the remainder being destitute of any appendages. Some days afterwards, the skin is again cast, and the young iulus then acquires seven pairs of legs. By successive changes of this kind, the species on which these observations were made (by Savi) obtained at the fifth moult forty-three pairs of legs, disposed on thirty segments, and at the final change the number of segments is increased to thirty-nine. These changes cannot be regarded as analogous to the metamorphosis of insects, in which the tendency is to diminish the number of legs and to concentrate the segments; but they rather resemble the annual exuviation of the skin in serpents, which correspond so closely in their general aspect with the *Iulidæ*.

Order II.—Scolopendridæ.

703. The animals composing the order Scolopendridæ may be distinguished from the *Iulidæ* by the greater development of the legs, by the diminution in their number, and in that of the segments, and by the flattened form of the body. The segments, instead of being composed of rings, are formed of two firm plates, covering the upper and under surfaces of the body, and united by a membrane at the sides. By this arrangement great freedom of motion is given to the body as well as to the legs; and these animals are not only enabled to run with facility, but, in spite of the breadth of their bodies, to wind their way through very tortuous passages. They lurk in the

737. What is said of its structure and habits?

738. What periodical changes do they undergo?

same dark and moist situations as the Iulidæ, but they prey upon the insects which frequent these, and upon decaying animal rather than vegetable matter.

704. Of the carnivorous propensities of the Scolopendridæ, the structure of the mouth affords sufficient evidence. It is provided, not only with a pair of horny jaws resembling those of insects, but with a pair of strong sharp claws, formed by an enlargement of the second pair of legs, which are perforated at the tip with a minute aperture through which a venomous fluid is probably instilled into the wounds made by them. Small insects seized in these claws are seen to die very speedily ; and in warm countries the bite of the large species of Centipede is a source of great irritation to man, being reputed more injurious than that of the Scorpion, though it is seldom fatal. The application of ammonia is the most effectual remedy for the pain, as well as for the constitutional effects of the bite.

705. The last pair of legs, also, undergoes some modification in this order, being directed backwards so as to form a kind of double tail, and not being used for walking except when the animal is moving backwards. The spiracles may be observed on the sides of the body, disposed regu-

a Lithobius Forcipus ; *b* Geophilus Longicornis.

larly like those of insects. The antennæ are longer and more perfectly formed than those of the Iulidæ ; and their eyes are more highly organized. Altogether, their structure is evidently adapted to a more active mode of life

739. How is the next order distinguished ?

740. What is peculiar in their structure and habits ?

741. What is the remedy for their bite ?

than that to which the first order is destined; and we have here an opportunity of remarking the difference, which becomes still more striking in higher classes, in the general conformation of animals of the same group, according as they are to be adapted to vegetable food always within their reach, or to search for and prey upon living animals.

706. The European species of this order seldom exceed two or three inches in length; but they present themselves by no means unfrequently. Like the *Iulidæ*, they frequent dark places, hiding themselves under stones, the bark of trees, in the ground, and especially in over-ripe fruit, which is likely to attract insects. In tropical climates, however, they attain a much larger size, and abound still more. Centipedes of the length of fifteen inches have been brought to this country; and it is stated by Ulloa that at Carthagena they have been seen exceeding a yard in length and five inches in breadth, and that the bite of these is mortal. It is doubtful, however, whether this statement may be relied on.

707. One of the British species, the *geophilus electricus*, deserves especial notice, on account of its power of emitting a phosphorescent light by night, nearly as bright as that of the glow-worm. It is about three-quarters of an inch long, of a dirty buff colour, with a black line down the back. During the day it resides under stones and in moss, and at night it is often seen on the footpaths. It leaves a strong light upon the fingers when handled. There is another luminous species, the *scolopendra phosphorea*, which is recorded by Linnæus to have fallen from the air upon a vessel in the Indian Ocean, a hundred miles from land.

742. What species are named?

CLASS X.—ANNELIDA.

708. The class of Annelida is the lowest in which the articulated structure is distinctly manifest. It is composed of animals having a worm-like body, without true jointed legs; and marked by transverse lines that divide it into a succession of rings or segments, which, except the first and last, differ little from each other but in size. Many of them are remarkable for the red colour of their blood; and, on account of this character, they have been regarded as approaching nearer to the vertebrated sub-kingdom than any other class of articulated animals. This is not universally observed, however, for in some species the blood has a greenish tint, and in others it is nearly colourless, as in Invertebrata in general. The body is usually soft and flexible, the rings being possessed of little firmness, and no internal skeleton of any description being present. It is not only flexible, but capable of great alteration in its dimensions as may be seen in the common earth-worm or leech.

709. The greater part of this class are solely inhabitants of the water, and are provided with external appendages for exposing the blood to its influence, which are analogous in function to the gills of fishes, but which are often distributed over the whole surface, and are also concerned in locomotion. It may be regarded as the *regular* form of these animals to possess such appendages upon every segment. But not unfrequently the body is enclosed in a tube, and then the gill-tufts are collected in the neighbourhood of the head, where they may be protruded from its opening. The earth-worm and a few other species are adapted to live on land; and they have a series of air-sacks arranged along the interior of the body on each side, opening externally by a small orifice, of which a pair may be seen on each segment.

710. The first segment, which may be termed the head, contains the mouth, sometimes provided with a formidable apparatus of jaws; and it is also generally furnished with eyes, and with variously-shaped tentacula, which are apparently instruments of touch. The last segment is occasionally destitute of the appendages with which the rest are provided; and these are replaced by a sucker, which is of great assistance in locomotion.

711. The class is subdivided into orders by the differences in general conformation and habits exhibited by the tribes which compose it, and especially by the character and distribution of the respiratory organs. The first order, DORSIBRANCHIATA, includes those which have the branchial appendages or gill-tufts disposed regularly along the body, sometimes extending its entire length, sometimes restricted to the segments about the middle. This order has been also denominated *Errantia*, from the active habits of the animals comprehended in it. In the next, TUBICOLA, we find worm-like animals inhabiting fixed and permanent residences like the Mollusca. Sometimes they are enclosed in shelly tubes formed by an exudation from their own surface, and sometimes in casings constructed by the agglutination of foreign substances. The disposition of the gill-tufts around the head is the principal character which distinguishes the animals themselves from those of the first order. In the third order, TERRICOLA, the body is destitute of all external appendages, except some minute and almost imperceptible bristles; for the respiratory organs are here developed internally, the animals being formed to crawl upon the ground instead of swimming through the water. And in the last, SUCTORIA, the body is destitute even of these bristles, but is furnished with a sucker at each end of the body. The two latter groups were regarded by Cuvier as forming one order.

744. What of their structure and habits?

745. How are they divided?

Order I.—Dorsibranchiata.

712. Of the foregoing orders, the Dorsibranchiata appear, on the whole, to possess the most complex structure, as well as the most varied faculties, and they also exhibit the most characteristic forms of the class. The head is almost always distinct from the body, and furnished with highly-developed organs of sensation, as well as with complex instruments of mastication. These marine worms do not attain any considerable dimension upon our own coasts, rarely exceeding a few inches in length; but in tropical climates some species are found of comparatively gigantic proportions, having their bodies composed of 400 or 500 segments, and occasionally measuring four feet from one end to the other. Their general form will be seen in the annexed figure, which represents the *Syllis*

Syllis Monilaris, with an enlarged representation of one of its appendages.

monilaris; and the enlarged view of one of the lateral appendages will show the parts of which it consists. In the centre there is a tuft of delicate bristles, which may be regarded as the chief organ of respiration, the blood being sent into them to be exposed to the air contained in the water; above and below there are separate bristles much more elongated, of which the lower one has a jointed character; these are instruments of locomotion, and may be regarded as rudimentary legs. The arrangement of these parts differs much, however, in the various tribes of this order.

746. Describe this first order.

747. What varieties are described?

713. Among the more interesting forms of this order may be mentioned the family NEREIDÆ, or Sea-Centipedes, of which many species inhabit our own coasts, but much larger ones are found in tropical seas. They have no venomous power, but are extremely voracious; and are often furnished with a complex apparatus for seizing their prey and reducing it to fragments. They lurk in narrow channels among the rocks; and their great flexibility enables them to thread their way amongst the most sinuous passages. Some of them line the cavities of the rocks which they inhabit with a slight silken web. Many are distinguished by their brilliant metallic lustre. One species (*N. prolifera*) is remarkable for its curious mode of propagation. The hinder part of the body is gradually transformed into an animal, perfect in itself; the head and its appendages being developed from one of the segments of the body of the parent. At last a separation takes place, and each becomes complete in itself. As many as three young nereids have been seen thus being developed in one length, from the hinder part of the body of the parent. After the separation, many new segments are added by each. This increase in the number of segments with advancing growth seems common to many of the order.

714. The *aphrodita* is an animal well known on our coasts under the name of *sea-mouse*; numbers are often cast up by a gale of wind. The body is flattened, and shorter and broader than that of other Annelida. The back is covered by two longitudinal ranges of broad membranous scales, under which the gills lie concealed. The most common species of sea-mouse are about six or eight inches long, and two or three broad. A great part of the body is covered by bristles of brilliant lustre, and of colours which vary with the light; so that the animal is scarcely surpassed in beauty of colouring by any other. In some species the strong bristles which project from the sides are barbed at the tip on each of the flattened edges, so as to become admirable weapons of offence and defence; and each is enclosed in a horny sheath composed

of two pieces, which can be separated to allow of its protrusion.

715. The *arenicola piscatorum*, known to fishermen by the name of *lob-worm*, is another species common on our coasts, and is eagerly sought as a bait. It burrows, like the earth-worm, in the sand, and the place of its excavations may be known by the little heaps which it casts up. The branchial tufts are confined to the centre of the body, where they form on each side a series of bunches, which are remarkable, during the life of the creature, for their beautiful red colour, derived from the crimson blood which circulates copiously through them.

Order II.—Tubicolæ.

716. Comparatively little is known of the structure of the animals of the order Tubicolæ, which never attain to such great dimensions, and do not offer to the naturalist the same facilities for examination. The structure of the casings which they form, however, has been fully investigated. One of the commonest of these is the shelly tube exuded by the *Serpula*. This is formed of calcareous matter resembling that of the shells of Mollusca, and apparently secreted from the surface of the body in a similar manner. These tubes, which are often very greatly contorted in form, are generally found incrusting the surface of stones or other bodies which have been immersed for any length of time at the bottom of the sea; they are closed at one end, which tapers to a point, and the wide end is open.

Serpula Contortuplicata, taken out of its tube

717. The animal forming this shell has its branchial filaments all assembled round the head, where they form a pair of most elegant fan-like appendages, which usually possess very brilliant colours. At the base of each tuft is a fleshy filament; and one of these, on the right or left

749. What of the next order?

750. Describe the several varieties.

side indifferently, is always prolonged and dilated at its extremity into a flat disk, which fits to the mouth of the shell, and serves to close it when the animal is withdrawn into the tube. There is a species of *Serpula* in the Antiles, of which the tube passes into masses of coral, which are built up around it. The *spirorbis* is an animal allied to the *Serpula*, but having a shell of tolerably regular spiral form.

718. The *sabella* is an animal very much resembling the *serpula*; but it constructs its tube by agglutinating particles of clay or fine sand. The animal buries itself and its case in the sand, with its head towards the surface, so as to enable it to protrude its tentacula in search of food. The *Terebella* forms a similar tube, by cementing together minute shells and fragments of larger ones, together with particles of sand, gravel, &c. It has a considerable number of tentacula upon its head, and the gills are much smaller in proportion. Some species of these animals live in aggregate groups, so that the clustering together of their tubes forms solid masses which may go on increasing to a considerable size. In none of these cases is the shell or tube to be regarded as part of the animal; it is merely its habitation. Annelide forms no muscular attachment to it, and its body can be easily drawn forth from its interior.

Order III.—Terricola.

719. The order Terricola includes very few genera, of which the *lumbricus*, or common earth-worm, is the chief. They live in general beneath the surface of the ground, either perforating the dry soil or burying themselves in mud, where many of them lead a semi-aquatic life. When the earth-worm is carefully examined, the adaptation of its structure to its peculiar mode of life becomes evident. It is destitute of the powerful limbs by which the mole and the mole-cricket work their way under ground; and it might not at first appear by what organs these are replaced. On looking at the anterior extremity

of the body, it is seen that the segments gradually taper to a point, in which situation is the opening of the mouth. The surface of the body is beset with a number of sharp spines or prickles; these are only felt when the finger is passed along from the tail to the head, being all directed backwards, and having a somewhat hooked form. When the worm is boring, it insinuates its pointed head between the particles of earth, amongst which it penetrates like a wedge; and in this position the anterior part of the body is fixed by the spines or bristles already mentioned, which prevent it from slipping. The hinder parts are then drawn forwards by a longitudinal contraction of the whole animal—a movement which the spines do not oppose. This swells out the anterior segments, and forcibly dilates the passage into which the head has been already thrust. The spines upon the hinder rings then take a firm hold upon the side of the hole thus formed, and prevent any backward movement; the head is again forced forward, and, by a repetition of the process, the animal easily makes its way through substances which it would at first have seemed impossible for it to penetrate.

720. The burrowing of earth-worms is a process exceedingly useful to the gardener and the agriculturist; and these animals are far more beneficial to man in this way, than injurious by devouring the vegetables set in the soil. They give a kind of under-tillage to the land—performing the same below ground that the spade does above for the garden, and the plough for arable land—and loosening the earth, so as to render it permeable to air and water. It has lately been shown that they will even add to the depth of the soil, and create mould where none existed before. This they do principally by the exercise of their digestive process. They take a large quantity of the soil through which they burrow into their intestinal canal; from this they extract the greater part of the decaying vegetable matter it may contain, and reject the rest in a finely divided state, forming what are known as worm-casts. By the accumulation of these, a field which

was manured with marl has been covered in the course of eighty years with a bed of earth, averaging thirteen inches in thickness.

721. It is commonly supposed that the earth-worm may be multiplied by the division of its body into two pieces, of which each will continue to live. This does not appear to be the case. If it be divided across the middle when in motion, each piece will continue to move for a time, but only that which bears the head will be found alive after a few hours. This forms a new tail, and soon shows little sign of the injury. But if the division be made near the head, the body will remain alive, and will renew the head; and the head, with its few attached segments, will die. The *Naiades*, however, have a much greater amount of reproductive power, for they may be cut up into many pieces, of which each will become a perfect animal; and it is stated that a separation takes place spontaneously, but to a much greater extent.

Order IV.—Suctoria.

722. The order Suctoria contains the common leech and its allies, which are all animals of aquatic habits, but not all agreeing in its blood-seeking propensities. Most of the tribe, however, live at the expense of some other animal. Sometimes they attach themselves to fishes or aquatic reptiles; sometimes they devour Mollusca, Annelida, or the larvæ of insects; and certain species seem to flourish only whilst sucking the blood of higher animals. No external organs of respiration are seen on their bodies, but a large number of minute sacs are contained in their skin, into which air or water is admitted. The skin of the common *leech* is very thin, and scarcely exhibits the division into segments; but the muscular envelope beneath it is more substantial, and is found to consist of three distinct strata of fibres running in different directions, transverse or circular, longitudinal and diagonal. By the ac-

753. Of what value are they to the soil?

754. What of their vitality and reproductive powers?

755. What of the next order and its variety?

tion of these they acquire that facility in moving in any direction, and in altering the form and dimensions of their bodies, for which they are so remarkable. The leech has a row of eight or ten simply-constructed eyes, seen as a semicircle of black points, just above the mouth; and the surface of the sucker, in which the mouth is placed, seems to possess a delicate sense of touch.

723. The *leech* has several modes of progression. On land, it sometimes crawls like the earth-worm; but more commonly it advances by means of the suckers at the two ends of the body, fixing itself by each alternately, and advancing the foremost. In water, however, it moves by swimming, for which it is capable of peculiarly adapting itself. By a contraction of the muscular integument, the body assumes the appearance of a flattened band, and in this condition the leech makes its way by a succession of very graceful undulations. It frequently crawls along the sub-aquatic surface, however, by means of its suckers, in the same manner as on land.

724. The structure of the mouth of the leech is very interesting. It is situated in the middle of the cavity of the anterior sucker; and three little cartilaginous bodies,

Leech, with the anterior sucker and teeth enlarged.

usually called *teeth*, but more properly *jaws*, are seen to be disposed around it, in such a manner that the three edges form three radii of a circle. Each of these has three rows of very minute teeth at its edge, so that it resembles a small semicircular saw. It is imbedded at its base in a

756. How does it vary its locomotion?

757. What variety is named?

bed of muscle, by the action of which it is worked in such a manner as to cut into the skin—a sawing movement being given to each piece separately. It is in this manner that the tri-radiate form of the leech-bite is occasioned, each ray being produced by a separate little saw. The lacerated character of the wound is very favourable to the flow of blood, which is farther promoted by the vacuum created by the sucker.

725. The greater number of the *Leech* tribe are inhabitants of fresh water; some, however, are only found in the sea; and there is one terrestrial species, a native of Ceylon, which appears to be more voracious than any other, and to be one of the greatest pests of that fine island. It infests both mountains, woods, and swampy grounds, particularly in the rainy season. When fully extended, it is like a fine cord, sharp at the extremity, and can thread any aperture; so that it can easily penetrate the light clothing worn in that climate, rendering it impossible to pass through the woods without being covered with blood. Dr. Davy counted fifty upon the same person. No sooner does any individual stop, than, as if they saw or scented him, they crowd towards him from all quarters. Other animals besides man suffer severely from them; horses are rendered so restive by their attack as to become quite unmanageable.

CLASS XI.—CIRRHOPODA.

726. The animals composing this class have so many characters in common with the Mollusca, that they have been generally regarded as belonging to that sub-kingdom. The body and its appendages are themselves quite soft; and the skin has the loose, spongy, muscular character which corresponds with the *mantle* of molluscs. From its surface is secreted a shell composed of several pieces, but not differing in general aspect from multivalve shells, be-

758. What of their blood-thirsty habits?

longing to that division. Further, the shells are either themselves firmly united at their base to some solid masses, or they are attached by a footstalk; so that the conditions in which the animal exist closely resemble those to which we observe the Mollusca peculiarly adapted.

727. On the other hand, when we examine the animal itself, we find that it is perfectly symmetrical in its form—a character nowhere existing among the Mollusca which are enclosed in shells. Its body is prolonged, and exhibits a tendency to division into segments; and from each of these there arises a pair of appendages on each side, which possess something of a jointed structure. These *cirri*, as they are termed, are long tapering arms, fringed with cilia, or little hair-like filaments; and they have gills at their base. Further, the mouth is furnished with lateral jaws, which no Mollusca possess; and the nervous system consists of a double cord, with a pair of ganglia in each segment of the body, precisely as in the other Articulata. The most interesting proof, however, that the Cirrhopoda belong to this division, is derived from the history of their development. On their liberation from the egg, they present a form much more analogous to that of the lower Crustacea than to that of the adult animal, which they only acquire after a series of metamorphoses. They are furnished with antennæ and eyes, and move freely through the water; but when they become fixed, they lose also these organs of sense. The shell is not formed of simple layers, like that of the Mollusca, but is traversed by a complex series of canals, through which nourishment is conveyed to it.

728. The Cirrhopoda are divided into two principal groups—the *pedunculated* and the *sessile*. The latter, of which the common *balanus*, or *acorn-shell*, is an example, have the base of the shell fixed immediately to rocks. In the former, such as the well-known *barnacle*, the shell is attached by a peduncle or footstalk, which consists of a

759. Describe the eleventh class?

760. What is peculiar in their structure?

761. How are they divided?

tube of leathery consistence, and is often of considerable length. In both groups the animals not being able to go in search of food, obtain it through the currents produced by the action of their cilia.

729. The shell of the common *barnacle* consists of five pieces, of which two are large valves, somewhat resembling those of a mussel; two smaller pieces are jointed to these near the point; and one unites the valves along the back edge. These cover the whole of the mantle. Barnacles are abundant in all seas, and fix themselves, in preference, to wood; so that a piece of timber which has been for a short time floating in the ocean is almost sure to

Group of *Anatifa*, attached to a ship's bottom.

be partly covered with them; and ships' bottoms, if not protected with copper, are rendered so foul as greatly to

762. Describe the diagram.

763. What of the shell of the barnacle?

impede their sailing. To the species common on our own coasts was once attributed the wonderful faculty of changing into a goose! In other genera allied to the barnacles, the valves are much smaller, and do not altogether cover the mantle, which appears between them; and in one, *otion*, the mantle is of cartilaginous texture, and the pieces of the shell, which are extremely small, are included within it. One curious pedunculated genus, the *lythoïrea*, has a piece at the base of the footstalk, analogous to the shelly base of the balanus, and has the power of penetrating stones for its habitation.

730. The *Balanus*, or Acorn-shell, has more of a globular shape, with a narrow mouth, and is composed of a certain number (varying in the different species) of plates, of a triangular form, so disposed that an addition to the edges of each shall preserve the general proportions of the shell, whilst increasing its cavity in all its dimensions in accordance with the growth of the animal. In this arrangement we recognise the same plan as that adopted in the shell of the echinus. The animal closely resembles the barnacle. The mouth of the shell is guarded by an *operculum*, consisting of two or more valves, which close it more or less completely. The rocks, piers, &c., on many parts of the coast, are covered with these animals; and small species of them also attach themselves to shells of various kinds. In some genera there is a considerable interval between the exterior and interior wall; this is either filled with a cellular shelly structure, or with the substance on which these animals fix themselves. The *coronula*, for example, is never found but on the backs of whales, and their skin rises into this hollow, or rather the shell is so far imbedded in the skin. Others, again, attach themselves to the backs of turtles.

764. What of their habits?

765. Describe the acorn-shell.

CLASS XII.—ROTIFERA.

731. The class Rotifera is one composed entirely of animalcules which can only be distinctly seen with the microscope; and it takes its name from the wheel-like organs with which most of them are provided, whence they are commonly known as wheel-animalcules. It is only within a very recent period that the complex structure of these beings has been understood, and that they have been separated from the animalcules of simpler organization. Whatever doubt still hangs over the real nature of their conformation, none exists in regard to these, at least on any material point. It is on account of the prolonged form of their bodies, the position of the mouth and eyes at one extremity, the occasional marking of transverse lines indicating a division into segments, and most of all by the character of the nervous system, where that can be detected, that the Rotifera are ranked in the articulated subkingdom. Unquestionably they bear more general analogy to that than to any other; but they must not be considered as characteristic specimens of it.

732. The structure of the common wheel-animalcule, *rotifer vulgaris*—which may be found in many collections of stagnant water, especially such as have been long and freely exposed to the atmosphere—will afford a good illustration of that of the class. The body exhibits a prolonged form when fully extended; but, as the integument is very elastic, it may be drawn up into a circle, or made to assume a great variety of shapes. At one end it is furnished with a pair of projections, which are surmounted by circular fringes of cilia. It is by the vibration of these cilia that the currents are produced in water around, which give an appearance as of the continual revolution of wheels. Between the wheels, a sort of head extends forwards, on which a couple of red spots may be observed, which are

766. What of the twelfth class?

767. Describe the most common form.

believed to be eyes. The mouth is situated at the base of this central projection. At the opposite end the body is prolonged into a sort of tail, furnished with three prongs; and by this the animal fixes itself when working its wheels for obtaining food.

733. The delicate membrane which covers the body has two series of muscular fibres disposed within it; one set running longitudinally from end to end; the other transversely, so as to form rings round the body. By the contraction of the former the body is shortened; by that of the latter its diameter is decreased, and it is consequently lengthened. This is the same kind of apparatus as that by which the form of the leech and worm tribe is altered. The transparency of the integument allows the contained organs to be distinctly seen; and these are perceived to have regular membranous walls of their own, and to be altogether distinct from the general substance of the body. The most curious of these is the gizzard, or set of jaws (as it may perhaps be termed) in which the food is ground down before it is transmitted to the true stomach. This is placed in the fore part of the body, and principally consists of a hard framework in two pieces, each of which bears two teeth. The two frames are moved by powerful muscles, and worked in such a manner that the teeth are made to interlock and to separate alternately, so as to tear all the food which is transmitted into the stomach. From the stomach there passes backwards a long straight intestine, which terminates near the posterior part of the body.

734. These animalcules feed chiefly upon others of smaller size and simpler character. The currents set in motion by the cilia are very powerful, and draw in whatever small bodies are within their scope; and the animal seems to select from these what is adapted to afford it nutrition. Sometimes it folds in its wheels, and moves along a solid surface by the suckers with which its head and tail are furnished, in the same manner as a leech; and sometimes it remains altogether inert for a considerable

period. One of the most remarkable points in its history is its power of being revived by the application of moisture, after having been entirely dried up. This experiment, however, does not always succeed.

735. The wheel-animalcules do not multiply by spontaneous division; but they are propagated by eggs, the development of which within the body of the parent may be very distinctly seen, on account of the transparency of the latter. These eggs are large and not very numerous, seldom more than four; but they rapidly arrive at maturity, and are soon capable of producing others. It has been calculated that from a single individual more than a million may be produced in ten days. In some of this class, the eggs are borne for some time on the outside of the body, attached to its posterior part.

736. Some of the more interesting varieties of form may now be noticed. As the principles upon which the class should be subdivided are not yet established, it will be better not to attempt any systematic distribution of them.

737. Although the external membrane is generally soft, it occasionally exhibits a horny consistence; and, it is probable, is consolidated in some instances by a deposition of earthy matter, without, however, losing its transparency. There is one very interesting species in which a regular cell is thus formed and attached to a fixed point, like that of the higher Polypifera; and there is a considerable space between its inner wall and the membrane covering the animal organs, which seems filled with fluid, so as to allow great freedom of motion to the interior structure. In this animal, the *stephanoceros eichornii*, we find another remarkable variation from the common type of the Rotifera, to which it conforms in the general aspect of the body and in the disposition of the internal parts. The cilia, instead of being arranged in two circular projections, are set as a fringe upon six arms or tentacula, which resemble those of the Bowerbankia (§ 928). Thus the structure of this

769. What of their reproduction ? -

770. What various species are named ?

animalcule may be regarded as intermediate between that of the *Bryozoa* and the true Rotifera.

738. In many species we observe an even greater complexity in the internal structure than in the *rotifer*. Thus the jaws are sometimes furnished with five or six pairs of teeth; and a pair of long tubular organs, which appear to have the secretion of a salivary fluid for their object, opens between them. The stomach is often provided with like tubular appendages, which appear to furnish secretions useful in the digestive functions. A system of vessels, ramifying beneath the integument, has also been seen in the most highly organized species. The cilia are disposed in various ways, but usually in a circular form. Sometimes they are placed in two rows all around the funnel-like edge in which the body terminates at its anterior extremity.

739. We observe the formation of a hard envelope in some of the highest as well as of the lowest species. The *brachionus* and its allies have the body encased in a sheath from which the tail projects at one end, and the head and ciliary organs at the other. These animals are evidently more analogous to the lower tribes of Crustacea, which some of them, indeed, much resemble. Their hard sheath is occasionally furnished with long spines, which may probably serve as means of defence. Their dental apparatus is formed on the plan of that of the rotifer, and they employ their wheels in obtaining food; but they have also the power of projecting the teeth beyond the mouth, and of thus masticating the vegetable substances upon which they partly feed. They are among the most abundant forms of the whole class, few ponds being without them in summer.

771. What other species is described?

CLASS XIII.—ENTOZOA.

740. This class derives its name from the peculiar condition in which the animals composing it exist, most of them being inhabitants, during their whole lives, of the bodies of other animals, mostly those of higher organization, from the juices of which they derive their nourishment. A number of species, differing almost as widely as the different vertebrated animals of the same country, are associated together by this character; and with these are united a few which are not parasitic, but which so strongly resemble particular kinds of them that they can scarcely be separated. The group is thus one of the most unnatural in the whole animal kingdom; and yet it does not seem easy to dispose of its component parts among other classes, so widely do they all differ from them, as well as from each other. Many of them possess a distinct worm-like form, the body being much prolonged, and exhibiting a division into segments, and the mouth being situated at one extremity. These, therefore, evidently belong to the articulated series. There are others which, in the absence of all distinct organs, and also in the circularity of their form, seem to approximate more to the Radiata. Some species formerly located in this class are now known to be low kinds of Crustacea.

741. A division of the Entozoa into two sections has been proposed, founded upon the general peculiarities of their structure, which it may be useful here to adopt. In the first and highest of these, there is a distinct intestinal tube, with an orifice at each end; and traces of a nervous and muscular system, more or less developed, may be detected. This division evidently approximates to the Annelida. It includes, among many other species, the *Filaria*, or Guinea-worm, which burrows in the flesh of man and other animals in warm climates. If undisturbed, it will often continue its operations for a considerable time with-

772. What is the characteristic of the thirteenth class?

773. What varieties of the first group are named?

out much uneasiness ; but if disturbed, it sometimes occasions the most excruciating pain. When it shows itself externally, it is extracted very slowly, for fear of breaking it, in which case the remainder would retreat, and continue to exist ; it grows to the length of several yards. The *ascaris lumbricoides*, or round worm of the intestines, also belongs to this group. It infests not only man but many of the lower animals, and often occasions severe disease, and even death. It derives its second or specific name from its resemblance to the earth-worm. The short, active thread-worms, sometimes infesting the lower part of the intestine, are another species of the same genus. One of the most complex in its structure of all these parasitic worms, is the *strongylus gigas*, which principally infests the dog, wolf, and other Carnivora. It grows to the length of two or three feet, and is as thick as the little finger. None of these animals possess any organs of sense, or any very distinct respiratory apparatus ; and though vessels for the circulation of the nutritive fluid can be traced in some, there is no distinct heart or muscular dilatation of the tubes for its propulsion. They possess no locomotive appendages of any description, and all their movements are performed by the body itself.

742. In the lower division of the class, there is no distinct alimentary canal ; the cavities for the reception of food, as well as those for other purposes, being, as it were, channelled out of the soft, almost homogeneous, tissues of the body. Some of these still preserve the worm-like form. Such are the so-called eels in vinegar, and the curious little parasites which have been recently discovered to infest the muscles of man. To this group also belongs the *tænia solium*, or tape-worm, in which we find a remarkable repetition of organs. The body is distinctly divided into joints or segments, which sometimes amount to several hundred, the whole animal occasionally attaining the length of ten feet. These segments are all connected by the nutritive canal, which runs from one end to the other ;

774. How is the other division characterized ?

775. What remarkable example is cited ?

but the reproductive apparatus is repeated in each division. The head is small, and possesses four mouths, surrounded by a double circle of small hooks. Its existence is essential to the life of the body, the latter dying if it be broken off; but if some of the joints remain attached to the head, it continues to grow and form new ones. In this repetition of parts we see a tendency towards the type of the Polypifera.

743. One of the most simple of all the Entozoa is the common *hydatid*, or acephalocyst (headless bag), which seems to consist of nothing but a globular membranous bag filled with a limpid colourless fluid. It exhibits no motion or indication of sensation, when stimuli of any kind are applied to it; and it is often difficult to distinguish it from the tissues in which it is found. Its power of reproduction, however, by the formation of *gemmæ* or buds between its layers, shows it to be entitled to the rank of an independent being; the young hydatids are thrown off internally or externally, according to the species. Other Entozoa, with the same general form, exhibit a more complex structure; thus, the cysticercus has a bag, similar to that of the hydatid, but to this is appended a sort of head, armed with spines for its attachment, and with suckers for the imbibition of nutriment. This parasite has been observed within the eye of man.

744. Amongst the animals associated with this group, though not conforming with it in their residence, is the *Planaria*, a very interesting genus, of which some species inhabit fresh water, and others are marine. The body is flat, and about three or four times as long as broad. Within its soft tissue are channelled out not only a complex digestive cavity, but also a system of vessels which absorb fluid from its walls and convey it through the system, and a reproductive apparatus. The stomach opens, not by a mouth at one end, but by a sort of sucker projecting from the middle of the body; and through this the *Planaria* imbibes the juices of various aquatic animals which it at-

776. What species of hydatid are described?

777. What other varieties are named?

tacks, mastering even active little worms, by twisting its body round them. The most curious part of their economy consists in their power of reproducing parts that have been lost, and of repairing injuries, which seems almost as great as that of the hydra among Polypes. They may be divided into three parts, of which the former shall contain the two minute spots which are believed to be eyes, the middle one the sucker, and the posterior one the reproductive apparatus; and in a short time, each part will develop itself into a new individual, perfect in all its parts. It may be partially split longitudinally, from either extremity, so that two heads or two tails will be formed, uniting at the middle point, but each being complete in itself.

745. Closely allied in structure to the Planaria is the *distoma*, or fluke, which infests the liver of sheep, and sometimes gives rise to severe disorders; it is also found in other domestic quadrupeds, and even in man. It is about an inch in length, and a quarter of an inch in breadth, having the form of a minute sole; and it possesses eyes situated on the most conspicuous part of the head. The power of multiplication of these animals is very great. The ducts of a single liver have been known to contain a thousand, with innumerable germs of others. They usually accompany the disease called *rot* in sheep; but they do not appear to be necessarily connected with it. They most frequently infest sheep that are pasturing on marshy grounds, in the waters of which their germs are probably contained; and it seems to be generally rather the unhealthiness of the situation than the development of the flukes, that is the real cause of the rot, since flukes infest the most healthy sheep during the autumn and winter months.

778. What of flukes and their habits?

SUB-KINGDOM MOLLUSCA.

746. The range of animal forms comprehended in this division of the Animal Kingdom is so great that it would be difficult to include them by any definition applicable to them all. The highest class approaches Fishes in many points of its organization; whilst in the lowest we not only lose sight of some of the characteristic peculiarities of the group, but we find a near approximation to the higher Polypifera. In all the Mollusca, the body itself is of soft consistence, as its name imports, and is enclosed in a soft elastic skin, lined with muscular fibres, which is termed the *mantle*. This skin, in many instances, is not applied closely to the body, but forms a membranous bag, having apertures (which are sometimes prolonged into tubes) for the entrance and egress of water; and through these the respiratory organs, which are situated within the cavity, are regularly supplied with the pure fluid necessary for aërating the blood: and the mouth, when it is not capable of being projected beyond this cavity, is supplied with food by the same stream.

747. The Mollusca possess in general a very complicated digestive and circulating apparatus; but the organs of sensation and voluntary motion are comparatively undeveloped. The great bulk of their bodies is made up of the stomach and intestines, the liver and other glands connected with the alimentary canal, the respiratory apparatus and the ovary for the production of germs (which is usually very large); and the muscular system, which in the Articulata forms so large a proportion of the whole structure, is here frequently reduced to a few scattered fibres, and in but few instances attains any complexity or power. A considerable number of Mollusca are formed for an existence as completely stationary as that of the Zoophytes; and are dependent for their nourishment on the supplies of food casually brought within their reach by the waves and currents of the ocean. A few, however, have powers of locomotion which enables them to search actively for it themselves; but the greater number wander sluggishly like the snail, from place to place, devouring with voracity such supplies as they meet with, and being capable of fasting for long intervals when none come in their way.

748. It is from the surface of the mantle that the calcareous matter is exuded which forms the shell, in those species which

779. Describe this sub-kingdom.

780. What of their internal organs?

possess such a protection; its particles are held together by a sort of glue, which exists in much larger proportion in some species than in others. In very hard and brittle shells, if the calcareous matter be removed by the action of an acid, the animal matter that remains appears in the form of separate flakes. But in many other shells thus treated, the animal portion retains its form after the removal of the lime; and there are a few in which the (so-called) shell consists only of a substance like horn, without any intermixture of calcareous particles. Such a substance appears to be formed by the young animal before the true shell is secreted; and it is also the first that appears when the animal is repairing the effects of an injury to the old one. It is this that constitutes what is commonly termed the *epidermis* of shells—a covering possessed in their natural state by all that are not enveloped in a fold of the mantle, but which is commonly removed when the shell is preserved, as it impairs the beauty of the exterior. The shell is most solid and massive in those species which lead an inactive life; and is usually light and thin, or altogether deficient, in those whose powers of locomotion are greater. Its thickness often varies greatly amongst different individuals of the same species, according to the roughness or tranquillity of the waters they inhabit.

749. As the shells of Mollusca are the parts of their structure by which they are best known, it was natural that the first attempts at classification should be founded on their peculiarities. Accordingly, Linnæus arranged them into *Univalves*, *Li-valves*, and *Multivalves*, according to the number of pieces of which the shell is composed; and this classification, from its simplicity and the apparent facility of its application, has been very generally adopted. But, as will hereafter be seen, it is only within certain narrow limits that the character of the animal can be known by the structure of its shell; and by the Linnæan classification, animals are brought together which are widely separated, and others are placed in distinct classes, which are closely allied. Again, such a classification is totally inapplicable to the very numerous shell-less Mollusca, some of which approach so closely to those bearing shells (as, for example, the *slug* to the *snail*), that scarcely any essential difference exists. It is obvious, then, that although the characters derived from the shell may often be valuable in enabling us to recognise the remains of particular animals, classification must not be founded on them, but on the general conformation of the animals by which they are produced.

781. What of their habits?

782. What of the formation of their shells?

783. How are they arranged by Linnæus?

784. What objection lies to this classification?

750. Following this principle, the Mollusca may be divided, first, into those having a *head*—that is, a prominent part of the body on which the mouth is situated, with organs of sense in its neighbourhood; and those which are *acephalous*, or headless. Among the former, we perceive three very distinct types of structure.

751. The CEPHALOPODA, or *Cuttle-Fish* tribe, have feet or tentacula arranged in a circular manner around the head. In this group we find the nearest approximation to the Vertebrata.

752. The PTEROPODA constitute a small but interesting class, characterized by the possession of a pair of wing-like expansions of the mantle, and by the great symmetry of their bodies. These expansions serve as fins by which they swim through the water with great velocity.

753. The GASTEROPODA are the most extensive group of the whole. The two former are confined entirely to the sea; amongst these we find species adapted to live in fresh water, and even on land. They have but one muscular expansion or foot, and this proceeds from the under surface of the body, as may be well seen in the snail.

754. In each of these orders, we observe a considerable variation in regard to the relative size, and even the existence, of a shell; for whilst there are some species in all of them which are entirely destitute of this protection (such being called naked Molluscs), there are others which possess it in a slight degree, having it generally concealed in a fold of the mantle, whilst in others it completely envelops the body, when they desire to withdraw themselves under its protection. In the different species of snail and slug, all agreeing closely in general structure, every variety of this kind may be seen.

755. In the headless Molluscs, on the other hand, we find two very distinct groups, in the first of which the shell is constantly present, whilst in the second it is as invariably absent. The general structure of the latter is much inferior to that of the shell-bearing class, and it approaches more nearly in several of its characters to the Polypifera.

756. The highest class of acephalous Molluscs is named CONCHIFERA, from the constant occurrence of a shell, which is nearly always formed of two pieces, or *bivalve*.

757. The lowest is denominated TUNICATA, the shell being replaced, as it were, by a leathery or cartilaginous envelope or tunic, which encloses the whole body.

785. What of their three types of conformation?

786. Describe each of them.

CLASS XIV.—CEPHALOPODA.

758. The class of Cephalopoda, which is so named from the arrangement of the feet or locomotive organs around the head, must be regarded as the highest among the Mollusca in respect to the complexity of its organization, and it is the one which approaches most nearly to Vertebrated animals. In the general form of their bodies, and in their adaptation to rapid motion through the water, many species bear a considerable resemblance to Fishes, and are, indeed, commonly reputed as such. The name of the class expresses the character which distinguishes it from all others. On the head, which is furnished with eyes resembling those of higher animals, and also with organs of hearing, and perhaps of smell, are disposed in a circular manner the curious appendages, which have received the names of *feet* or *arms*, and to which either term may be justly given, as they are organs of prehension as well as of locomotion. These are usually eight or ten in number; but in the true *Nautilus* they are much more numerous, amounting to nearly a hundred. These arms may be regarded as analogous to the tentacula or feelers which will be described in the lower classes of Mollusca, and some rudiments of them may be traced in the fleshy prolongations of the lips of certain fishes.

759. The mouth, which is situated in the centre of the circle of arms, is provided with a pair of firm horny mandibles or jaws, of which one is sharply pointed and overlaps the other when closed, so that the whole very much resembles the bill of a parrot. This beak encloses a large fleshy tongue, roughened with horny prickles; and the œsophagus leads to a muscular stomach, which much resembles the gizzard of birds. All the Cephalopoda are aquatic, and consequently breathe by gills. These are disposed symmetrically on the two sides, and are covered in by the mantle. This envelope includes the whole body, but there is an opening in it which gives passage to the head. Through this opening the water enters to the gills, and it is expelled through a tubular prolongation of the mantle termed the *funnel*, which also serves as the excretory canal for other fluids.

760. Most of the Cephalopoda possess something analogous to the shells of other Mollusca, although it often exists in a form and position which might almost prevent its being recognised as such. The only species at present known in which

787. What other species are described?

788. What of the structure of this class?

the body of the animal is enclosed within it, as in the shells of Gasteropoda, are the *nautilus* and the *argonauta* (paper-nautilus). In the former of these the shell is spiral, and is divided by transverse partitions into chambers, in the last or outermost of which the animal lives; and, when it wishes to enlarge its shell, it prolongs the mouth of it, which widens as it is prolonged, and throws a new partition across the bottom. The shell of the argonaut has no such chambers, and the animal, when hiding within it, occupies the whole of its cavity. In the common *sepia* (cuttle-fish), on the other hand, the shell is reduced to the form of an oval plate, commonly known as the *cuttle-fish bone*, from which pounce is derived, that may be picked up on almost every shore; and this is enclosed within a fold of the mantle, and lies upon the back of the animal. In some of the more slender and flexible species, even this is nearly wanting; all that remains of a shell in the *loligo* (squid) being a narrow horny plate, somewhat resembling a feather in shape, whence it is termed the pen.

761. The *nautilus* is not the only Cephalopod which possess a spiral chambered shell. Such a one is found in the *spirula*;

Ammonites.

it does not protect the animal, however, externally, but is enclosed within it, like the bone of the cuttle-fish. There is reason to believe that this is the character of the fossils termed *ammonites* (commonly known as snake-stones), which abound in almost every rock containing organic remains, but of which no living representatives are known. If this be the case, the cuttle-fish to which these shells belonged must have been of enormous size, as ammonites have been found measuring four or five feet in diameter, although most of them are much smaller. No entire specimens of gigantic cuttle-fish at present living have been seen by naturalists; but there is no doubt, from the frag-

789. Describe the several species named?

790. What of the nautilus?

ments which are preserved in museums, that such exist in the South Seas, where they are feared by the islanders more than sharks.

762. The arms of all the Cephalopoda are covered with very curiously constructed suckers, by which they are enabled to take firm hold of any thing to which they are applied. These act by excluding the air, and thus producing a vacuum, exactly upon the principle of the boy's leather sucker. In this manner they are enabled to master animals which it would have been supposed entirely out of the power of their soft unprotected bodies to combat successfully. They are generally agile as well as voracious, and prey upon almost all other classes of marine animals. Their especial articles of food, however, are fishes and crustacea, and they are probably the only animals which are able to restrain the inordinate multiplication of the larger members of the latter class. The firm armour of the crab or lobster, and its powerful claws, are no protection to it against the soft-limbed cuttle-fish, which wind their arms round the bodies of the latter, and, fixing every part by means of their suckers, tear apart the division of the shell with their hard parrot-like bills. So firmly do these suckers adhere, that, while the muscular fibres remain contracted, it is easier to tear away the substance of the limb than to release it from its attachment.

763. The Cephalopoda, which are unprotected by an external shell, are furnished with a curious means of escaping from their enemies. This is a secretion of a dark fluid, which, when emitted by the animal, tinges the water around to such a degree that it can escape in the cloud it has made. The fluid is usually stored up in a bag communicating with the funnel, through which it is ejected under the influence of alarm. This ink-bag, as it is termed, is collected from the species inhabiting the Indian seas, as the ink forms a valuable pigment, known to the artist as *sepia*, the name of the animal which furnishes it. The ink-bag has been discovered in a fossil state; and its occurrence along with certain chambered shells affords a presumption that these were included, like the cuttle-fish bone, within the body of the animal, and did not serve for its external protection. In many of the species, the skin is brightly spotted and has the power of changing colour, like that of the chameleon; it is not improbable that this may be an additional provision for defence, by enabling the animals to elude observation.

791. Describe the ammonites.

792. What is said of their habits?

793. What remarkable faculty have they?

764. The class of Cephalopoda may be subdivided into two orders. In the higher division which approaches the nearest to vertebrate animals, the *branchiæ*, or gills, are two in number, and the order is termed **DIBRANCHIATA**; whilst in the one most closely allied to the Gasteropod Mollusca, the *branchiæ* are four in number, and the order is therefore termed **TETRABRANCHIATA**.

Order I.—Dibranchiata.

765. The Dibranchiate order includes all the best known forms of the class. It is divided into two tribes, in one of which there are but eight arms, whilst in the other there are ten, of which, however, two are different from the rest. The first of these, termed **OCTOPODA**, may be considered as the highest in point of general organization; the second, termed **DECAPODA**, presents many points of approach to the Tetrabranchiate order, both in the increased number of arms, and in the presence of an inner circle of short tentacula, as well as in several internal characters.

766. The *sepia*, or common cuttle-fish, is a characteristic example of the **DECAPOD** family. Some species of it abound in almost all seas. It has two long slender arms, which are furnished with suckers only at their extremities, and by these the animal is said to fix itself, as by anchors, when exposed to a rough sea or strong current. They are probably employed also in seizing prey, which is brought by them within the range of the others. The *Sepiæ* are often brought up in large numbers by the fisherman of the British coasts, and cause them great annoyance by devouring a large quantity of fish whilst imprisoned with them in their nets. On the coast of Newfoundland, they arrive at a certain part of the year in large shoals, and they are caught for the purpose of serving as bait to cod-fish, one hundred thousand of which are annually captured by their means. The *bone* or shell is of an oval form, and thick in the centre. It is chiefly composed of a number of very thin parallel calcareous laminæ, joined together by multitudes of little hollow columns placed perpendicularly in the spaces between them. Besides this shell, there is a cartilaginous framework within the body, supporting and protecting the nervous system; this is the first appearance of an internal skeleton for that purpose, and is the rudiment of that which is so largely developed in the Vertebrata. The eggs of the *Sepiæ* are attached together in clusters, and are commonly known as sea-grapes.

794. How are they divided into orders?

795. What subdivisions are made of the first order?

796. Describe the cuttle-fish.

767. The *loligo*, calamary, or squid, is another Decapod genus, differing from the previous one chiefly in the slenderness of the body, and in the expansion of the two sides of it into fin-like processes; so that the general aspect much more closely resembles that of fishes. It is by the stroke of the body upon the water that these animals swim, and not by any movement of the arms, which are short, and comparatively powerless. It is even said that some species have the faculty of leaping from the water, in the manner of flying-fish. The *loligopsis*, an allied genus, is remarkable for the enormous length of the two prolonged tentacula, which attain several times the dimensions of the body. These remind us of the long tentaculata which the brown hydra possesses, and the use of them is evidently the same.

768. Although not used in Britain as articles of food, there is no reason why these cuttle-fishes should not be employed for that purpose. They formed a favourite dish with the ancients, and were not considered unworthy of the most exquisite cookery. The arms, cut into portions and prepared for the table, are frequently to be seen in the Neapolitan market; and they are found to be nutritious as well as palatable.

769. To this group we are probably to refer the *spirula*, a little chambered shell, the animal of which is very imperfectly known; and a large number of fossil chambered shells, known as *ammonites*, *belemnites*, &c.; the animal of which was probably analogous to the *sepia*, including the shell, like the bone of the cuttle-fish, within the body. With the *belemnites*, which are shells of a conical shape, surrounded by a solid sheath are occasionally found the remains of ink-bags and mandibles, so that no doubt can reasonably exist as to the nature of the animals to which they belonged. Probably the *orthoceratiles*, *hamites*, &c., are to be also viewed as internal shells, belonging to an animal more nearly allied to the cuttle-fish than to the nautilus, with which they have been usually associated.

770. The OCTAPODS, which form the highest family of the Dibranchiata, have but eight arms, without tentacula; and they are destitute of lateral fins, so that they depend entirely upon the arms for their movement through the water. Accordingly, it is found that these are very large and powerful, and that the body is proportionally short. The arms are generally united at their bases into a kind of circular fin, by the motion of which the animal can swim backwards with great energy.

771. The common *octopus*, or *poult*, of European shores, has the arms six times the length of the body, and each furnished

797. What various species are described?

798. What are the characteristics of the Octapods?

with 120 pairs of suckers. It can leave the water, and creep over the beach, taking hold of the ground before it by the extension of its arms, and then dragging the body towards the points at which the suckers are attached. It is considered very destructive of the Crustacea, and it is stated to lie in wait for them in cavities of the rocks, by which the body is concealed, the arms ranging in search of prey. The flesh of the octopus is tougher than that of the sepia, but it is eaten by the inhabitants of the Grecian archipelago. Many marvellous stories are related by the older naturalists in regard to the size which this animal occasionally attains. According to Aristotle, there are species whose arms are about six feet in length, and his usual accuracy gives weight to his statement. Pliny, however, goes much farther, and tells of one which had arms thirty feet long, and a head the size of a large cask. It is probable that some of the accounts of the *kraken*, a gigantic marine monster reported to have been seen by many navigators, are to be referred to large species of Octopi; but they must be stripped of the marvellous, and reduced to plain and definite statements of fact, before they can be received by the naturalist.

772. A very interesting species of the Octopod group is the *argonauta argo*, commonly called the *paper-nautilus*, from the whiteness and delicacy of its shell. As the animal has little in common with the true Nautilus, it would be much better if the latter designation were entirely abandoned, and the term *argonaut* substituted for it. The shell is not chambered, but possesses one spiral cavity, into which the animal can withdraw itself entirely; this, however, has no muscular attachment to it, whence it has been supposed by many naturalists that it was only a parasitic inhabitant which had taken up its abode within it, and that the shell, from its resemblance to that of *Carinaria*, was formed by a Gasteropod mollusc allied to that genus. It has been lately proved, however, by the interesting experiments of Madame Power, that the shell increases regularly with the growth of the animal, which possesses the power of repairing it when injured; so that no doubt can exist that the argonaut is the original constructor of it.

773. Of the eight arms of the argonaut, six taper gradually towards the extremities; but two are expanded into wide membranous flaps. From very early times this animal has been reputed to swim on the surface of the water, using its arms as oars, and spreading these expanded membranes as sails to the wind. But it is now known, by accurate observation of the living animal, that this is altogether a fiction (though an in-

799. What of the next variety named?

800. Describe the argonaut.

teresting one), and that the expanded arms are spread over the sides of the shell, meeting along its keel or edge, and almost completely enclosing it. It is by these, indeed, rather than by the surface of the body itself, that the calcareous secretion is poured out for the enlargement or reparation of the shell. By the action of the arms, the argonaut swims backwards in the same manner as other Octopi; and it can also creep along the bottom of the sea.

Shell of Argonaut, with animal in the reputed position.

774. The only known fossil of this group is the *bellerophon*, whose shell resembles that of the argonaut.

Order II.—Tetrabranchiata.

775. From the remains preserved in a fossil state, the Tetrabranchiata appear to have formerly abounded in our seas; but the only living representative of them is the *pearly nautilus* (*N. pompilius*). In the animal which forms and inhabits the well-known chambered shell found on most tropical shores, we observe many differences from the usual type of organization in the Cephalopods. The arms are very numerous, amounting to nearly a hundred; they are unprovided with suckers; and they are short and slender, resembling closely the tentacula of many Gasteropods. The mandibles placed in the midst of them are strengthened by calcareous deposit, and are not sharp at their points or edges; being moved by powerful muscles, they are thus more adapted to break to pieces the hard shells of Mollusca, than to lacerate the soft bodies of Fishes.

801. What fabulous idea is corrected?

802. Describe the second order.

776. The head of the *nautilus* supports a large fleshy disk, upon which it is believed that the animal crawls upon the bottom or sides of the ocean, as a snail upon its foot. The animal frequents deep waters; and though it is occasionally found at the surface, it sinks upon the least alarm, so that it has been very rarely captured, although the empty shell is so common. This power of rising and falling in the water appears in some degree connected with the structure of the shell, and with the mode in which its chambers communicate with the body by a membranous tube which passes through all the partitions, and is called the *siphuncle*. But of the mode in which this operates, no very satisfactory account has yet been given.*

Section of Nautilus Pompilius.

777. A large number of fossil shells analogous to that of the nautilus, and hence called *nautilites*, are found in various strata, from the oldest limestones and sandstones of the Silurian system to those covering the chalk. The fossilized mandibles, termed *rhyncholites*, which were at first supposed to have belonged to birds, are also abundant in some strata, especially in the lias at Lyme Regis.

CLASS XV.—PTEROPODA.

778. The Pteropoda are a small but remarkable class of Mollusca, distinguished by the adaptation of their structure for active locomotion in water only. Their general organization is higher than that of the Gasteropods; and they are particularly distinguished by the possession of a pair of fin-like organs, which are attached to the anterior part of the body, and are evidently adapted for propelling it rapidly through the water. The body is uniformly symmetrical; that is, its two sides precisely correspond—a condition obviously favourable for rapid movement. It is from the wing-like character of these lateral appendages that the name of the class is derived; and the animals composing it may be regarded as holding an analogous position among the Mollusca to the insects among Articulata, and to

* See Dr. Buckland's Bridgewater Treatise, for an attempt at explanation. This is deficient in its application to all those cases in which the siphuncle is a shelly and not a membranous tube, as in the *spirula*, *ammonite*, &c.

803. What of the habits of this species of nautilus?

804. What of this fifteenth class?

birds in the Vertebrated series. They are unprovided with any means of creeping along solid surfaces, and appear only modified for swimming.

779. The dimensions of the animals composing this class are uniformly small; but the number of individuals which associate together in shoals is often enormous, so that the sea appears literally alive with them. Some of them are possessed of a shell, whilst others are unprovided with such a protection. Wherever it exists, it is very light and delicate, and it seldom covers more than the posterior part of the body. In one beautiful little mollusc, the *cymbulia*, it is of a slipper form; the wings or fins issuing from the large opening. The head is usually prominent, possessing eyes and sensitive tentacula; and the interior organization is of a very complex nature.

780. One of the best known genera of this group is the *clio*, which abounds both in the Arctic and Antarctic seas, and is a very important article of food to the whale. The aspect of this animal will convey a good general idea of that of the whole class. The *clio* is itself eminently carnivorous; and in its whole organization is fitted to seize and prey upon the yet more minute inhabitants of the deep. The six tentacula which are seen upon its head, are found, when examined with the microscope, to be covered with numerous red spots. These, when still further magnified, are seen to be evidently distinct organs, placed with great regularity, and their number may be roughly estimated at about 3000 on each of the tentacula. Every one of them is found, when still more closely examined, to consist of a transparent cylinder, resembling the cell of a polype, and containing about twenty little suckers, which may be protruded from its mouth for the purpose of attaching themselves to prey. Thus, about 60,000 of these suckers may be computed to exist on every one of the tentacula; and the entire head of the little *clio* will be furnished with 360,000 of them.

781. Besides these organs of prehension, which, for complexity of structure, are probably unparalleled in the animal creation, the *clio* possesses two slender tentacula, analogous to the feelers of the snail, by which it takes cognisance of the presence of food. When its prey is drawn towards the mouth, it is reduced by a series of sharp horny teeth, set like those of a comb, upon a pair of firm jaws; and it is drawn into the gullet by the tongue, which is covered with regular rows of spiny hooklets, all directed backwards, and evidently intended to assist in the act of swallowing, as well as in the division of the food.

805. What of their structure?

806. What is remarkable in the genus *clio*?

807. How else are they distinguished?

782. The *Clio borealis* is well known to the whale-fishers and others as *whale's food*; this species swarms in the Arctic seas, and, when the weather is calm, these little animals may be

Clio Borealis.

seen floating in myriads upon the surface. According to Cuvier, the sea is sometimes so glutted with them that the whales cannot open their mouths without engulfing thousands of these small molluscs. An analogous species, the *C. australis*, appears equally abundant in the polar regions of the southern hemisphere.

783. The *hyalæa* is a little pteropod possessed of a shell, which is formed almost upon the model of that of the Conchifera. It consists of two valves or plates applied to the two surfaces of the body; of these one is larger than the other, and from the aperture between them, the animal sends forth two large yellow and violet wings or sails, by the action of which it moves with great velocity on the surface of the sea. "The animals of this order," observes Mr. Kirby, "both from the beautiful colouring of their filmy sails or wings, and from their number and symmetry, are better entitled to the appellation of the butterflies of the ocean, than the scallop-shells (*Pectens*) which have sometimes been so called." Their delicate structure is ill adapted to encounter an agitated sea, or the dangers of a rocky or shallow shore; and it is only in the vast and deep ocean that their elegant forms and colours, and their graceful movements, delight the mariner's eye, when the glassy surface of the still sea reflects the rays of the setting sun.

808. What other variety is described?

809. Describe the last species named.

CLASS XVI.—GASTEROPODA.

784. It is in the animals of this class that we find the characters of the Mollusca most prominently displayed, namely, the high development of the nutritive apparatus, with very feeble powers of locomotion. In all the more perfect forms, which are usually carnivorous, a distinct and prominent head exists, furnished not only with *tentacula* or feelers, but also with eyes, and with what appear to be rudiments of organs of smell and hearing. In this part, we usually perceive that *symmetry* or correspondence between the two halves, which has been spoken of as characterizing the *animal* organs in general; whilst in the posterior part of the body, which is made up of the organs of vegetative life, this symmetry is seldom to be discerned. The whole organization of the animals of this class is superior to that of the Conchifera. None of them are necessarily attached by their shells to other bodies, although in some instances they become so in consequence of their peculiar habits, as will be presently explained. They have the power of crawling from one place to another, by means of the expanded muscular disk or foot with which they are furnished; and as this foot proceeds from the belly or under surface of the animal, the class receives the name given to it. The mode in which it is used may be well seen by placing a snail or slug on a piece of glass, and looking at it from the under side. Many of those which inhabit the water can swim with considerable rapidity; but this power is chiefly possessed by those species which have no shell, or but a very slight one, and can bend their bodies in any direction.

785. The general character of the shelly structure, where it exists, is the same as in the Conchifera. It is in general composed of one piece, and called a *univalve*; in some instances, however, it is a *multivalve*; and in many species there is a small *operculum* or lid to the mouth of the shell, which may in some degree be regarded in the light of a second valve. The body is attached to the interior of the shell by muscles, which can withdraw it or project it at the will of the animal; and the operculum can be drawn down upon the mouth with considerable force. It is the habit of some species (as the *limpet* and *haliotis*) to attach themselves by the expanded surface of the foot to rocks, &c.; these are able to draw the shell closely down upon the rock, with great muscular power, just as the Conchi-

810. Describe the general structure of this sixteenth class.

811. What varieties are described here?

fera draw together their valves—a short interval existing, however, when the animal is not alarmed, for the admission of water or air to the cavity of the shell. A very slight irritation will cause the animal to draw the shell close down on the rock, from which it is then very difficult to detach it.

786. The shell is formed, as in other Mollusca, by an exudation from the mantle; and is enlarged at intervals, in accordance with the increasing size of the animal. In some, the addition of an entire new interior layer, projecting beyond the old one, is made at every such period as in the Conchifera; but in others, the new matter is secreted only at the edge of the previous shell, and is joined on, as it were, to it; in these the line of addition is usually marked by a prominent rib on the exterior, but the interior is beautifully smoothed off.

787. The forms of the shell in this class vary extremely; but those which appear most widely separated may be shown to be connected by intermediate links. The open cone of the limpet may be regarded as one of the simplest forms. In an allied genus, the *pileopsis*, we find the point prolonged, and somewhat rolled upon itself; and, by various links of this kind, we are brought to the regular spiral of the snail. From this we may return to the long straight form, by the *scalaria*, in which the coils of the spire touch each other only by their ribs; and by the *vermetus* and *magilus*, in which the commencement only of the shell possesses a spiral form, the remainder being prolonged into a straight tube. When the shell is spiral, and the point and mouth are not in the same plane, a sort of central pillar is formed, like that round which a spiral staircase is constructed. This is called the *columella*; and it is usually grooved at its lower part for the passage of water to the respiratory organs which are placed within the shell.

Murex Tenuispina.

788. The margin of the shell is not unfrequently fringed with spines, as in the *murex*: these are formed, like similar appendages in the Conchifera, by prolongation of the mantle; and the dissimilar number of them in different specimens has caused the establishment of many species, which, now that the habits of the animal are better known, prove to be but different forms of the same. For it has been ascertained that the animal has not only the power of forming new spines, but of removing old ones, especially such as would interfere with the continued growth of the shell. The edge of the mantle is applied against their bases, and a kind of absorption of shelly matter seems to take place—a notch being formed, which causes them to be easily broken off. Various analogous changes are produced by a similar action in other shells, the portions first formed being wholly or partially removed. Sometimes the walls of the older portion are thinned for the purpose of lightening the shell; and in other cases the top of the cone is altogether removed, a groove having been formed around its interior, which renders it so weak as to be easily broken off: in these last cases, the animal previously withdraws itself from the part that is thus to be separated, and throws a new partition across, by which the top of the shell remains closed after the division. A shell thus deprived of its apex is said to be *decolated*.

789. It is not only by such removals that the form of univalve shells undergoes a great change. Sometimes additions are made to them, which completely alter their figure, so that two individuals of different ages would be scarcely supposed at first sight to belong to the same tribe. But in all these cases, the form of the young shell may be traced in that of the adult. The accompanying figures of the *pteroceas* show this change in a moderate degree; in other genera it is much more remarkable. In another group of shells, of which the common *cowry* is an example, a still more curious alteration takes place. In the young shell, the edge is sharp, and the mouth or opening of considerable breadth. This state continues as long as the shell is increasing in size; but when it has arrived at adult age, the outer lip is thickened, and brought so near the other as to leave but a narrow chink between them. At the same time, a prolongation of the mantle on each side deposits a new layer of shelly matter on the outside of the previous one; and as the two prolongations meet along the back (the line of their junction being usually evident on the shell), this additional coat,

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- 813. What peculiar powers are ascribed to them?
 - 814. Describe the changes in the shell?
 - 815. What of the diagrams?

which is very hard and *porcellaneous* in its texture, encloses the whole previous shell.

Young Shell.

Adult Shell.

Pteroceras Scorpio.

790. The *operculum* is principally confined to the aquatic Gasteropoda. It is sometimes of the same texture as the shell itself, and sometimes horny. It does not always close the entire mouth of the shell, but it is sometimes made to fit it, at all stages of growth, with the most beautiful accuracy. Some of the land species also possess an operculum; but in general they are destitute of it, and they form during hybernation a temporary closure to the mouth of the shell, by a viscid secretion, which hardens into a thin plate, and includes within it a bubble of air. Behind this, a second, and even a third, similar partition is occasionally found, as in the common snail.

791. The subdivision of this extensive class into orders, may be best affected by arranging the different tribes according to

816. What other changes are cited?

817. What other species is mentioned?

the character and position of the respiratory organs. The following are those adopted by Cuvier.

Young Shell.

Adult Shell.

Cypræa Exanthema.

(I.) **PULMONEA**.—These are terrestrial species, adapted to breathe air by means of a pulmonary sac, or air-cavity, the orifice of which they can open or close at will. Many have no shell.

(II.) **NUDIBRANCHIATA**.—These, as well as all the succeeding orders, are aquatic, being adapted to respire water by gills, like other Mollusca. The animals of this order have no shell, and they carry their branchiæ, which present various forms, on some part of the back.

(III.) **INFEROBRANCHIATA**.—These are similar in many respects to the preceding, but the branchiæ are situated under the margins of the mantle.

(IV.) **TECTIBRANCHIATA**.—In the greater part of the animals contained in this order, the branchiæ are situated upon the back, or on the side, and are covered in by a fold of the mantle, and this fold usually includes a shell more or less developed.

(V.) **HETEROPODA**.—This is a small order, characterized by the peculiar form of the foot, which is not spread out horizon-

tally, but compressed vertically into a sort of fin. They carry their branchiæ, the tufts of which are generally protected by a shell, upon the back.

(VI.) PECTINIBRANCHIATA.—The animals of this order, to which belong all the spiral shells, except those of the Pulmonea, are so named from the comb-like form of their gills, which are usually situated in a cavity behind the head, corresponding with the respiratory sac of the Pulmonea. This is by far the most numerous order of the whole.

(VII.) TUBULIBRANCHIATA.—These have many affinities with the last order; but the shell is spiral only at its apex, where it is commonly fixed to (or rather enclosed by) other bodies, and is prolonged in the shape of a tube more or less regular.

(VIII.) SCUTIBRANCHIATA.—In these, also, there is a considerable resemblance to the Pectinibranchiata in the form and position of the gills; but the shells are very open, scarcely in any degree spiral, and cover the body and gills like a shield; and they also differ essentially in their mode of reproduction.

(IX.) CYCLOBRANCHIATA.—These molluscs have their gills disposed in little tufts under the margins of the mantle, much as in the Inferobranchiata; but they have shells, which are spread out over the body, and differ from that order in their mode of reproduction.

Order I.—Pulmonea.

792. Although the greater part of the molluscs of this order live on land, some are aquatic; but these, like the aquatic air-breathing Insects and Vertebrata, are obliged to come occasionally to the surface to breathe. They all feed chiefly upon vegetables, and many of them exclusively so; but some are extremely voracious, and will devour almost any organized matter that falls in their way. They are diffused through all climates, particular species being restricted to each. Those without a shell, commonly known as *slugs*, constitute the family of LIMACINÆ. In the common *slugs*, as in most of the terrestrial species of this order, we observe a prominent head, with four tentacula, and at the end of the longer pair the eyes are situated. These tentacula can be drawn inwards by a process resembling the inversion of the finger of a glove. On the back there is a kind of shield or disk formed by the mantle, which sometimes encloses a small shell. This shield covers the pulmonary sac, the opening of which is in its right side, and the head can be withdrawn beneath it. The *testacella* is a kind of slug, which has the disk of the mantle at the posterior extremity, and this always contains a small shell. This animal, which

feeds largely on earth-worms, is abundant in the south of France, and has lately been introduced into the gardens of this country, where it is multiplying rapidly.

793. The *snails* and their allies, constituting the family HELICINÆ, are closely allied to the *slugs* in organization; differing in but little else than the possession of a shell into which the body may be withdrawn. The common garden snail of this country, and the *helix pomatia*, or edible snail of France and Italy, are well-known examples of this family. More striking ones are to be found, however, in tropical climates, where some species of the genus *Bulinus* attain to great size, the eggs being as large as a pigeon's. In some species, the direction of the coils of the shell is opposite to what it is in other spiral shells; such are said to be *reversed*. A European species of this genus is one most remarkable for the decollation of its shell. An

Achatina Zebra.

Achatina Virginea.

other large snail of tropical climates is the *achatina*, which feeds on trees and shrubs, chiefly on the western coast of Africa and

820. Describe the second family.

821. What species is presented in the diagram?

822. What other varieties are named?

in the West Indies. Several of its species are distinguished by the beauty of their colours.

794. The aquatic Pulmonea have only two tentacula. From the necessity of coming to the surface to breathe, they can only live in water of inconsiderable depth; and they chiefly inhabit ponds and shallow streams, or the banks of rivers. Some, however, live on the sea-shore. The *Planorbis*, the shell of which is quite flat, having all its coils upon the same level, is a very common genus in this country; as is also the *Lymnæa*, which feeds upon seeds as well as the softer parts of plants, and the stomach of which has a very muscular gizzard.

Order II.—Nudibranchiata.

795. The animals of this order, which might be designated *sea-slugs*, are all marine; and, being adapted to breathe water at any depths, and also, in many instances, to swim with facility, they are often found at a great distance from land. When they swim, it is usually in a reversed position, the foot being turned upwards; this is made concave by muscular action, so as to serve as a kind of boat, the buoyancy of which keeps the animal at the surface without effort. This order is a very numerous one, and some of its species attain a considerable size; but, from their habits, little is known of them. The eggs of many species are united together in a ribbon-like form, and the mass is extremely large in proportion to the size of the animals. The *doris* and *tritonia* are inhabitants of the British seas, and are occasionally found on our shores. The latter is remarkable for being able to produce a sound resembling the clear tone of a small bell sharply struck. One of the most interesting forms in this order is that of the *glaucus*, an inhabitant of the Mediterranean. It is distinguished by the great prolongation of the gills into fan-like appendages, by means of which the animals swim on their backs with great agility. They are beautifully coloured, having silver hues intermixed with azure-blue, whence their name is derived.

Order III.—Inferobranchiata.

796. The few molluscs contained in this order differ but little from the last, except in the position of their gills, and their incapability of swimming. They are, therefore, confined to the sea-shore; where they subsist, as do the Nudibranchiata, upon sea-weeds and other aquatic plants.

823. Describe the second order.

824. What is remarkable in the species named?

Order IV.—Tectibranchiata.

797. This order begins to show an approximation towards that disposition of the gills which characterizes the great bulk of the class; the animals composing it are marine, and live chiefly on the shore or on floating sea-weeds. A very characteristic example of the order is the *aplysia*, commonly termed sea-hare, which is abundant on many parts of the British coasts. Its vernacular name is probably derived from the peculiar form of the superior pair of tentacula, which are flattened and hollowed, like the ears of a quadruped. The head has a very distinct neck. The branchiæ consist of leaflets arranged in a complex form, and situated on the back, beneath a fold of the mantle, which also encloses a flat horny shell. The digestive apparatus is very complicated, consisting of a membranous crop like that of birds, a gizzard having cartilaginous walls, and a third stomach beset with sharp hooks in its interior. These animals feed on sea-weed. They are very sluggish in their movements; but have a peculiar means of defence, con-

Bursatella Leachii.

sisting of a deep purple liquid, which they can discharge from the edge of the mantle when alarmed, and by which the surrounding water is discoloured, so that they cannot be discerned.

825. How are the third and fourth orders distinguished?

826. Describe the several species.

In the *Bullæa*, an animal which is found on oozy bottoms in almost every shore, the shell is calcareous, and is more or less rolled into a spiral. It is still, however, enveloped in a fold of the mantle, and is much too small to contain the animal. The *Bursatella* is a very curious allied genus, in which the body has a somewhat globular form; there is no trace of shell; and the branchiæ project considerably from the cavity formed for their protection. It is an inhabitant of the Indian Ocean, and sometimes attains considerable size.

Order V.—Heteropoda.

798. This is a very small order, but the animals contained in it differ remarkably from all other molluscs. At the edge of the vertical muscular plate, which has been mentioned as occupying the position of the foot in the other Gasteropoda, is a small conical sucker, by which the animal can attach itself, and which represents the expanded disk of other orders. The gills are placed on the back, and close behind them are the heart and liver, which seem, as it were, external to the body. In one of the few genera which the order contain, these parts are protected by a small shell; whilst in another there is none. The body, consisting of a semi-transparent gelatinous substance, enclosed in a muscular envelope, is elongated, and generally terminated by a compressed tail; this body can be distended with water. The animal swims in a reversed position, the fin-like foot being uppermost, and the shell depending below. They are limited to warm latitudes; one species of the *Carinaria* inhabits the Mediterranean, and occasionally appears on particular coasts in large numbers; whilst others are peculiar to the tropics, where most of the allied genera also exist. The shell of the *Carinaria* is interesting, on account both of its extreme delicacy and fragility, and on account of the strong resemblance which that of the argonaut or paper nautilus bears to it.

Order VI.—Pectinibranchiata.

799. This order is not only by far the most numerous in the whole class, but contains the animals which may be regarded as its most characteristic examples. They have all two tentacula and two eyes, sometimes raised on stalks as in the snail. The mouth is prolonged into a sort of proboscis; and the tongue is furnished with little hooks or recurved spines, which enable it to wear down the hardest bodies by slow and oft-repeated action. The cavity in which the gills are fixed occupies the last whorl of the shell; and in some of the order there is a tubular prolongation of the mantle, termed the *siphon*, for

the purpose of conveying water into this cavity, so that the animal can breathe without leaving its shelter. By the presence or absence of this organ, and by the form of the shell, which here appears to bear a sufficiently constant relation with that of the animals, this large group may be arranged under the following families:—(I.) *TROCHOIDÆ*, in which there is no siphon, and which have the mouth closed by an operculum. (II.) *CAPULOIDÆ*, which have a wide open shell, very much like that of the limpets, without operculum or notch at the margin for the passage of a siphon. (III.) *BUCCINOIDÆ*, which have a spiral shell and a canal at the end of the columella for the passage of the siphon; this is sometimes extremely prolonged, as in the *muræx*; and the genera exhibiting this character are all carnivorous in their habits.

800. (I.) Of the family *TROCHOIDÆ*, a characteristic illustration is the common *periwinkle* of our coasts; but tropical species attain a much larger size, and are among the most massive of univalves. Among the most remarkable species of this family, which is a very extensive one, may be mentioned the *Trochus agglutinans*, peculiar on account of its habit of gluing and attaching to its shell, as it grows, different foreign bodies, such as gravel, fragments of other shells, &c.; by this its shell acquires a weight and power of resistance, which the matter secreted from the animal itself is not sufficient to give. Many of this group have the form, and in some degree the habits, of the *Helicinæ*, being able to live out of the water, and even ascending trees, in search of food. Of those confined to water, some can only live in fresh streams, and others in the sea; whilst some species appear to flourish as well in either, and fix themselves to situations at the mouths of rivers, where the tide will wash them with salt and fresh water alternately. A very remarkable marine species is the *janthina*, or violet-snail, which possesses a peculiar floating apparatus, composed of a number of foam-like vesicles, attached to its foot, and apparently formed by it. When the sea is calm, these beautiful animals may be seen floating over it in considerable numbers; but when rough, they speedily sink, absorbing, in some unknown manner, the air which these vesicles contain. To the under surface of the float they also attach their eggs. When alarmed, they emit a deep blue fluid, which tinges the sea around, and hides them from their enemies. An allied genus, the *Litiopa*, lives on the gulf-weed, whence it has the power of suspending itself by a thread, as a spider from the ceiling; and

828. Describe the general characters of the sixth order.

829. How is it divided into families?

830. What of the first variety?

by the same thread it can remount at pleasure to the surface of the weed.

801. (11.) The animals of the small family CAPULOIDÆ were formerly arranged with the *Patellæ* or *limpet* tribe, under the order Cyclobranchiata, but differ from them in having the gills comb-shaped, and arranged in a cavity behind the head, as in the other Pectinibranchiata. As the species it contains present little of general interest, this slight notice is sufficient.

802. Of the BUCCINOIDÆ, the common *whelk* (*buccinum undatum*) of our own coast is a characteristic example. This animal seems to be omnivorous, devouring sea-weed and animal matter with nearly equal readiness; its eggs are laid in adherent masses, which are much larger than the animal itself

Buccinum Undatum.

in its usual condition. The animals inhabiting the greater proportion of the univalve marine shells preserved in cabinets, bear a considerable resemblance to this in structure and mode of life, and present no peculiarities worth special notice. The varieties in the form and structure of the shell are very interesting to the naturalist; but the mere technical description of them would be superfluous here. The following well-known tribes, however, may be mentioned as contributing to form this family:—The Cones, Cowries, Volutes, Ovulæ, Olives, Whelks, Helmets, with the Murex, Fusus, Strombus, Pteroceras, Pyrula, &c.—these last having the siphon very long, and being for the most part carnivorous.

831. What various species are named?

832. Describe the other varieties here cited.

833. What of the diagram?

Order VII.—Tubulibranchiata.

803. This group, though small, possesses many points of interest. The irregular shelly tube which is formed by some of the animals composing it, so much resembles that formed by certain Annelida, as to be scarcely distinguishable from it, although the animal is distinctly molluscous in the one case and articulated in the other. Hence, before the animals received that attention which was at first given to their shells, these were associated with the Serpulæ. The order contains only three genera; and of these, two have the same habits, to which their power of adapting their structure is very remarkable. The shell is formed in the first instance upon the spiral plan; but the animals frequent coral-banks, and having no proper foot, and no other means of locomotion, they are liable to be enclosed in the coral with its advancing growth. They avoid the ill effects of this by prolonging the cavity of the shell in a line more or less straight, so as to keep its orifice on a level with the surface of the coral, so that it can never be closed up. All molluscous animals seem to avoid living in a cavity which is too large for them; and when they withdraw from a portion of the shell which they no longer inhabit, they either fill it up or throw a partition across it. The *magilus* does the first, and the *vermetus* the second. The shell of the *magilus* is sometimes found buried in madrepore, the tubular part having a length of as much as three feet, and the part first formed being entirely solidified. On the other hand, the *vermetus*, which lives in the same circumstances, throws a partition across the portion of the shell it has quitted; and this is renewed as often as it extends its tube, to keep pace with the growth of the coral, and quits its lower part; so that a series of little chambers is thus formed, which may be compared in some degree to those of the chambered Cephalopoda, but are not connected by a siphon. The third genus of this order is the *Siliquaria*, the tube of which has a fissure along its whole extent, which gives admission, through a corresponding fissure in the mantle, to the water required for the supply of the gills, which are disposed in a beautiful fringe along its entire length.

Order VIII.—Scutibranchiata.

804. This order is also a small one, containing but two principal genera, which do not differ widely from the Limpets, except in the disposition of the gills. The shells are very open, without an operculum; and the greater number are not in any

834. How is the seventh order characterized?

835. What of the eighth order, and its species?

degree spiral. In the *haliotis*, the shell is slightly twisted; and from a faint resemblance it is thought to bear to the ear of a quadruped, it has been called the *sea-ear*. This animal, in its living state, is one of the most beautiful of Gasteropods, on account of the variety and richness of its colours. Its shell, when the surface is polished, possesses a pearly lustre with resplendent metallic hues. It is consequently much sought for as an ornament. The shell of the *fissurella* and its allies closely resembles that of the limpet; but it has a small aperture at the top, through which the water is introduced that supplies the branchiæ; these are pectinated, like those of the sixth order, and arranged in a cavity on the back, as in them.

Order IX.—Cyclobranchiata.

805. The general form of the *Limpets*, which principally compose this order, is well known; and the peculiarity in the position of their gills has already been mentioned. They have a very long ribbon-like tongue, covered with spines, and this appears to be their principal means of obtaining their food, which chiefly consists of sea-weeds. When they desire to move from one part of the rock on which they affix themselves to another, they crawl slowly, by the elongation and contraction of the fleshy disk that constitutes the foot, just as does the slug. At other times, especially when left dry by the tide, they are quite inert, unless an effort is made to move them, which they will resist by drawing themselves hard down upon their base. Closely allied to the Limpets in general structure, but differing remarkably in the formation of the shell, are the *Chitons*, of which some small species inhabit our shores, but which attain to much greater size between the tropics. Their shell is composed of a number of plates arranged behind one another with great regularity, and connected by a very complex series of ligaments and muscles, which reminds the naturalist of those which unite and move the different segments in the articulated animals. The edges of these plates are bound together by the mantle, which sometimes assumes the appearance of shagreen, and is sometimes beset with spines, hairs, or bristles. The Chitons are the only Mollusca which exhibit any approach to the articulated structure; and they seem to connect these two sub-kingdoms through a group of Crustacea now altogether extinct, the *Trilobites*, which had probably a considerable affinity with them.

836. Describe the ninth order.

837. What other groups are described?

CLASS XVII.—CONCHIFERA.

806. This class is nearly synonymous with that of the *bivalves* in the Linnæan arrangement, since all the animals which construct bivalve shells belong to it; but it also contains a few species whose shells are *multivalve*, and some others in which there appears at first sight an entire departure from the usual form. The molluscs belonging to this class are, in common with the *Tunicata*, destitute of a head; that is, the mouth is not situated upon a prominent part of the body, nor assisted in its choice of food by organs of special sensation in its neighbourhood; but the entrance to the stomach is buried between the folds of the mantle. Hence these two groups were associated by Cuvier into one class, to which he gave the name of *ACEPHALA*, Headless Molluscs; but there is quite sufficient reason for separating them, on account of the superior organization of the group at present under consideration.

807. The part of the structure of these animals which is best known, is the *shell*. This is composed of particles of lime, exuded from the surface of the mantle, in combination with a gluey secretion, by which they are united together. If one of the valves of a bivalve shell be examined, it will be seen to consist of a number of layers, of which the outer one is the smallest, each inner one projecting beyond the one which covers it. This is more evident in such shells as that of the oysters, in which the layers adhere loosely together, than in others in which they are more compact. The shelly matter is thrown out at intervals from the surface of the mantle; and as the animal enlarges at each interval, the new layer extends beyond the old one. In this manner, a constant relation is preserved between the size of the animal and that of its shell; and the addition of the newly-formed portions, not to the edge only, but to the interior of the whole previous shell, strengthens the latter in proportion to its increase in size. The regular coloured markings often seen on the valves are due to the secretion of colouring matter, which is incorporated with the calcareous exudation, from glands in particular portions of the mantle; and the spines or other prolongations which many shells possess, are formed by little processes or extensions of the mantle for that object.

808. The valves are connected together in various ways. In the first place they are jointed by a *hinge*, which is in some

838. How is the seventeenth class distinguished?

839. What of the peculiarities of shell?

instances so firm and complicated, that it holds them together when all the soft parts have been removed. This hinge is sometimes formed by the locking of a continuous ridge on one valve into a groove in the other, and sometimes by a number of little projections, or *teeth*, which fit into corresponding hollows in the opposite valve. In the neighbourhood of the hinge (sometimes outside, sometimes inside, or both) is fixed the *ligament*, which is composed of an elastic animal substance; this answers the purpose of binding the valves together, and at the same time of keeping them a little apart, which may be regarded as their natural position. When the animal wishes to draw the valves closely together, it does so by means of the *adductor* muscle, which is fixed to the interior of both valves at some distance from the hinge, and of which the insertion can be easily traced by a somewhat rough depression of the interior surface of each valve. In some Conchifera this muscle is single, and in others it is double, the two parts being even at opposite ends of the valve. Upon this character it has been proposed to found the primary division of the class into orders; but the classification thus formed is not a natural one, inasmuch as it brings together kinds which have little resemblance, and widely separates others which are closely allied.

809. In order to describe the general structure of the Conchifera, it will be advantageous to select some particular illustration; and the common *mussel* is well adapted to this purpose. On opening such a shell, it is seen that the two valves are lined by a membrane which corresponds with the tunic or *mantle* of the Tunicata. This is divided into two halves along a considerable part of the edge of the valves, but it is united near the large end. In some Conchifera, as will be presently noticed, the two halves of the mantle are separated along their whole extent; whilst in others, as in the Tunicata, they are completely closed, with the exception of the two orifices for the ingress and egress of water, which are sometimes drawn out into long tubes. In the muscle the water enters through a slit in the closed part of the mantle, and passes out by another in its neighbourhood; but the water thus introduced is principally for the supply of the gills, as the mouth or entrance to the stomach is placed at the small end of the shell, where the mantle is quite open, and can take in food from the surrounding water, which comes into free contact with it. The gills in all Conchifera consist of four ribbon-like fringes, fixed to the mantle along the edge of the shell most distant from the hinge. Near the small end of the shell is seen the stomach, with the short

840. Describe the structure of the valves.

841. What of the mussel tribe?

tube leading to it, the orifice of which is furnished with four tentacula or feelers. To the right of this is seen the long and complicated intestinal tube, with the liver lying in separate masses amongst its folds. And nearer the large end, the cavity of the shell is chiefly occupied by the ovarium, in which the eggs are formed. Close to this is the powerful adductor muscle, by which the valves can be drawn together with considerable force. The intestinal tube is seen to terminate near the opening at the posterior (or right hand) extremity of the shell, which discharges its contents, and serves for the exit of the respiratory current.

Interior of Mussel: *a*, right valve; *b*, left valve; *c*, hinge, *d*, stomach; *e*, tentacula; *f*, foot; *g*, byssus; *h*, branchial orifice; *i*, vent; *k*, termination of intestine; *l*, liver; *m*, gills; *n*, adductor muscle; *o*, ovarium.

810. The foregoing description will apply, with slight variations, to the structure of almost all Conchifera; but we have now to notice two organs, which are absent in some, and in others more largely developed than in the present instance. From the lower part of the shell passing out between the separate edges of the mantle, is seen the *foot*, a fleshy muscular organ, somewhat resembling the tongue of higher animals, and not containing any hard support, or being protected by any envelope. This foot, which is the only special locomotive organ possessed by the mollusca of this class, serves a great variety of purposes, sometimes enabling the animal to leap with considerable agility along a hard surface, sometimes being used to bore into the sand or mud, and sometimes serving only to affix the animal to some firm support. From the base of this foot there proceeds, in the muscle, a band of hair-like filaments, forming what is called the *byssus*. These sometimes exist in great abundance, and serve, by being fixed by their extremities to the shore or

842 Describe their peculiar structure.

843. What of the diagram?

bottom of the sea, to anchor the shell, and yet to allow the animal considerable freedom of motion within certain limits. Frequently the byssus is altogether absent.

811. The Conchifera have usually more power of locomotion than the Tunicata. Some of them, however, as the oyster, are attached to one spot during all but the earliest period of their lives. Others adhere by the byssus, or by the foot, by which they obtain a certain range; and others are free during the whole of their lives, swimming and leaping with considerable agility. In these movements some of them appear to be directed by powers of sight, and in these are perceived small red spots at the edges of the mantle, which are believed to be eyes. They do not appear to have much choice of food, nor are they provided with any other means of obtaining it than the ciliary action which introduces constant currents of water into the mouth. In general they do not attain any great size, but they are on the whole larger than any Molluscs except the Cephalopoda; and a few species attain considerable dimensions—a *pinna* having been known four feet long, and a *tridacne* (giant clamp-shell) having been known to weigh 600 lbs. They are distributed over the whole globe, principally frequenting the shores or shallows. Each region has certain species peculiar or most abundant in it, and there are few which are not limited to one hemisphere. The temperate zone appears as favourable to the development and multiplication of some species, as the torrid zone to others; but the largest kinds are only found in warm latitudes.

812. In the subdivision of this class into orders, the degree in which the two lobes of the mantle adhere along the margin of the shell, is the character chiefly rested on; the presence or absence of the foot, and of the byssus, also, are important characters; and along with these the structure of the hinge should be attended to. On these grounds, the five following orders are established by Cuvier: (I.) OSTRACEÆ, the *Oyster* tribe, in which the two halves of the mantle are separated the whole way round, and the foot absent or very small: they are usually fixed by the shell to solid bodies. (II.) MYTILACEÆ, the *Mussel* tribe, in which the mantle remains open in front (at the end where the mouth is situated) and close behind, an aperture being left for the egress of the fluid. They have a foot strong enough to crawl by, and commonly affix themselves by a byssus. (III.) CHAMACEÆ, or *Clamp-shells*; in these the mantle is closed, with the exception of three apertures, two of which are for the ingress

844. What unusual organs are described?

845. What of their locomotion?

846. How are they diversified?

and egress of water, and the third for the passage of the foot, which is here usually more powerful. (iv.) CARDIACEÆ, or *Cockle* tribe, in which the mantle is not only closed, but extended at the respiratory apertures into tubes of greater or less length. The foot is very strong. (v.) The INCLUSA, in which the mantle has only one opening for the passage of the foot; at the posterior end it is prolonged into tubes of great length, that can be extended far beyond the shell, as in the common *Solens* or *Razor-shells*.

Order I.—Ostraceæ.

813. The Ostraceæ, of all these orders, exhibit the nearest approach to the Tunicata, both in the absence of the foot, the entirely fixed condition of the body and in the low grade of their organization in general. The shell itself is usually fixed by adhesion to other masses; sometimes the animal is attached by a byssus; and some species, which are unattached, have a slight power of changing their place, by suddenly closing their valves, and squirting out the water that was between them. In the true *Oysters*, there are no teeth in the hinge, which is held together by the ligament only. Several species exist, some of which are as abundant in tropical regions as the common oyster of temperate seas is on the shores of Britain. Their continued abundance, notwithstanding the large quantities constantly being consumed, is less surprising when we reflect upon their astonishing fertility; as many as 1,200,000 eggs having been detected in a single individual. The *Pectens* have a hinge like that of the oysters, but differ in having the surface of the valves raised up into ribs, and in having two angular projections, commonly termed *ears*, by the sides of the hinge. Many of them are very elegantly coloured; and they are the most active of the whole order, being entirely unattached, and swimming with greater quickness than would have been expected from their imperfect means of locomotion. The *Anomia* are nearly allied to the oysters, but have a remarkable peculiarity in the structure of the shell. The greater part of the adductor muscle passes through a fissure in one of the valves to be attached to a third plate, sometimes shelly and some-

Anomia Ehippium.

847. Into what five orders does Cuvier divide them?

848. What is remarkable in the first order?

849. What varieties are described?

times horny, by which the animal adheres to foreign bodies ; the remainder joins one valve to the other. Thus, we have a *multivalve* shell formed by an animal which, both in structure and habits, corresponds closely with the bivalve oyster. The *Spondyli* are also allied to the oysters, but have a more complex hinge, each valve having two teeth which enter into pits in the opposite valve ; one species is remarkable for the distance which often intervenes between the different layers of which the convex valve is composed ; a series of cavities being thus formed, which bear a slight resemblance to those of a chambered shell, and which usually contain water.

814. The foregoing tribes of Ostraceæ, and many more which might be enumerated, are distinguished by the presence of only one adductor muscle ; in the remainder of the order, as in most other bivalves, there exists a second. Among these may be first mentioned the *etheria*, which is a sort of fresh-water oyster. The *Aviculæ*, which furnish the greater number of the pearls so highly prized as ornaments, are commonly called *Pearl-Oysters*, from their general resemblance to the same tribe. The valves are extended into ears or wings, on each side of the hinge ; and these are frequently very long on one side. The pearl is produced from the same substance as that which lines the shell, and which is generally known as mother-of-pearl. It seems usually to result from some irritation of the mantle, which causes it to excrete an unusual quantity of pearly matter at one spot ; and grains of sand, or other small particles which, by getting between the membrane and the shell, seem to have caused such an irritation, are often found in the centres of pearls. Sometimes, again, pearls are found at points where the shell has been pierced by a boring animal ; and it has been proposed to cause the formation of pearls by perforating the shell ; but the pearls so produced seldom have that regularity in their form which is as important to their value as is their size. Pearls are also produced within many other shells. The *Pinnae*, or Wing-Shells, approach the Mussels in many respects ; they are remarkable for the length and silky character of the byssus, by which they attach themselves to rocks, and which is collected in the Mediterranean for the manufacture of gloves and other articles, for which it is well adapted by its strength and durability.

Order II.—Mytilaceæ.

815. The order Mytilaceæ is well represented by the common *mussel*, which has been already described. The various species

850. What is peculiar in the other species named ?

851. Whence are pearls derived ?

of this group are extensively diffused; and from their abundance in particular localities, and their palatability, they serve as important articles of food. Belonging to this order are some remarkable *boring* shells, which have the power of penetrating hard rocks, and making deep holes, which are enlarged as they advance, in accordance with the growth of the animals, and which, therefore, they cannot quit. By what means they accomplish this is unknown. The flattened form of the shell is a sufficient proof that it is not by mechanical action, as in some

Anodon Dipsas. On the right and left of the upper valve are seen the muscular impressions on the interior of the shell.

of the boring shells of the order *Inclusa*. The *Anodon* is a fresh-water mussel, closely allied in general conformation to those inhabiting the sea, but differing remarkably in the absence of teeth in the hinge, whence the name of the genus is derived. The *Unio* is another fresh-water genus, having a more complicated hinge. It is remarkable for the pearly aspect of the lining of the valves and for producing small pearls, sometimes in considerable abundance. These are not so pure in their colour, however, as those of the *Avicula*, and are but little esteemed. Some species of *Unio* are common in the lakes and rivers of Britain, but the greater number are peculiar to North America; many of these are remarkable for their size and colour. There are some marine *Mytilaceæ* allied to the *Unios*, one of which burrows in coral.

852. What of this second order?

853. What different species are described?

Order III.—Camaceæ.

816. The order Camaceæ includes but a comparatively small number of species, most of which are peculiar to tropical climates. The most remarkable is the *tridacne gigas*, or giant clamp-shell of the Indian Ocean. When young, this animal attaches itself to rocks by means of its tendinous foot, which serves as a sort of byssus; but when its shell becomes so massive that it is in no danger of injury, it detaches itself, and the groove of the shell is filled up. The enormous weight sometimes attained by this animal has already been mentioned. Smaller specimens are often brought to this country; the valves being used to receive water from small fountains, &c., and, on the continent, being employed as reservoirs of holy water in the churches. The foot has a structure so tough, that, to separate the shell attached by it, it is necessary to chop it with a hatchet like a cable. The animal being edible, is sought by the natives of the islands near which it lives, especially the Molluccas. It is usually seen in water a few feet deep, with its valves slightly separated; a pole is pushed down between them, which alarms the animal, and causes it to draw the valves together. The pole is thus firmly grasped, and by this the shell may be lifted from its bed.

Order IV.—Cardiaceæ.

817. In the animals of the Cardiaceæ, or *Cockle* tribe, we usually find greater activity than in any others of the class. The foot now comes to be a very important organ, possessed of great muscular power, and capable of being applied to a variety of uses. Many of these animals bury themselves in sand or mud; and it is in these that we find the respiratory orifices prolonged into tubes. In the common *cockle*, however, these tubes can scarcely be said to exist, the orifices not being prolonged beyond the shell. Its foot is very large, and can be bent nearly double in the middle; by doing this, and then suddenly straightening it, the animal is enabled to take considerable leaps. The hinge is very beautifully constructed, and the two valves lock closely together. The *Trigonia*, a very interesting genus, abundant in former ages of the globe, but now restricted to the shores of New Holland, seems allied to the cockle in the structure of its hinge and shell, in the size of its foot, and in its general organization, although its mantle is divided into two lobes along the whole margin of the valves,

854. What is the general character of the third order?

855. Describe the fourth order and their structure.

as in the oyster. This is an instance of the impropriety of basing our classification on any single characters. There are other Cardiaceæ, which obviously conduct towards the next order. Such is the *tellina*, of which the valves, when closed together, gape at the posterior extremity; and through this passage there pass out two long tubes, which terminate in the branchial orifices and funnel. These tubes have an elastic structure, and can be entirely drawn within the shell. These long tubes are seen also in the *venus* and its allies, of which one species is remarkable for the long spines which guard its posterior end; and also in the *macra*, and the animals allied to it. In some cases the tubes are united along their whole length, and appear to be single, but they are always in reality double. All these animals are in the habit of burying themselves in sand, or mud, or in stones; and the tubes serve to introduce fresh water from the entrance of their burrow.

Order V.—Inclusa.

818. In the order Inclusa, we usually find the valves, when joined together, presenting more or less of a cylindrical form, as in the common razor-shell. A hollow is left at each end, and from one the foot is projected, through a passage in the mantle, whilst the other gives exit to the respiratory tubes, which are often prolonged to a great length. The animals live almost uniformly buried in sand or mud, in rocks or wood. The *solen*, or razor-shell, is a very characteristic example of the order, which contains, however, some forms that depart very widely from it. The foot, which can be projected from the lower end, is firm and pointed, and serves as an admirable boring instrument, by the use of which the animal can burrow in the sand with great rapidity, sinking very deep when alarmed. The *mya* approaches, in the form of its shell, and in its general organization, to the previous family; but some of its species also closely approximate to the solens. The *pholas* is a very interesting genus, the animal of which nearly resembles that of the solen, whilst the shell is formed of several pieces, and would thence be called a *multivalve*. There are two principal portions, and a variable number of accessory pieces. Some species of this genus bore in mud, others in rocks, and a few in wood. Their action seems purely mechanical. They fix themselves firmly by the powerful foot, and then make the shell revolve; the sharp edges of this commence the perforation, which is afterwards enlarged.

856. What various species are described?

857. How is the fifth order distinguished?

858. What varieties are named?

by the rasp-like action of the rough exterior; and though the shell must thus be constantly worn down, yet it is replaced by a new formation from the animal, so as never to be unfit for its purpose.

819. We now pass on to some very remarkable forms of this order, in which the bivalve character of the shell gradually disappears, being replaced by a new structure, of which no examples have been yet seen. The *teredo*, or wood-worm, as it is commonly termed, is an animal of the same general organization as the pholas; but its valves are smaller in proportion to the body, and its tubes still more prolonged, at least when the animal may be regarded as full grown. By means of the mechanical action of its valves, it perforates timber, in the same manner as the pholas penetrates stone. As it advances, the respiratory tubes are prolonged, so that their orifice remains at the entrance of the burrow, which is very small in proportion to the cavity formed by the animal as it increases in size. This orifice is furnished with a pair of valve-like shelly plates, termed *palmulæ*, by the action of which a current of water is driven towards the body of the animal, in order to serve for its respiration, and at the same time for the supply of its food. The gallery is lined by a calcareous exudation from the surface of the tubular prolongation of the mantle, which forms a kind of secondary shell. The *teredo* is an animal extremely destructive to timber, especially in warm climates, from which it seems to have been originally introduced into the sea-ports of Europe.

820. In the *Gastrochæna*, this secondary tube is found to line not only the part of the passage behind the valves, but also the deepest extremity of the burrow, so that it includes the valves, which bear but a small proportion to it; the shelly tube is itself partly divided, along nearly its whole length, into channels for the entrance and exit of water. In *Clavagella*, one of the valves is incorporated with the tube, whilst the other is free, and seems to have a function somewhat similar to that of the *palmulæ* of the *Teredo*. Lastly, in *Aspergillum*, we find the valves extremely small, and completely incorporated with the tube, where, however, they may be distinctly traced. The large extremity is not completely closed, but is perforated with numerous small holes, some of which are prolonged into little tubes. This animal burrows in sand; and there is reason to believe that, through these orifices, it obtains a supply of water, which it has no special means of introducing into the cavity.

821. Besides the orders now described as composing the

859. How is the boring performed?

860. What varieties are described?

861. What other groups are named?

class Conchifera, there is a very curious group which should also be included in it, although established as a separate class by many naturalists. This is the group of BRACHIOPODA, containing only three genera at present known, namely, *Terebratula*, *Lingula*, and *Orbicula*; but formerly of much greater comparative importance. These animals have all bivalve shells, differing in no essential particular from those of the Conchifera in general. The two former genera are attached, however, by a footstalk, proceeding from an opening in one of the valves near the hinge, to solid substances; and in this respect they have an affinity with the Tunicata. The *Orbicula* are attached, like an oyster, by one of the valves. They bear considerable resemblance to the Tunicata also, in the structure of the nutritive system—the digestive apparatus, heart, gills, &c. But in the complexity of the muscular apparatus provided for giving motion to the valves, they much surpass the highest of the other Conchifera. There are not only several muscles provided for the closure of the shell, but another set to open it—an organization which no other bivalves possess. The most peculiar part of their structure, and that from which they derive their name, consists in the presence of two very long arms or tentacula, between the origin of which the mouth is situated. These can be projected to a considerable distance from the shell, or drawn in and coiled up spirally within it. They do not appear, however, to seize upon prey, but rather, by means of the cilia with which they are fringed, to create currents

Terebratula:

A, valve with the spiral arms; B, valve with arms removed.

which may bring food to the mouth. In the *Terebratula*, these arms are affixed at their bases to a very curious framework within the shell, the use of which is uncertain; but it is be-

862. How is this group subdivided?

863. What is peculiar in their structure?

864. Describe the diagrams.

lieved to aid, by its elasticity, in separating the valves from each other. This framework is most complex in the species in which the arms are shortest. The species of Brachiopoda at present known live at great depths in the ocean; and many of their peculiarities seem to have reference to that particular condition. They are distributed through all latitudes.

CLASS XVIII.—TUNICATA.

822. The lowest and simplest of the Molluscous classes is that to which the name of Tunicata has been given, in order to mark the peculiar structure of the animals composing it. They bear a general resemblance to the animals which form bivalve shells, but are of inferior organization. They are peculiarly distinguished from them, however, by the entire absence of any shelly envelope, and by the possession, instead of it, of a *tunic* or external coat, of greater firmness than the rest of the structure, which surrounds the whole body and affords it protection, besides being the medium of its attachment to the fixed substances upon which these animals usually rest. This external tunic is extremely variable in colour, consistence, and form. Sometimes it is dark, and of leathery toughness: sometimes even cartilaginous; and in many species it exudes a glutinous matter by which particles of sand, gravel, comminuted shells, &c., are attached together, so as to form an additional envelope, which possesses great firmness. Sometimes, on the other hand, the whole body is extremely soft and delicate in its structure, and the tunic is a thin transparent membrane, the colour of which depends upon the intensity of the light transmitted through it.

823. A vast proportion of the animals of this class are attached, during the greater part of their existence, either to each other or to solid bodies. In a few species, a number of individuals are united by a stem, which contains vessels establishing a connection amongst them all, so that they closely resemble the compound Polypifera. More commonly, however, the Tunicata live in societies, each individual being distinct from the rest, but a number adhering together to form one mass, which is often enclosed in a common envelope. In other instances, each animal is completely separated from the rest although a number are found in the same locality. Where this is the case, the animals are severally fixed to rocks or

865. What of the eighteenth class, and their structure?

866. What is remarkable in this group?

other solid masses, either by the adhesion of the tunic itself, or by a sort of footstalk prolonged from it.

824. The *tunic* is always provided with two orifices; these are sometimes placed near each other, and are sometimes at the opposite extremities of the body; in some species, too, they are simple apertures, surrounded by a muscle which can open or close them, whilst in others they are situated upon tubular prolongations of the general envelope. One of these orifices serves for the entrance of water into the cavity of the mantle, the other for its exit. The great bulk of the body may be considered as a respiratory chamber, that is, a cavity lined with a membrane upon which the blood is plentifully distributed, in order that it may be exposed to the action of the air contained in the water introduced into it. Accordingly, a continual current of water is maintained by the action of the *cilia* (minute, constantly-vibrating, hair-like filaments), which clothe the lining membrane; and this current also serves to supply food to the inactive creature which produces it. The true mouth, or entrance to the canal that leads to the stomach, is situated at the bottom of the *branchial sac*, or respiratory chamber; and part of the water introduced into the latter passes into the stomach, and, after traversing the intestinal canal, and parting with whatever nutritive materials it contained, is ejected from the second orifice of the tunic, with the stream that has merely passed over the respiratory membrane.

825. In these actions nearly the whole life of the Tunicata appears to consist. Those which are adherent to rocks have no power of changing their place when once attached; and those which float in water, either singly or adherent to one another, seem to have no means of locomotion, except what they derive from the currents just described. The only other movement ordinarily noticed, is the contraction of the whole sac, which takes place when the animal is irritated in any way, the water contained in it being violently ejected.

826. The figure on the next page will give a general idea of the structure of one of these animals. On the right hand it is seen in its natural condition, with its attached footstalk; the two projections on the right side are short tubes terminating in the orifices by which water is introduced and expelled. On the left hand is shown the interior of the sac, which has been laid open; it is seen to be nearly empty, the intestinal canal on the left side occupying but a small proportion of the cavity; and the membrane lining it is disposed in folds, which are traversed by blood-vessels, so as to expose the greatest extent of

867. How is their respiration performed?

868. What of their habits and structure?

surface to the action of the water, by the air contained in which the vital fluid is purified. The orifice by which the water enters this chamber is called the *branchial* aperture, because it is chiefly for the admission of water to the *branchiæ* or gills, and that through which it passes out is called the *funnel* or vent.

Ascidia Australis: A, external aspect; B, internal structure.

827. The division of this class into orders is most satisfactorily based upon the relative position of these two orifices, which will be found to have a close relation with the modes of life of two groups of animals respectively. In the *ASCIDIÆ*, the two orifices approach one another more or less closely, and the body is either immediately fixed to some solid mass, or attached to it (as in the example just referred to) by a foot-stalk. In the *SALPÆ*, on the other hand, the two orifices are situated at the opposite extremities of the body, which usually has an elongated form. They seldom attach themselves to fixed objects, but float freely amidst the waters. Without any special means of locomotion, they are continually changing their place, by means of the currents of water they produce; for the fluid being drawn in at one end, and expelled at the other, they advance in the direction to which the branchial orifice points. The *Salpæ* are usually of much more delicate structure than the *Ascidæ*. Some of the more interesting species of each group will now be noticed.

Order I.—*Ascidæ*.

828. Although some of the *Ascidæ* present a nearer approach to the animals forming bivalve shells, than do any of the *Salpæ*,

869. What of the diagrams?

870. How are they divided?

it can scarcely be doubted that the group as a whole is inferior; and in it only do we find instances of that connection of several individuals by a common stalk, through which blood passes from one to the other, which indicates an approach to the Polypifera, especially to the order Ascidioida. In these compound Ascidiæ a curious phenomenon is witnessed, which resembles the movement of fluid that will be described in one of the compound Polypes, the Sertularia. The stem which supports them contains two large vessels, which send off branches into the footstalks that support the several individuals. The branch from one trunk goes at once to the heart of each ascidia, which is but a simple bag, formed by a dilatation of the tube, having muscular walls; and that from the other is connected with the vessels which return from the intestinal tube and respiratory membrane, which are supplied with branches proceeding from the heart. The blood may be observed ascending for a time towards the heart through the first of these trunks, passing thence to the general structure, and returning through the footstalk by the second. But, after a short time, the current is reversed, and the blood ascends through what was before the returning trunk, and descends through the heart. In a short time the flow is again reversed; and this change is repeated with great regularity, just as in the Sertularia. Although this alternation may be best observed in these compound Ascidiæ, in which the direction of the flow through the stem and branches may be clearly traced, there is reason to believe that it is common to the whole group of these curious animals.

829. In other members of this order, there is no connection between the internal structure of the different individuals, but several are associated together under one common envelope, encrusting stones or other solid bodies, and even attaching themselves to larger species of isolated Ascidiæ. Such are the animals of the genus *Polyclinum*. On the other hand, the *Botrylli* attach themselves in preference to floating bodies, and arrange themselves in the form of stars, the funnels of all being directed towards a central space, and the branchial orifices, which are nearly at the opposite extremity of the body, being turned outwards. Both in their structure and habits, therefore, these *Botrylli* seem intermediate between the entirely fixed Ascidiæ and the Salpæ which move freely in numbers attached to each other without any extraneous support. The most highly organized Ascidiæ live quite separately, though a number often affix themselves to rocks side by side, so closely

871. What is peculiar in their circulation?

872. What varieties are described?

that, if one contract on being touched, it will jostle its neighbour, which will contract in its turn, and this will cause the contraction of the rest, and so on through a whole row. The Ascidiaë are diffused through all latitudes; and many species exist on the shores of Britain, belonging to the different groups which have been mentioned. In their young state they enjoy considerable locomotive powers, by the vibration of a sort of tail (like that of a tadpole) with which they are furnished; but when once fixed, this disappears.

Order II.—Salpæ.

830. The Salpæ are most abundant in tropical climates, and possess a greater delicacy of organization than the Ascidiaë, being generally almost or completely transparent. Most of the species belonging to this group are also remarkable for their luminous properties. In no species does there appear to exist such an internal connection as has been described in the lowest Ascidiaë; but scarcely any of them are entirely solitary. They generally associate together in masses of considerable extent, adhering either by their whole external surfaces, or by little projections from it, which seem formed for the purpose of attaching them to each other. Sometimes these masses assume the form of long bands, composed of Salpæ adhering together side by side, all lying in the same direction. In others, again, the form of a star is presented, by an arrangement similar to that of the Botryllus. One of the most interesting of all, however, is the *Pyrosoma*, in which a number of these stars are piled, as it were, on one another, so as to form a cylindrical tube, which is closed at one end. The orifices of all the animals composing it are disposed in the same direction, so that water is constantly being drawn in on the exterior, and expelled from the interior of the tube; as it can only pass out at one extremity, a current of sufficient force is produced to occasion the steady movement of the aggregate mass in the contrary direction. The luminosity of the *Pyrosoma*, the length of which varies from five to fourteen inches, is extremely vivid.

873. What is remarkable in the second order?

874. Describe their peculiarities.

SUB-KINGDOM—RADIATA.

831. The general fact formerly stated, that in every complete natural group there are some members which exhibit most plainly its characteristic peculiarities, whilst there are others in which they cannot be distinctly traced, or are altogether obscured, is nowhere more evident than when we compare together the different classes which are associated into this sub-kingdom. For whilst in some we find the *radiated* arrangement of parts almost invariably preserved, and, if left at all, only slightly departed from, we can only trace it indistinctly in others; and in others, again, it cannot be at all perceived. Thus, when we examine a star-fish, a medusa, or a sea-anemone, we observe that they all have a circular form; that the mouth is in the centre of one of the surfaces, and that the several parts arranged round these are but repetitions of one another; and an internal examination would show the contained organs to have the same character. If from these we pass to certain other species of the same groups, we should find the external form slightly modified, being prolonged or shortened in one particular direction, and the disposition of the interior organs no longer radiated. Again, in the Sponges, all trace of a circular arrangement of parts disappears. Yet these, and other groups in which the radiated type is equally absent, must be associated with the classes more characteristic of them, on account of their general conformity of structure, and in some instances their very close alliance with them.

832. Moreover, in comparing the different forms of this group, we see exemplified another general principle, namely, that the *aberrant* members of it, those which depart most widely from its regular type, connect it with other groups. For among the species in which the radiated arrangement is obscure, we find some that conduct us toward the Mollusca, and others that lead us to the Articulata; whilst in the Sponges and Corallines we have an evident approximation to the vegetable kingdom. So close, indeed, is this approximation, that there are many beings of which the true character is yet in doubt: they live and grow, and multiply very much in the manner of plants; and it cannot be ascertained with certainty whether the feeble motions they exhibit are to be regarded as spontaneous or not.

875. Describe the characteristics of this sub-kingdom.

876. What different species are named?

877. What is said of the Sponges and Corallines?

878. What variety of structure is found?

833. The great diversity, not only in form, but also in degree of organization, that exists amongst the radiated classes, prevents much being stated of their general characters that shall be applicable to all of them. Thus, although the skeleton is external in some species, as the sea-urchin and star-fish, it is internal in others, as the Corals and some of the jelly-fish. Although most of them have a distinct mouth and stomach for the reception of aliment, others imbibe it, like plants, only by absorption through their exterior. Although some exhibit a high degree of sensibility, others are so apathetic as scarcely to manifest any feeling of injury when severely wounded.

834. The class **POLYPIFERA**, containing the coral-forming animals, may perhaps be regarded as the most characteristic of the group. These animals usually associate themselves together into compound masses, of which every part is capable of existing independently of the rest, and each polype exhibits in itself the radiated structure, which cannot be detected in the entire mass; but all have a certain degree of connection with each other, which may be compared to that existing among the different buds of a tree. Even the species which do not form solid structures, such as the sea-anemone, remain almost constantly attached to the same spot.

835. The **ACALEPHÆ**, commonly termed Sea-Nettles, or Jelly-Fish, have no such tendency to aggregation; and they never attach themselves to solid bodies, but wander at large through the ocean. By these characters, and by their extreme softness, these animals are readily distinguished.

836. The **ECHINODERMATA** also live solitarily, and have the power of free movement, except in a few species which approach the Polypifera; but they are readily distinguished from the Acalephæ by the density of their texture, and especially by the roughness of the integument, which is usually beset with prickles or spines, as in the star-fish and sea-urchin.

In the two following classes, no distinctly radiated structure can be seen :—

837. The **POLYGASTRICA**, which are ordinarily known as Animalcules, are beings of extreme minuteness, and general simplicity of structure. In the absence of distinct organs for the various purposes of the economy, they correspond with the lower Radiata; but they differ in the extreme activity of their movements. A separate division of the animal kingdom might almost be formed for them alone, so difficult is it to assign

879. Describe each of the radiated classes.

880. What of the Animalcular variety?

them any place in the ordinary scale. Some of them exhibit a tendency to associate into compound structures like the Polypifera.

838. The PORIFERA, or Sponge tribe, are, of all animals, those which approach nearest to plants in the absence of the characters peculiar to the kingdom in which they are placed, and in the want of definiteness of form. Certain movements exhibited by them, however, and their close affinity with some of the Polypifera, render it proper that they should be classed among animals.

CLASS XIX.—POLYGASTRICA.

839. This class includes the greater part of those minute beings termed *Animalcules*, which have been, from the time of the discovery of the microscope, such fertile sources of wonder and delight, both to those who have themselves observed them and to those who have heard from others of their marvels. Previously to that epoch, it was not suspected that beings existed of such minuteness as to be invisible to the eye, much less was any idea entertained of the extreme smallness of many species; and still more improbable and absurd would the statement have been deemed, that such beings are not of rare occurrence, but abound in every drop of stagnant water, and even exist in the whole mass of the ocean. Yet such has been shown to be the fact; and every improvement in the powers of the microscope has enlarged our ideas of the extent of animal life in the fluids of the globe. So that the philosopher is now ready to admit no limit to the possible minuteness of living beings, but looks to still further improvements in the microscope as a means of extending his acquaintance with them, and not as likely to set any bound to his inquiries.

840. In the general term *Animalcules* have been included a large number of beings which have no claim to a place in this class; all the minute forms of animal existence, in fact, were so denominated, whether they were beings perfect in themselves or only the embryos of higher forms into which they would subsequently be developed. And, thus, the gemmules of Polypus, and the larvæ of Insects, have been confounded with the true *Animalcules*. The term *Infusoria* has also been applied to them,

881. What is said of the Sponge tribe?

882. By what means was this class discovered?

883. What wonders are thus disclosed?

from the circumstance of their abounding in infusions of decomposing animal or vegetable matter. It is, in fact, from containing a large quantity of such matter, that the waters of ponds and ditches are an especial resort of animalcules; and it may be doubted whether they *can* exist in water which is perfectly pure. But under the general term of Infusoria has been included a tribe until recently confounded with these other and probably simpler beings; this tribe, consisting of the Wheel-Animalcules and their allies, will be hereafter described as a separate class, under the name of Rotifera.

841. Animalcules may be obtained without difficulty for microscopic examination, during the warmer part of the year, by skimming the surface of ponds, especially those in which the water exhibits a red or green tinge, or in which it is covered with duckweed, or with the slimy film which may often be noticed. Many curious species frequent these situations; but the commoner ones may be obtained with even less difficulty, by placing soft vegetable matter, of almost any description, in vessels with water, and exposing the mixture to the sun and air for a few days. As soon as decomposition begins actively to take place, animalcules may be detected in the fluid, and in a short time they often crowd it most densely. These are generally at first of a simpler kind, but new species soon prevail, and those first seen disappear. Different kinds of vegetable matter seem to favour the development of the different species; and there are some animalcules that can be produced in no other way than from an infusion of some particular substance. Asparagus stems that have been boiled, will favour the production of animalcules, with perhaps as much readiness as any vegetable matter; hay, chopped straw, the leaves of plants, and other common ingredients, may also be advantageously employed.

842. When such facts are stated, the question naturally arises, from what source are these animalcules developed? Are they actually produced by the dead and decaying matter in the midst of which they are found, in the same manner as maggots are popularly supposed to be bred in putrid meat? or, are their germs constantly floating about in the air, ready to spring into active life wherever they find a fluid adapted to afford them materials for their development, as some seeds are wafted from place to place, until they find a fitting soil in which they may take root? The latter of these suppositions, improbable as it may appear (especially when we consider that there are many hundred different kinds of animalcules, and that we must suppose that the

884. What varieties are mentioned?

885. Whence may they be obtained?

886. What other methods of obtaining them?

germs of all these are diffused through the atmosphere in order to account for their appearance in the several situations they frequent), must be regarded as nearest to the truth. It is quite certain that no fluid, the communication of which with the external air is prevented, will produce animalcules: and thus it would appear that the invisible germs are sown, as it were, like seeds, in the solution, and are called from their previously torpid state into active life, by the nutriment they find there, different kinds of which are adapted to different species of animalcules.

843. In the class Polygastrica are included all the most minute species of true Animalcules, and some among the larger ones; but as a whole, the beings composing it are smaller than the Rotifera, and far smaller than those of any other class. The largest among them are but with difficulty seen by the naked eye, and of the dimensions of the smallest the mind can scarcely form an adequate conception, although they may be numerically stated. The class takes its name from the belief entertained by the celebrated Prussian naturalist, Ehrenburg (who has devoted almost his whole life to the study of the microscopic forms of existence), that the animals composing it may be characterized by the possession of many distinct stomachs or digestive sacs. There is some doubt upon this question, however; that which can actually be seen will be presently stated, and it will be preferable to enter no further into the question in this place.

844. The bodies of these Animalcules are of very soft con-

Various forms of Animalcules.

sistence, and very transparent, so that they resemble flakes of very thin jelly. Their forms are extremely variable; and, in some species, the same individual at different times alters its

887. How is their generation accounted for?

888. To what class do the smallest belong?

shape so completely that it could scarcely be recognised. Indeed, many mistakes have occurred from this cause. The softness of the tissues of the Polygastrica is also seen when, in swimming, they encounter an obstacle; there seems scarcely any limit to the change of form to which many will submit, in order to pass the obstruction. They are not all so flexible, however, for in some species the body is enclosed in a silicious sheath of very great delicacy, which gives support and protection to the still more delicate structures it contains. It is the accumulation of such sheaths that has given rise to the collections of Fossil Infusoria (as they have been termed), which will be hereafter noticed. Sometimes the whole body is contained within the sheath, whilst in other instances a sort of trunk or foot may be projected from its opening.

845. The bodies of the Polygastrica are usually fringed with cilia, by the vibrations of which they are assisted in their own movements, and also in the acquirement of their food. Sometimes these cilia are disposed along the whole extent of the edges of the body; in other instances they surround the mouth only, and from that part they are seldom absent. In the *vorticella*, an animalcule which is very commonly found clustering round the stems of duckweed, a complete circle of cilia may be observed, at the top of the funnel-shaped body, the lower end of which is prolonged into a stalk that serves for its attachment. This last peculiarity is by no means confined to it, however; for although the greater part of the Polygastrica are endowed with the power of active movement, some remain attached, like Polypes, during a great part of their lives, and others fix themselves occasionally. In some instances, too, we find a number associated into one compound plant-like structure, exhibiting the habit of the Polypifera, although the several parts are analogous to other Polygastric Animalcules.

846. For some time after the discovery of the Infusoria, it was supposed that they must obtain their nutriment by absorption through the substance of their bodies, for no mouth, stomach, or alimentary tube, could then be discerned. But, by placing them in water through which very small particles of colouring matter (such as indigo or carmine) were diffused, it was perceived that these particles are introduced into the interior of the body, and are collected in cavities hollowed from the general mass. And, subsequently, the improved powers of the microscope have enabled an entrance to the interior of the body, or mouth, to be discovered in almost every instance, and a second orifice in a considerable number of species. The

889. What of the variety of form and structure?

890. What of their locomotive powers?

mouth is commonly furnished with a border of cilia, and sometimes with a set of projecting, bristle-like teeth, which are used in laying hold of smaller animalcules, on which the possessor of this apparatus feeds. The introduction of food into the cavity of the body, in those species which are destitute of this appendage, may be best watched by diffusing colouring particles through the water in which the animalcules are swimming. They are seen to be drawn into the mouth by the vortex or whirlpool occasioned by the action of the cilia; and soon after entering it, they are observed to be united together into little round balls, as if they had been compressed in a small spherical cavity. These balls are sent, one after the other, into the general cavity of the body, where they seem to lie in the midst of a soft gelatinous pulp, and in which they perform a slow revolution—the foremost ones escaping at intervals from the second orifice, whilst new ones are being pushed in from the mouth behind.

847. This is all that can as yet be certainly stated in regard to the digestive apparatus of the Polygastrica; since the opinion of Ehrenberg, that the whole body is occupied by a series of small distinct globular cavities or stomachs, connected by an intestinal tube, is not adopted by other naturalists. Nothing will therefore be said of his classification of these Animalcules, which is principally based upon characters furnished (according to his idea) by the arrangement of the stomachs. Some further details of the physiology of this interesting class will be more profitable to the reader.

848. The largest species of the Polygastrica probably never exceed 1-20th of an inch in length; the smallest at present known are about 1-200th of a *line* in diameter; but there is no reason to suppose that this is by any means the limit of minuteness. They usually multiply by spontaneous division, the body of the parent splitting into two or more parts, each of which soon becomes a perfect being, capable of going through the same process. From observations which have been made upon the species in which these changes are most rapidly effected, it has been calculated that, under the most favourable circumstances as to food, temperature, &c., a hundred and forty million millions may be produced in four days—a degree of fertility which assists in explaining the almost universal diffusion of these animalcules, and their sudden appearance in countless swarms.

849. A peculiar mode of reproduction exists in one very curious compound animalcule, the *volvox globator*, or globe animal-

891. How is their internal structure made visible?

892. What is said of their minuteness?

cule, which is one of the most beautiful and interesting of all the species with which the microscope has made the observer familiar. Each globe was formerly regarded as a single animalcule, moving through the water by its own will; it was seen to contain smaller globes, which gradually increased, and at last gained exit by the rupture of the parent sphere, these second globes often being seen to contain within themselves a third generation before they escape from the first. It is now known, however, that each sphere is a collection of animalcules; the little projections upon its surface being distinct individuals, each having its own cilia, by the simultaneous action of which the globe is caused to roll through the water. They are all connected by a delicate transparent membrane, which forms the wall of the hollow sphere, and which is to the individuals something like what the polype-structure is to its component polypes; these walls are traversed by vessels, which establish a certain degree of connection between the several beings. The interior globes consist of newly-formed associations of a similar description; they are of darker colour than that which contains them, because the animalcules of which they are composed are packed more closely together, the intervening walls not being yet developed. Many other such compound structures exist in various forms; some of the most common being flattened shields, each of which separates into four divisions, every such part containing a certain number of individuals, and gradually assuming the form and size of its parent.

850. Our ideas of the great amount of animal life existing in this class have lately received a vast extension by the discovery that their remains, minute as they are, not unfrequently accumulate into masses of great extent. It is only of those species in which the bodies are covered with an envelope containing earthy matter, that the remains can be

Fossil remains of Animalcules forming Tripoli.

thus preserved; and the substance formed by their aggregation seems to be an impalpable powder, such is the minuteness of each particle. Such substances have long been known under various names. One is the Tripoli, or Rotten-stone, used in the arts for polishing metals. Another is the silicious meal

893. What wonderful instance is described?

894. What instances of fossil remains are cited?

which has been used in Sweden, on account of its supposed nutritious qualities, mixed in bread with flour and the inner bark of trees, in times of scarcity. Both these, as well as many other substances, consist entirely of the silicious shields or envelopes of Animalcules, closely allied to, if not identical with, species at present existing; and the quantity of animal matter which is dried up in the latter, and which may be determined by the effect of heat, (this dissipating the animal portion, and leaving the silicious particles unchanged,) is sufficient to account for its nutritious properties.

851. The mode in which such deposits were formed is readily understood from an examination of the bottom of the waters in which the existing species abound. Here a kind of whitish mud is seen to be slowly deposited; and this, when highly magnified, is seen to consist entirely of the remains of past generations of the Animalcules, to which constant additions are being made. Of the countless multitudes that must thus accumulate in order to constitute an appreciable quantity, some idea may be formed from the fact that, of the larger species, 187 millions are estimated to go to a grain; and that of the smallest, a cubic line is reckoned to contain 1000 millions. It is probably not only in the formations in which they can be distinctly seen, that these extraordinary beings have had a share, for in many others some remains of them can be traced, which have the appearance of having been partially dissolved by the action of water, which, by afterwards depositing the silix, has again consolidated them. This is the case in agates, opals, and many flints.

CLASS XX.—ECHINODERMATA.

852. The class of Echinodermata, comprehending those well-known animals, the *Asterias* (star-fish) and *Echinus* (sea-urchin), takes its name from the prickly skin with which most of the tribe it includes are provided. But this is not a universal character; for some of the species, which border upon other groups, have a skin destitute of any appearance of spines. There is little difficulty, however, in distinguishing the animals of this class from all others; for in nearly the whole of them the radiated structure, or the arrangement of parts in a circular form, is very evident; and they are the only animals among

895. How are they shown to be innumerable?

896. What species are comprised in the twentieth class?

the Radiata which have the power of moving from place to place, and have at the same time an integument firm enough to resist pressure.

853. Although the character and degree of organization in the different subdivisions of this class may be regarded as about the same, the form of the organs, and the mode in which they are arranged, are very different; so that it will be better to describe each group separately. The class may be distributed into three orders—the *STELLERIDA*, including the star-fishes and their allies; the *ECHINIDÆ*, including the echinus and its allies; and the *HOLOTHURIDÆ*, a group less commonly known, and differing much from others.

Order I.—Stellerida.

854. The common *asterias*, or star-fish, which may be taken as a type of the order Stellerida, is covered with a tough leathery skin, beset with prickles. The animal has the form of a star, with five or more rays springing from a central disk. In the middle of one side of the disk is situated the mouth; and this side, according to the usual habits of the animal, must be considered the lower one. In this respect, the position of the mouth corresponds to that of the medusa. The mouth opens into a globular stomach, which sends out prolongations into the several rays; but there is no intestine in this animal, nor any second orifice to the digestive cavity; so that the indigestible parts are rejected by the mouth, as in the sea-anemone. The rays also contain the ovaria, in which the ova or eggs are produced; and these are liberated through openings surrounding the mouth. A system of vessels for the absorption of aliment from the stomach, and for the transmission of the nutritive fluid from one part of the body to another, and also a set of nervous fibres forming a ring around the mouth, may be observed in this animal, and show the complexity of its structure to be greater than what has been displayed in the lower classes.

asterias : upper surface.

855. But it is in the skeleton, and in the organs of motion, of the *star-fish*, that the most remarkable complexity is displayed. If the tough prickly skin be removed, it is seen that it is supported by a series of bony plates, beautifully jointed together. Along the under side of each ray, the plates exhibit a series of perforations, through which there issue, in the living state, a large number of minute tubes, which may be occa-

897. Into how many orders are they divided?

898. Describe the first order

sionally seen projecting on the outside. These tubes are termed the *feet*, on account of the use to which they are subservient. Every one of them is connected, on the interior of the shell, with a small vesicle or bag, which is capable of being distended with water by a system of vessels adapted to the purpose, and of contracting so as to force its contents into the tube. The tube consists of a delicate elastic membrane, covered with two layers of muscular fibres, the one circular, the other longitudinal, and furnished with a sucker at its extremity. When distended with water, the tube projects from the body; and if the sucker be then applied to any movable substance, it will be drawn towards the body by the elasticity of the membrane, when the distending force is relaxed. Although each sucker is small and weak, the combined efforts of many give the animal considerable power not only of drawing prey towards the mouth, but of moving its own body from place to place.

856. The rays or arms of the *star-fish* are in some degree movable, both from side to side, and towards or away from the mouth. These animals feed upon almost any organized substance, living or dead, that falls in their way; and, by means of the suckers on the rays, and the motion of the rays themselves, they can convey to the stomach various living animals that have come within their reach. In some of the species there is reason to believe that eyes exist at the extremity of the rays, little red spots being seen there, like the eyes of others among the inferior classes, and the motions of the animals, in their change of place, and in their search for food, appearing to be directed by some visual sense.

857. The order Stellerida includes a large number of forms, having a general resemblance to the *star-fish*, but differing much in the relative proportion of the body and rays. Thus, in some species, the arms seem to make up the entire animal, no central disk being present, save that formed by their union. In others, the arms appear simply appendages to the central disk, to which the stomach and other important organs are confined; one of these is called *Ophiura*, from the resemblance of the arms to serpents' tails. In some instances, the arms send off lateral appendages, and these occasionally again subdivide, so that a branch-like structure is produced, such as we find in the *Comatula*.

858. A very remarkable tribe, included among the Stellerida—once a group very important in its numbers, and in the

899. What is remarkable in its structure?

900. Describe its complex skeleton.

901. What variety is described?

extent of its diffusion through the sea, but now presenting only two or three comparatively small species—is that known under the name of *Crinoidea*, or lily-like animals. These are formed much upon the plan of the *Comatula*, but they are attached by a jointed stalk to solid substances, usually to the bottom of the sea. They thus remind us of the *Polypifera*, which they seem to connect with the *Echinodermata*. This group contains two principal subdivisions—the *Encrinites* and the *Pentacrinites*. The former are distinguished by the roundness of their stems, the joints of which, being flat and perforated in the centre, are known under the name of wheel-stones, or St. Cuthbert's beads. The latter have pentagonal stems. The former seem to have been the most ancient. Their remains abound in the transition limestone of Dudley, and other strata of that period; but the tribe has now entirely disappeared from the surface of the globe.

859. The *Pentacrinites* are found in more recent strata; and two species of the tribe, one a very small one, found in the Bay of Cork, and a larger one in the West Indian seas, still now remain to us. They are extremely beautiful structures, and the number of distinct parts they contain is often enormous. It has been reckoned that in the *P. briareus*, the total number of the pieces of the skeleton is certainly not less than 150,000. And, as each piece was furnished with at least two sets of muscular fibres, the skeleton must have been put in motion by 300,000 such muscles. The *Encrinites* seem to have been attached by spreading roots, which prevented them from moving when once affixed. The *pentacrinus*, on the other hand, seems to attach itself by a kind of sucker at the bottom of the stem, so that it can quit its support at pleasure, and go in search of a new one.

Order II.—Echinida.

860. In the *Echinida* we find the body usually of a somewhat globular shape, and enveloped in a firm shell, composed of a very regular series of plates jointed together. In the *echinus*, the shell of which is commonly known as the sea-egg, we observe two orifices situated at the poles, as it were, of the globe. The larger of these orifices is the mouth; at the smaller one the intestinal tube terminates. The mouth, as in the star-fish, is generally directed downwards. It is furnished with a very curious apparatus of teeth, which are worked by powerful muscles attached to projections of the shell, that may

902. Name the next tribe and its divisions?

903. What is wonderful in the last mentioned?

904. Describe the peculiarities of this order.

be seen on the inner margin of the mouth; and their points can even be protruded beyond the mouth, so as to lay hold of prey brought to them by the long tubular feet. By the action of the teeth, the food is ground down before it passes into the intestinal tube, which is here of considerable length, and takes a couple of turns round the shell before its termination. Round the second orifice of the shell are disposed the ovaria, which are very largely distended with eggs at some seasons, and are eaten under the name of the *roe of the sea-egg*.

861. It is the exterior organization of these animals, however, that presents us with the greatest sources of interest. On looking at the *Echinida* in their living state, we see that most of them are covered with spines of considerable size, instead of with such small prickles as the *Asterias* bears. Moreover, these spines are seen to be movable at their bases, and this power of motion is due to their peculiar connection with the shell. Each spine is spread, at its root, into a cup-like form, and the hollow of this cup fits upon a little knob or tubercle projecting from the surface of the shell, so that a complete ball-and-socket joint is formed. The spines are connected to each other, and held on the shell, by the skin which covers the latter, and which is attached around their roots; and it is by the contractions of this skin that they are moved. In the *Cidaris*, which may perhaps be regarded as the highest form of the *Echinida*, the spines are generally few in number, but of large size; their tubercles are very prominent; and they are united by an elastic ligament which is imbedded in the top of each knob, and the hollow of each cup, like the round ligament of the hip-joint in man. Thus, they are firmly held together, and great freedom of motion is allowed.

862. On looking at the exterior of the shell of an *echinus*, it is seen that the tubercles are arranged with great regularity, and that the larger ones are confined to particular rows of plates, which are hence called *tubercular plates*. Between these are smaller plates, commonly bearing smaller tubercles, and perforated with a number of minute holes for the passage of the tubular feet; these are called *ambulacral plates*. The tubular feet, like the spines, are much longer than in the star-fish. They are always capable of being projected

Shell of *Echinus*: *a*, tubercular plates; *b*, ambulacral plates.

905. What of their external structure?

906. How is this described?

beyond the spines; and, taking an attachment by the suckers at their extremities, they can cause the shell to roll, as it were, upon the points of these. In some species, the spines are five or six inches long, whilst the diameter of the body is much less. The tubular feet often escape notice on account of their transparency; and the animal appears to be walking upon its spines, when it is merely resting upon them as fulcra, and drawing itself forwards by these curious organs. It is to be remembered that the body will weigh much less in water than in air, and thus may be supported upon spines of great delicacy.

863. The structure of the shell itself, and the mode of its increase, are not among the least interesting parts of the history of this animal. The shell is composed, as already stated, of a large number of plates disposed with great regularity, and accurately fitted together. These plates are usually of an hexagonal shape, but, where small and large ones join, there is of course some modification. Now, it is obvious that a shell of globular form can only be regularly increased in all its dimensions by the equal growth of every part of it. But the hard structures themselves, in beings of this low grade of organization, are not traversed by vessels which shall cause any growth of their substance; and, as in the skeletons of the Poly-pifera, the parts once deposited undergo little or no subsequent change. All the growth takes place at their edges, and by the peculiar division of the shell of the Echinida, a corresponding addition to every plate will preserve the form of the whole. This addition is provided for by the interposition of a thin layer of membrane, from which the shelly substance may be deposited between the edges of all the plates; and this membrane also answers the purpose of forming a connection between the skin covering the shell and the organs of nutrition within.

864. These animals are generally found on sandy shores, and especially in little nooks secluded from the direct influence of the waves. Some of them excavate hollows in the sand by means of their spines, and one species even works its way into solid rock. Their food is of a mixed quality. Fragments of shells, Crustacea, and other marine animal products, are found in their stomachs, as well as portions of sea-weed. They obtain their prey whilst lurking in their hollows, by allowing their tubular feet to play loosely in the water around; and when any small animal touches the sucker at the end of one of them, it is soon secured by the assistance of others, and drawn within the range of the powerful teeth.

865. It is not in every species of Echinida that the globular

907. What is said of the growth of the shell?

908. What is said of their habits?

form is so well marked as in the sea-egg. There are many in which the shell is more or less flattened, and in which one or both of the apertures of the alimentary canal are out of the centre. In these the dental apparatus is either absent or comparatively feeble. Among these we may notice the *spatangus*, in the various species of which we may observe a gradation from the globular form of the *echinus* to a very much flattened one, with the second orifice placed rather at the side, or even on the under surface, than at the upper pole. The mouth, too, leaves the centre, and is usually situated at the part of the under surface opposite to the vent. The whole body is prolonged in the direction of the line joining the two orifices, so that the radiated type is here considerably departed from. The *spatangus* feeds upon the animalcules and decaying organic matter mixed up with the sand in which it burrows; and to obtain this, it takes a large quantity of sand into its stomach, which is always found full of it.

866. The *clypeaster* is another of the Echinida in which the characteristic form is in some degree departed from. Here, too, the shell is flattened, and the second orifice, or vent, leaves its summit, but the mouth retains its central position on the lower side; and thus as the vent, in the different species, becomes more and more removed from its original position, it approximates the mouth. In the same proportion, usually, the shell is flattened, so that, in these two characters, an approach to the structure of the *star-fish* is indicated. This is very remarkable in some species of *Scutella*, in which the shell is not only extremely flattened, but even divided in some degree at its edges, or by partitions within; and the two orifices are so near each other as almost to unite, and thus resemble the single orifice of the *asterias*. There are, however, other characters by which their true place in the scale is made clear.

867. It is remarkable that, judging from the order of their fossil remains, the *Crinoidea* should have abounded in the ocean long before the Echinida existed in any large numbers. The mountain limestone, in which whole beds are sometimes made up of Encrinites, contains very few Echini. The number of these last increased, however, as the others diminished, and in later strata, such as the chalk, they are very abundant. Hence, we derive an inference in regard to the former temperature of the globe similar to that which the consideration of the fossil Polypifera afforded; for whilst the only large species of *Pentacrinus* at present existing is confined to tropical seas, the Echi-

909. What different species are described?

910. What geological inference is derived here?

nida range over almost the whole globe; and thus we may conclude that the temperature of the parts at a distance from the equator was formerly higher than at present, and that it has gradually cooled down.

Order III.—Holothurida.

868. In the last order of Echinodermata, the Holothurida, we find the characters of the class remarkably blended with those of Articulated animals. The body is not enveloped in a hard shell, but in an elastic skin, destitute of spines or prickles. It retains, in some species, the globular form, but in many it is very much prolonged, so as to be almost cylindrical, and thus to resemble that of the Worm tribes; and it is occasionally even marked by transverse bands, indicating a division into segments. Still, however, a distinctly radiated conformation may be seen around the mouth, and some of these animals look as if a star-fish were set as a head on the body of a large worm. In the general conformation of the internal organs they correspond with the Echinida, but they are in some respects more complex, and the respiratory organs are constructed upon the plan of those of the Articulata. They thus form a very interesting link of connection between the Radiated and Articulated sub-kingdoms.

869. The skin of most of the Holothurida is so very elastic, that they can change their size and form in a remarkable degree. They are capable, too, of swimming with considerable rapidity, and some of them crawl like slugs upon solid surfaces. Small species are occasionally found in British seas; but in some tropical shores they are very abundant, and grow to the length of eighteen or twenty inches. They are sometimes eaten by the poor on the Neapolitan coast; but in the Malay archipelago they are regularly sought and conveyed to the Chinese market, where, under the name of *trepang*, they fetch a high price.

911. Describe this third order.

CLASS XXI.—ACALEPHÆ.

870. The name of the class next to be described, the Acalephæ, is derived from the stinging power possessed by nearly all the animals composing it. The word is the Greek term for *nettles*; and by the designation *sea-nettles*, *stang-fishes*, &c., these animals are popularly known, as well as by another, also expressive of a character by which the group is distinguished, *jelly-fish*. It is rather difficult to give any description of the structure of the class that shall include all the members of it, so much do they vary among each other. They all differ from the Polypifera in being unattached to solid bodies, and in having the power of freely moving through the sea; and they differ from the Echinodermata in not being covered with a dense integument. Their extreme softness is one of their most remarkable characters. Some of them attain considerable size, yet with an almost entire absence of any hard support or framework. Indeed, it is only in a few species that any such exists; and thus we have here a remarkable contrast with the Polypifera, in which the absence of a firm skeleton was seen to be the exception, not the rule.

871. The tissues of the Acalephæ are so soft, that they seem almost like masses of jelly, whence originated their common name. They consist of a sort of network of animal filaments, the interspaces between which are filled up with water; and so large a proportion does this bear, that it drains away when the animal is kept out of its element for a short time, leaving but a thin film of membrane behind it.

872. The arrangement of the mouth, stomach, and other organs, is subject to great variation in the different subdivisions of this class; and we here encounter the very remarkable fact of the existence of animals of complex structure and varied powers, which do not possess any regular mouth, but imbibe their food like plants by root-like filaments. Owing to the difficulty of examining the structure of beings which can be so imperfectly preserved, however, the organization of many of the more curious species is as yet very imperfectly understood; and it will be better to confine ourselves here to the consideration of those most certainly known.

873. One of the commonest forms of this class is the *medusa*, which is often seen floating in vast numbers on calm sunny days, at a little distance from the shore. The animal consists

912. How is this twenty-first class distinguished?

913. What of the most common form?

of a large umbrella-shaped disk, from the under surface of which hang down four broad and long tentacula. Both disk and tentacula exhibit a very beautiful assemblage of colours, like those of the rainbow, when the rays of the sun are reflected from their surface. On the under side of the disk is seen the mouth, situated in the centre, and surrounded by the origins of the tentacula. This is the entrance to a stomach, which lies in the middle of the disk, and is surrounded by four ovarial chambers, having separate external orifices. The animal may thus be compared, in some degree, to a sea-anemone detached from its base, and swimming with its mouth downwards. The membrane of the disk extends much beyond the stomach and ovarial chambers (which may be described as occupying the part corresponding to that included between the metallic stretchers of the umbrella); and this broad, free margin is endowed with muscular powers, and performs a series of regular undulations, by which the animal is propelled through the water.

Medusa : A, under surface, showing the mouth in the centre, surrounded by the tentacula, and the ovarial chambers exterior to the origins of these ; B, side view, showing the tentacula hanging down in their natural position

874. The extreme softness of the tissues of these *Medusæ* is an obvious reason why they should not expose themselves to the rough surface of the ocean, where they would be beaten to pieces by the waves, or to the proximity of the shore, from which they would soon receive fatal injury. Although so soft, however, they have the power of mastering prey of much firmer structure ; and hard Crustacea, as well as other marine animals of higher organization, supply them with food. It is probable that the stinging power with which the tentacula are furnished, assists them in mastering some of the animals upon which they feed ; but this can have scarcely any effect upon Crustacea.

914. Describe the diagrams.

915. What other peculiarities are named

875. The *medusa* shares in another property possessed by most of the class—that of luminosity or phosphorescence. It is chiefly to the smaller tribes, accumulating in immense numbers, and so transparent as to escape notice by day, that the occasional phosphorescence of the sea is due. This very beautiful phenomenon may be seen not unfrequently on the shores of Britain, but it is most splendid in warmer seas, especially in the Mediterranean. In the midst of the diffused luminosity, caused by the glow of innumerable multitudes of small Acalephæ, and even of animalcules far smaller, the larger ones shine out like stars in the milky way. The cause of this beautiful appearance is ill understood. It has been ascertained to exist in a secretion formed from the surface, which can be washed off, and can thus communicate the phosphorescence to various fluids, in which it seems to remain until decomposition has taken place. The light is rendered more brilliant when exhibited by the animal itself, by any thing which irritates it; and this fact is observed in the case of most luminous animals.

876. An interesting species, allied in general form to the *medusa*, but differing from it in a remarkable particular, is the *rhizostoma* (root-mouth). No mouth is seen in the centre of the inferior side of the disk, but the stomach sends canals into the substance of the tentacula, which terminate in a number of minute pores at the extremity of those organs. By these small pores, as by the roots of plants, nourishment is absorbed into the system; for the ends of the tentacula fix themselves like suckers upon the surface of the animal they have grasped, and imbibe its juices. These and other Acalephæ, which move through the water by the undulations of their membranous disk, are included in the order PULMONIGRADA. There is reason to believe that some of them possess organs of vision, for little red spots, similar to what are known to be simple forms of eyes in other tribes, are observed at the edge of the disk; and their mode of swimming often displays a power of avoiding obstacles which cannot otherwise be accounted for. All the Acalephæ of this order exhibit a very regular disposition of their parts around a centre, so as to be truly *radiated* animals. Some of them attain a diameter of two or three feet.

877. A curious little group, allied in some respects to the last, is one of which examples are rarely seen on our coast. The animals composing it are distinguished by the possession of a very delicate cartilaginous plate in the place of a membranous disk. In the *porpita* this plate is round; in the beautiful little *velella* it is oval, and has a vertical plate or crest, which rises above the surface, and acts as a sail when the animal is float-

ing at the level of the water. On the under side of the horizontal plate, the organs of nutrition are disposed; but instead of a single stomach and four tentacula, we find here a large number of tendril-like filaments, termed *cirri*, the base of each of which is dilated into a cavity; and the one in the centre being more largely developed than the rest, may be regarded as the principal stomach, into which food is received by the suckers at the extremities of the numerous appendages. Being partly propelled by the rowing motion of these organs, the animals of this group are designated by the term *CIRRHIGRADA*. Large numbers of the *velella* have been occasionally driven by the wind on the western shores of Britain.

878. The next tribe of *Acalephæ* deserving notice, is one in which the body is furnished with rows of *cilia* upon its surface, and is propelled through the water by the vibration of these minute organs. Hence this order is termed *CILIOGRADA*. In many of the animals belonging to it, the radiated form is very evident, so that they are easily distinguished from those of any other tribe. But, in some species, a very curious modification presents itself, which, if external form alone were relied on, would separate them from others, to which their internal structure shows them to be closely allied.

879. Among the former, one of the most interesting is the *berœ pileus*, a small animal not unfrequently found on the coast of Scotland. When at rest in the water, it looks like a bright globe of jelly, about half an inch in diameter. An opening is seen at each pole of the globe; one of these is the mouth, and at the other the alimentary canal, which runs straight across the body, terminates. Its surface is marked by eight bands, running, as it were, from pole to pole. These bands seem to be of firmer texture than the rest of the body, and on them are placed the rows of cilia, which can act either together or separately, so as to give every possible variety of motion to the body. The animal usually swims by means of them, mouth forwards, through the water; and thus a current of water is driven into the stomach, without any further effort on the part of the animal. But it is provided with other means of obtaining its food, in two long tentacula, which arise from the posterior part of the body, and are furnished with a number of lateral filaments; these can all be withdrawn and folded into two cavities excavated, as it were, in the substance of the body, and are

Berœ: a a, tentacula; b, mouth; c, termination of intestine.

easily unrolled when required for use. These animals are very lively in their movements; and a few of them, placed in a tumbler of sea-water, may be watched with much interest. Their long filaments appear to serve as fishing-lines for entrapping prey of much firmer structure than that of their own bodies.

880. Allied to the berœ in structure, but differing widely in external form, is a very curious species found in the Mediterranean, the *Cestum veneris*, or Girdle of Venus. This is a ribbon-shaped jelly-fish, sometimes attaining the length of six or eight feet, its breadth not being as many inches. Its mouth is not at one end, but in the centre of one of the sides; and the alimentary canal, short and straight like that of the berœ, runs across to the other, and terminates there. Both margins are covered with cilia: by the vibration of these, the animal is propelled through the sea; and they must also serve to convey its food to the mouth, as it has no tentacula. Several species exist, which are intermediate in form between the berœ and the *cestum veneris*, having the rounded body of the former, but a sort of wing-like extension on each side, like the thin flat surface of the latter.

881. A very common form of this class, in some climates, is the *physalus*, known to the sailors as the *Portuguese man-of-war*. This is distinguished by its large air-bag, surmounted by a vertical membrane or crest, which usually floats above the surface of the water, and is acted upon by the gentle breeze, in the same manner as the little sail of the vel-ella. The animal organs placed below are very like those of the Cirrhigrada. No distinct stomach can be perceived; but the tentacula are dilated at their roots into chambers, of which each may perhaps be regarded as a digestive cavity. Some of the tentacula are very long, and hang down in the water to the depth of fifteen or twenty feet, when the animal is floating. They possess considerable stinging power, and probably serve to entrap the food upon which the shorter tentacula, with their sucker-like extremities, then affix themselves, for the purpose of taking up nutriment by absorption. These Acalephæ have been termed *hydrostatic*, from the power they possess of rising or falling in water, by increasing or diminishing the bulk of the air-bag; but by what means they effect this change is not known.

Physalus.

882. In some species, comprehended with the *physalus* in the or-

918. What curious varieties are named here?

919. What species and variety are described?

920. Describe the tribe shown in the diagram.

der *Physograda*, several small air-bags exist, instead of a single large one. These are usually fixed to the same stalk, like currants upon their stem; and this rises out of the apparatus of tentacula, &c., of which the animal may be said really to consist.

883. The *Acalephæ* inhabit all climates, but the largest forms are to be seen in tropical seas. The *berce* is so abundant in the Arctic ocean, as to serve as an important article of food to the whale. In voyaging between the tropics, the mariner will often encounter fleets of some one species, extended over a very large tract, and, a few miles farther, will fall in with another. Their gregarious character is very remarkable; and it is generally by such assemblages that the luminous appearance of the sea is produced, although other marine animals contribute to this interesting phenomenon. The *Medusa* and the *Cestum veneris*, and other jelly-fish of larger size, are frequently seen glowing with light in the midst of the diffused brilliancy which is due to the minuter tribes. The animal which is most commonly the cause of this appearance on the western shores of Britain is very minute, being about the size and appearance of a grain of boiled sago. In all cases the light is increased by any cause which irritates the animal; and a gentle pressure will often cause it to dart out for a time with great vividness.

CLASS XXII.—POLYPIFERA.

884. The animal character of the beings composing the class Polypifera was formerly doubted, as that of the Sponges is at present. The structures which they form, known as corals, corallines, &c., have often so much of the plant-like aspect, and sometimes also of an apparently woody structure, that, even in recent times, naturalists have been deceived into a belief in their vegetable nature. This belief has been strengthened, in the minds of uninformed observers, by the flower-like appearance of the separate polypes by which these structures are formed; for they may be easily mistaken, upon a superficial view, for blossoms growing upon their submarine stems. In many places the idea of their partly vegetable nature is still popularly retained; the common name for those species of Sea Anemone and its allies, which are distinguished for the brilliancy of their colours when expanded, being *animal flowers*.

885. Another popular error in regard to this group, is the attributing the formation of coral to *insects*, and the supposition that it is their habitation, constructed under the same circum-

921. What is said of their habits?

922. Why is the nature of this class doubted?

stances as the comb of bees or the pyramids of the termites. Now, the real fact is, that the masses of *coral*, *madrepore*, &c., as well as the *sea-fans* and other similar structures, with many smaller and more delicate ones, of which some are ranked among the *sea-weeds* and others commonly known as *coral-lines*, are the *skeletons* of the animals by which they are produced, and are to be regarded as parts of the living structure, so long as the flesh which clothes or lines them retains its vitality. They bear this resemblance to plants, however, that the different parts which are united into one mass are capable of existing separately, and may be regarded as distinct individuals, like the several leaf-buds on a tree; but still they are all united by living tissue, and, so long as this connection is maintained, they must be considered as forming but one.

886. If, for example, the stem of the common *red coral* be examined, when clothed with the living flesh, its surface is seen to be scattered over with polypes, the structure of each of which bears some resemblance to that of the sea-anemone; but these, so far from being independent of one another, like so many sea-anemones attached to the same rock, are connected by a system of vessels, which traverse the flesh, and bring them all into communication. Nevertheless, any one of these would live, if detached from the rest, and would gradually produce others, until a new structure is formed, similar to that of which it was a part. Moreover, if a piece of gelatinous flesh be stripped from the stem, *this* will be competent to form both new polypes and a new skeleton.

887. It is thus seen that, if the whole stem with its living flesh be considered as forming one animal, we have only to regard it as capable of being multiplied by subdivision to a great extent, in order to account for its phenomena. And this is probably the most correct way of viewing the matter, since, as a general rule, the lower the degree of organization, and the greater the resemblance among the several parts, the greater is the power of being thus multiplied. We shall presently find that not only the polypes themselves can exist separately and form new structures, but that even these may be cut into fragments, of which every one shall reform all the parts wanting to the complete being.

888. Such compound beings, then, of which the polypes only form a part, (like the leaves or flowers of plants,) are not improperly termed Polypifera, or Polype-bearing Animals. But there are many kinds of Polypes which have no tendency to

923. What is said of coral, &c.?

924. What of their structure and habits?

925. What of their reproductive power?

this kind of aggregation, and which are never found but in a solitary state. Such are the *Sea-Anemones*, and the *Hydra*, or Fresh-water Polypes. And various degrees of intimacy of connection between the Polypes of compound structures may be traced in different species; some of these will be hereafter noticed.

889. Whilst the real nature of polype-structures was misunderstood, their classification could not be effected on correct principles. The particular form of the stem and branches of a coral cannot be assumed as a guide, for this is liable to great alteration under varying circumstances of growth, and it differs much in species, of which the structure of the individual parts is much alike. Nor can its character—as whether massive or light, stony or flexible—be correctly made the ground of primary division, since some are thus associated in which the structure of the living animal is very different, and others widely separated in which it is nearly allied. The only sound method is to regard the structure of the individual polypes as the basis of classification, and to draw secondary characters only from the circumstances of their association. In this way we shall be able to form four orders, characterized by four distinct types of structure; in each of these we shall find polypes existing almost or altogether independently of one another, and species closely allied to these, in which they are intimately associated.

890. As the distinguishing characters of these orders cannot be understood without a knowledge of the structure of the polypes belonging to each, it will be better to proceed at once to the description of them—the amount of popular information on the subject being small. We shall begin with the one generally accounted the simplest.

Order I.—Hydroida.

891. The *hydra*, or fresh-water polype, is a minute animal, often found in great abundance, clustering round aquatic plants in stagnant pools. It seems to consist only of a kind of bag, constituting its stomach, round the mouth of which is disposed a circle of long arms, or *tentacula*; whilst the opposite end is prolonged into a foot, terminated by a kind of sucker, to which the animal attaches itself. Two kinds are commonly met with in this country; the *H. viridis*, or green polype, and the *H. fusca*, or brown polype. These differ not only in colour, but in the relative length of their tentacula and bodies. In the green hydra, the arms cannot be extended much beyond the length of

926. Into how many orders are they divided?

927. What of the first and its species?

the body, the whole animal being less than an inch from the foot to their extremities, when at full stretch. But in the brown hydra, the arms often extend themselves as much as seven or eight inches.

892. The changes of form in this polype are very remarkable. The body has sometimes the shape of a long cylinder, whilst at others it is contracted into a sphere, the arms having shrunk alike into small projections around the mouth. This appearance is generally presented when the stomach is replete with food.

Hydra.

893. The *hydra* is an extremely voracious animal; and, although little able to move from place to place, it secures an abundant supply of food by its long arms, which serve as so many fishing-lines. When any aquatic worm or insect touches one of them, it is entrapped by it, and other arms are speedily brought to its assistance; so that, by the simultaneous contraction of the whole, the prey is conveyed to the mouth, even if strong enough to make powerful resistance. There is reason to believe that the arms are furnished with a series of sharp spines, which can be made to transfix the object they enfold, and that these convey into it a poisonous liquid, by which its death is soon occasioned, even if it be not swallowed. Not unfrequently the prey can be seen to move about violently within the stomach, for some little time; but the powerful digestive secretion speedily begins to act upon it, and its soft parts are dissolved, the hard ones being unusually ejected by the mouth. When this solution has been performed, the fluid which results from it is seen to be distributed by a kind of circulation, through the walls of the stomach and the arms.

894. Nothing in the history of the *hydra* is so remarkable as its power of being multiplied by division, and of repairing the effects of other rough treatment. In regard to this, there really seems no limit. Not only can the body reproduce the arms, the mouth reform the tail, and the tail the mouth, but from a minute fragment the perfect hydra is reproduced, so that an individual, cut up into forty or fifty pieces, will be converted into as many separate polypes. Two bodies, also, may be grafted together by the side, the tail, or in any other way; and monsters with two heads, two tails, &c., may be easily produced. It was, in fact, on account of this tenacity of life and tendency to reproduction as a consequence of injury, that the name *hydra*

(after the fabulous monster of ancient times) was given to this little creature, when first discovered about a century ago. The power of any one part to perform the functions of the rest, is remarkably shown by the fact, that the polype may be turned inside out—so that what was before the lining of the stomach becomes the external integument, and *vice versa*—without its comfort being perceptibly impaired.

895. The *hydra* is not known to subdivide spontaneously, however; but it propagates itself by a process resembling the budding of plants. A little knob first projects from the side of its body; this enlarges, and from the top of it are seen to spring a number of small processes, which are the arms. In the centre of these an opening appears, constituting the mouth of the young polype, which gradually assumes the form of its parent, and begins to catch prey for itself. Still, however, the cavity of its stomach communicates with that from which it was at first prolonged; but the passage is gradually narrowed, and at last obliterated. When quite independent, the young polype detaches itself from the parent, and has no further relation with it. Several of these buds may spring from the same polype at once, provided it be well supplied with food, and the temperature be warm; and a second generation may even show themselves upon the first, whilst still continuous with the parent structure.

896. No other organs of sensation than the arms, which evidently serve as instruments of touch, can be detected in the *hydra*; but it is obviously influenced in its movements by light, perhaps in somewhat the same manner as plants are affected by that agent, and probably without possessing any thing like a sense of sight. It has various means of changing its place, and uses a great number of devices for entrapping its prey, so that it is an extremely interesting animal to the microscopic observer. A very low power is sufficient to enable its general structure to be perceived, and its habits to be watched.

897. The entire substance of the *hydra* is soft, and no part seems possessed of greater firmness than the rest. In some other species, however, we find a tendency to the consolidation of the exterior into a kind of horny tube or sheath; and when a number of polypes are associated together, a compound structure is thus produced. In the *Tubularidæ* it would seem as if the lower end of the body (terminated in the *hydra* by the sucker or foot) were greatly prolonged, so as to form a tube, the exterior of which is somewhat horny, and is continuous with the exterior of the body, while the lining of it is soft, and seems an extension of that of the stomach. Into this tube the stomach,

929 What of its vitality and reproductiveness?

930. Wherein do they resemble plants?

or polype, opens at its lower part by a throat-like aperture, which is capable of being enlarged or contracted, or entirely closed. The *tubularia* is a marine animal, and the tube, which often attains the length of from eight to twelve inches, is attached at its base to rocks. A very curious circulation of fluid takes place within it, the current passing up one side and down the other; this appears independent of any movement of the polype at its summit. In some species, the tubes send off buds or branches, and the polypes do not appear at their extremities until they are fully formed, which shows that the horny tube, and the contained membrane, are themselves endowed with independent vitality.

898. In another group we find the polype itself enclosed in a horny cell of similar character, from which its body can be protruded in search of food. This is the case in the family of SERTULARIDÆ, so named from the *Sertularia*, which is its most common and characteristic genus. In these compound structures, the cells are connected by stems and branches, in the same manner as the buds of a plant; and through the base of each cell there is a canal, lined, as in the *Tubularia*, by an extension of the lining membrane of the polype, and uniting with the channels which pass through the whole structure. Thus all the polypes are brought into connection with each other, and with the general mass or polypary; and the circulation of fluid, which may be observed to take place in the stem and branches, independently of any mechanical action of the polypes, proves the vitality of the former. Indeed, we may rather say that the polype is an extension of the lining membrane of the stem, than the latter a prolongation of the stomach of the polype; for the stem and cells upon it are formed before the polype makes its appearance; and all new buds proceed from the former, whilst the latter occasionally drops off and is renewed.

Portion of *Sertularia*: *a a*, polype cells with polypes; *b b*, ovarian vesicles.

899. These polyparies, formed by the association of hydraform polypes, are among the most graceful and elegant of all the structures with which this class presents us. They are of minute size, when compared with the massive productions of other tribes; and the uniform absence of stony deposit gives them a degree of flexibility which adds much to their gracefulness. There are few shores on which some forms of them may not be

931. What is peculiar in their structure?

932. What species is found in a shell?

picked up. They are commonly mistaken for sea-weeds. The genera are formed according to the disposition of the cells. Thus, in the *Sertularia* these are closely set against one another on both sides of the stem and branches; in the *Plumularia* they are only on one side; and in the *Campanularia* they are seen as bell-shaped terminations to their sub-divisions.

900. The mode in which propagation takes place in the Tubularidæ, is that in which it is occasionally effected in the hydra—the separation of little gemmules, like those of the sponge, from the tissues of the body. These gemmules swim about for some time, and when they have fixed themselves, they soon lay the foundation of the solid structure, which makes some progress before the polype appears. In the Sertularidæ, however, the polypes, being enclosed in cells, do not share in this function, for which a special apparatus is evolved. A set of horny vesicles (*b b*), usually much larger than the polype cells, are developed at intervals from particular parts of the stem and branches, and it is in these that the reproductive bodies or gemmules are formed. Each vesicle is provided with a lid, which falls off when the gemmules are mature and ready to swim forth; and the vesicle itself afterwards shrivels and drops away, like the seed-vessel of a plant that has shed its seeds. The whole of this process very much resembles the fructification of mosses, in the mode in which it is carried into effect.

901. These are the principal forms of Polypifera allied in structure to the Hydra, and forming an order which may be termed that of HYDROIDA, or *Hydra-form* Polypes. This order contains three families—the *first* of which includes no more than the genus *Hydra*, the only solitary polype belonging to this order that does not form a horny tube or cell; the second, that of TUBULARIDÆ, is a small one, including but few distinct forms; whilst the third, the SERTULARIDÆ, is a very numerous family. The order is pretty uniformly distributed over the globe—not abounding more in tropical than in temperate regions. Scarcely any fossil remains of it are to be found.

Order II.—Helianthoida.

902. A common form of polype, apparently so different from the hydra that the relationship between them would not have been suspected by an uninformed observer, is the *acima*, or sea-anemone. There are probably no shores over the whole globe, except the very coldest, on which some species of this

933. What of its peculiar structure ?

934. What of its propagation ?

935. How is this order classified ?

interesting creature are not to be found. Although so different in aspect from the hydra, it is essentially the same in structure. The mouth is in the centre of the upper surface, and is surrounded by tentacula; but these are numerous, and arranged in several rows. The under side forms a large sucker or disk; by this a very firm hold is taken of the rock or other surface to which the animal adheres. We may thus liken the body of the sea-anemone to that of the hydra in its greatest state

Actinia seen from above.

Section of Actina: *a*, cavity of stomach; *b*, surrounding chambers.

of contraction. There is this important difference, however; the stomach does not occupy the whole cavity of the body, but only the central portion; and the space between its wall and the outer integument is divided by vertical membranous partitions, passing directly from one to the other, into a number of radiating chambers, in which the germs of young *Actiniae* are produced, and sometimes nearly matured. The tentacula are hollow, and their cavity is continuous with that of those chambers; at the extremity of each is a small aperture, through which water is occasionally taken in, and then ejected with considerable force. This process seems to be of the nature of the action of respiration in higher animals.

903. The tentacula of the *sea-anemone* can be contracted in the same manner as those of the hydra, and they are furnished with a sort of sucker at their extremities, by which they can draw towards the mouth any substance which comes in contact with them. Although each seems weak in itself, the combined action of many is sufficiently effectual for maintaining an ample supply of food. These animals are extremely voracious. Not being able to move from place to place in search of particular kinds of nutriment, they are adapted to digest almost any which comes within their reach. Shell-fish and small Crustacea appear to be their usual diet. These are

936. What of the diagrams?

937. What of the habits and structure of these?

swallowed alive, in spite of their struggles, but are soon destroyed by the powerful solvent action of the juices of the stomach. The hard portions are ejected from the mouth, and in getting rid of them from its stomach, the actinia often everts the lining of the latter through its entrance, so as almost to turn its body inside out. There is reason to believe that this sometimes takes place completely, and that the animal remains in that condition; its exterior integument, and the lining of its stomach, being as mutually convertible as those of the hydra.

904. The muscular force exerted by the *sea-anemone* is often very considerable. It will retain large shells within its mouth, in spite of strong efforts to withdraw them; and it takes such firm hold, by its fleshy base, of the inequalities of the surface upon which it is attached, that it is often easier to tear the animal structure than to detach it entire. It can, however, easily quit its hold, and has the power of crawling over a solid surface, somewhat in the manner of a slug, by the alternate contraction and extension of different parts of its disk. At other times it will contract itself into the form of a ball, altogether quitting its attachment, and committing itself to the mercy of the waves, by which it is carried to some new abode.

905. The contraction and expansion of the tentacula are partly influenced by the state of the atmosphere and the degree of light to which the animals are exposed. They usually display themselves to the most advantage in shallow water, when the sky is bright and the air clear, but when the sun does not shine directly upon them. In lowering or stormy weather, they contract themselves, sometimes to such an extent that the tentacula are entirely hidden, the body assuming the form of a hemisphere attached by its flat surface. This is usually their state, also, when uncovered, as they frequently are, by the receding of the tide, in the places they usually haunt, since they seldom fix themselves beneath low-water mark. This alternation is, therefore, probably advantageous to them; and when these animals are kept for observation (as they may very easily be) it is desirable to imitate it—changing the water daily, and allowing them to lie uncovered for an hour or two each day.

906. The powers enjoyed by the *actinia* of reproducing different parts which have been removed, and of multiplication by the division of its body, are nearly as great as those already described in the hydra. It may be divided either vertically or transversely; and each part will, in time, supply what was deficient, and become an entire animal. This reproduction has

938. What of its muscular power?

939. What of its habits and faculties?

taken place, in some instances, from small fragments; but it does not appear that the same number can be reproduced by the subdivision of one, as in the hydra. We do not find here the same process of multiplication by buds, as in the hydra, but distinct germs, or *ova*, are formed in the radiating chambers which surround the stomach (hence called *ovarial* chambers); and from these, as from the eggs of higher animals, new beings like the parent are produced. The development of them may take place whilst yet within the body of the parent; and thus, as the young ones pass out from the mouth, it appears to cast them up from its stomach.

907. The *Actinæ* serve to restrain the excessive multiplication of the small crustacea and shell-fish, and also of the smaller species of fish, as well as of other tribes on which they prey. In their turn they serve as the food of the larger species of these tribes. They are not unpalatable articles of food for man, and are used by the inhabitants of some coasts as ordinary articles of diet, whilst on others they are esteemed as delicacies. Along the shores of Britain there is a remarkable neglect of these and other marine productions, to which recourse might be had in times of scarcity, even if they be not constantly employed.

908. The sea-anemone is not the only solitary polype possessing the kind of structure which has just been described. Several other species exist, in which the same type is presented with various modifications. Thus, in the *Actinodendron*, the tentacula are branched; and in the *Lucernaria*, they are set in bunches upon a few large arms. But these have the same general structure of the stomach and radiating chambers.

909. There are some among these solitary species which form a stony deposit in the substance of their base, and in the membranous partitions between the radiating chambers. Of these one small species inhabits the British seas; it belongs to the genus *Caryophyllia*. A very beautiful coralline formation of this description is that produced by the *Fungia*; an animal allied to the sea-anemone, and inhabiting only tropical seas. It consists of a thick round plate, sometimes several inches in diameter, from one surface of which arise thin vertical plates radiating very regularly from the centre to the circumference. This is, in fact, a single cell of a large solitary polype; and from it the structure of other coralline masses will be understood.

910. The cells of such solitary polypes are not always round, but are sometimes very much prolonged in one direction, so that the depression in the centre, marking the place of the

940. What of their utility?

941. What other species are described?

mouth, towards which all the radiating plates are directed, becomes a long groove. These stony masses contain a considerable quantity of animal matter, by which the particles of carbonate of lime are glued together, and when a sufficiently fresh specimen of a stony coral is submitted to the action of an acid which dissolves these, the animal substance will retain its form. It appears, therefore, that we are to regard them as standing in the same relation to the simple tissues of these beings, as bone does to the more highly organized structure of the Vertebrata; both being produced by the consolidation of the soft living tissues by earthy matter, but the bone, for obvious purposes, being made more susceptible of subsequent alterations.

Mass of *Astræa Viridis*: *a, a*, expanded polypes; *b, b*, polypes withdrawn into their cells; *c, c*, stony mass uncovered by flesh.

911. The number of stony corals, formed by the compound Polypifera, is very great; and of the more massive kinds a large proportion belongs to this order. Those which are to be ranked as the skeletons of animals allied in structure to the sea-anemone, are distinguished by a character very easily recognised. In each cell, however minute it may be, the arrangement of radiating plates described in the *Fungia* is seen; and from the presence of these thin plates, or *lamellæ*, the whole of this group of corals and madrepores have been designated as *lamelliiform*. A lamelliiform coral is, then, always formed by a polype similar to the sea-anemone (or *actiniform*); and thus, by attending to the mode in which the growth of the coral depends upon the structure of the animal, we obtain a valuable character, on which we can always rely.

942. What of the diagram?

943. How is their formation described?

912. The individual polypes belonging to such structures are connected by a gelatinous flesh enveloping the whole, which seems to answer to the membranous pith lining the stems of the compound Hydroida. It is by this flesh, rather than by the polypes themselves, that much of the stony mass is deposited, as may be seen by examining many species in which the intervals between the cells are considerable. The variety of aspect which these masses present is very great, but there is little difference, so far as is known, in the structure and habits of the individual polypes, which form part of the beings in their living state. Sometimes several lie together in one cell. This is the case in the *Meandrina*, or Brain-stone Coral; on the surface of which we see a number of long tortuous furrows, instead of cells approaching to the rounded form, and these furrows, in the living state, are occupied by rows of small polypes, arranged side by side. The points at which they abutted against each other may be distinguished by the difference in the direction of the radiating lamellæ, which converge towards as many distinct centres as there were polypes in each furrow.

913. None but *stony* corals are formed by the Polypifera of this order; but there are many of that description which do not belong to it, of which we shall hereafter speak. However, it is to this order that the greater part of those species belong which are concerned in erecting the massive structures known at present under the names of coral reefs and islands, as well as those which appear to have existed in still greater amount in former epochs of the earth's history, and to have given origin to the greater part of the limestone rocks which constitute so large a proportion of the crust known to us. This subject will be better considered, however, after the other stony corals have been described. It will at once be seen, from the absence of all appearance of cells on its surface, that the *Red Coral* does not belong to the order just treated of. This order may be denominated that of *Actiniform* Polypes, from the general resemblance of the animals composing it to the sea-anemone; or *Helianthoida*, from their similarity in aspect, when expanded, to the sun-flower.

Order III.—Asteroïda.

914. The next order of Polypifera is one which brings us nearly to the form of the Sponge. In the compound groups we have been last considering, the polypes form an important part of the general structure, and in some instances each may be regarded as existing almost for itself alone, even where many are united by the connecting fleshy matter. But in the group

944. What other varieties are described?

to be next treated of, the polypes seem quite subordinate, and the general mass seems to have (as in the sponge) much more of the character of a single individual. In these structures we observe, too, that the hard basis or skeleton is seldom so distinct from the living tissue as in the *lamelliform* corals, the two often passing into each other by almost insensible gradations. The density of the skeleton varies considerably in the different species. Sometimes it is of a spongy character, as in the *Alcyonia*; sometimes of a stiff horny texture, as in the *Gorgonia*, or Sea-Fan; and sometimes of a stony hardness, as in the Red Coral.

915. The *Alcyonia* approach so nearly to Sponges in their aspect and general character, that they have by many naturalists been associated with that group. However, they may be readily distinguished in the living state by the existence of polypes in the former and their absence in the latter. Their dried remains, however, cannot be so easily distinguished: in fact, it is only by the irregular position of the vents of the sponge, contrasted with the great regularity in the polype-cells of the *Alcyonia* (which are their representatives), that a judg-

Alcyonium: A, portion enlarged, showing the polypes.

ment can be formed, and even a practised naturalist is at fault in determining the character of some of their fossil remains. These facts are important in regard to the doubts, formerly alluded to, as to the animal character of the PORIFERA. The connection between the two groups is most clearly established

945. What is the character of this third order?

946. What genus is shown in the diagram?

by the *Clione*, a curious intermediate genus hereafter described (§ 950).

916. The *Alcyonia* are found abundantly on many parts of the British shores, and are known to fishermen by the names of *dead-man's hand*, *sea-fingers*, *sea-paps*, &c., from their flabby texture and the peculiar forms they present. Their structure is spongy, but they have usually a more distinct envelope than the true Sponges, and this has sometimes a leathery character. Their interior is traversed by a series of canals, which ramify and inosculate with each other; and, on cutting into the mass, it is observed that nearly the whole tissue is composed of a network of these passages, separated by the animal fibrous tissue, which is sometimes condensed into a fabric of considerable firmness. The large canals have no direct external opening, however; but they terminate in prominences of the spongy mass, from which the polypes protrude.

917. The polypes themselves have some resemblance to the sea-anemone, but they are usually much smaller, and of more delicate structure. There are, however, some important differences, upon which the character of the order is founded. The tentacula, instead of being numerous, and arranged in several rows, are only eight in number, and form one circle. They are broad, and almost leaf-like, instead of being round and slender. The mouth is situated in the midst of them, and leads to the stomach, which occupies the centre of the body; around the stomach are the *ovarial chambers*, separated by radiating partitions, but only eight in number. The stomach opens into the canal, upon the end of which the polype is placed; and all the fluid which enters the mass appears to be taken in through these mouths. The ovarial chambers also communicate with the canal beneath; indeed, they may be said to be a continuation of it, for the partitions between them are prolonged downwards into the canal, forming plaits or folds of its lining membrane, in which the ova or germs are developed; so that these are produced from the general mass rather than from the polype, and the whole structure may be regarded as a higher kind of sponge.

918. The polypes are capable of being drawn entirely within the protuberances on the surface of the *Alcyonia*; and even these projections become flattened when the animals are in a state of great contraction. In this condition they are often left by the tide, and if then placed in a glass of clear water, their gradual expansion may be watched. The protuberances from the surface first show themselves, and the polypes one by one

947. How does it differ from the sponge?

948. What is peculiar in their structure?

appear at their summits, and slowly expand their tentacula, until the whole surface appears covered with delicate blossoms. The entire mass, then, not unfrequently swells to twice or thrice its original size. If any one of the polypes is irritated, it shrinks into its hiding-place, but those near it are not affected. If the irritation of the part be prolonged, however, those in the neighbourhood gradually show themselves influenced by it, and draw themselves in; and in this manner the whole mass may be ultimately affected. The same effects, however, may be produced by irritating a portion of the spongy substance intermediate between the polypes. From this it is evident, that sensibility to impressions is not confined to the polypes alone, but that the whole mass must be regarded as possessed of animal properties.

919. The *Alcyonia* increase by the extension of their own structure, as well as by the formation of new germs; and it is interesting to remark that this extension takes place from the spongy mass, and not from the polypes. When a bud, or prolongation of the parent structure, is formed, the polypes do not at first appear on it, but it has in every important respect the character of sponge. This is an instance, to which several parallel ones will hereafter be added, of the passage of a being, during the progress of its development, through the form characteristic of an inferior class, as the insect does when in its caterpillar state, and the frog whilst a tadpole.

920. The *Alcyonia* grow in the same circumstances with Sponges; and their correspondence is further shown by the existence of crystals of silice in their tissue, which are not found in other polype-structures, the earthy matter in these being entirely calcareous. The different species of the *Alcyonia*, like those of the Sponges, may be distinguished by the form of the spicula preserved in the skeleton.

921. In other forms of this order, we find the skeleton, or firm support, in a more concentrated form. Thus, in the *Gorgonia*, a beautiful framework of horny matter, consisting of a stem and a minute network of branches, occupies the centre of the structure; and this is clothed with a soft flesh, through which the channels pass that connect the polypes together. This flesh is covered with a firm skin, in which a great amount of earthy crystals is deposited, so as to form a crust, and in this are the hollows or cells by which the polypes are protected. In the dead structures, with which we are familiar under the name of *sea-fans*, the dark horny flexible stem is seen to be co-

949. What of their habits?

950. How do they increase?

951. What varieties are described?

vered in many parts with a brittle crust, often brightly coloured, which can be scaled off it and crumbled to powder. Between the two, in the living state, the fleshy coat existed; the inner part of it being in contact with the exterior of the horny stem, which was then soft and scarcely distinct from it, whilst the exterior part was consolidated by the earthy matter into the firm integument.

922. In the *Isis*, we find less stony matter on the outside of the flesh, but a deposition of it at intervals in the stem, which thus obtains a jointed character, being flexible at the points at which the horny matter has not been consolidated. And in the *Red Coral*, the entire stem is converted into a very firm stony axis, which presents no indication of polype-cells, these being excavated only in the flesh that clothes it. The *Pennatula*, or sea-pen, is an interesting species belonging to the same

Pennatula.

group, and in some respects resembling the red coral. It has a stony axis, but this is flexible at the extremities; and it is not attached by a solid basis, but is carried about at the mercy of the waves. From the central axis, which is nearly straight, a regular series of lateral branches passes off on each side, like the barbs of a feather, and on these the polypes are situated. By the simultaneous movements of their tentacula, the animal (if it is to be called *one*) seems to have some power of directing its course, if not of propelling itself through the ocean. A small species, which is luminous at night, inhabits the British seas.

Single Polype of Pennatula.

923. There is one species in this order which differs from all the rest, in the consolidation of the exterior rather than of the interior tissue, so that a stony tube is formed, instead of a central stem. This is the *Tubipora musica*, of which the skeleton is known as Organ-pipe Coral. The polypes are not here

952. What varieties are described here?

953. Describe the last-mentioned species.

connected by any system of vessels, or uniting flesh; each lives for itself alone; but a number (probably all produced from the same stock, and by offsets from each other) unite for mutual support in one structure. Each polype has a cylindrical form, and its exterior membrane is progressively consolidated into a stony tube, which is thus gradually increasing in length by a new deposit at its upper end. At certain intervals, the soft membrane (which is always projecting beyond the mouth of the tube) is flattened down into a sort of collar, which is consolidated likewise; and the collars of the neighbouring tubes, coming in contact with one another, form a sort of floor or shelf which greatly strengthens the mass. After this collar is formed, the tube is continued as before for another period, when a similar floor is again produced by the simultaneous action of the numerous polypes composing this beautiful structure.

924. To this order the term of *Alcyonian* Polypifera (from the name of one of its principal groups) may be conveniently applied; it is also known by the designation of *Asteroida*, from the star-shaped form presented by the tentacula when expanded. Its most luxuriant kinds are natives of tropical seas; thus, the *Alcyonium poculum*, or Neptune's cup, which abounds in the neighbourhood of Singapore, is one of the most bulky species at present existing. But the smaller tribes abound in our own seas. No massive stony polyparies are formed by the animals of this order.

Order IV.—Asciidioida.

925. The last order of Polypifera far surpasses all the rest in the complexity of its organization; although so little distinguished from them in external form that a cursory examination would not reveal the points of difference. In fact, many of the species belonging to it have been associated with the *Hydroform* Polypes, by naturalists of eminence; and it is only by means of a high and clear magnifying power that their true structure is capable of being ascertained. The stony character of the polyparies formed by others, has led them to be grouped with the *Actiniform* Polypes; and it is only within a very recent period that opportunities have been afforded for that examination of their living condition upon which alone reliance can be placed.

926. The polypes of this order seem more independent of one another than they are in the associated groups of the others; but they are not known to exist in an absolutely isolated con-

954. What is said of this fourth order?

955. What species is described?

dition. A species lately discovered on the British shores, the *Bowerbankia densa*, will afford an excellent illustration of the structure of the separate polypes. These arise like buds from a sort of creeping stem, which connects them all, and which has the power of extending the structure by its own growth; but no communication has been observed between the interior of this stem and the stomachs of the polypes, like that which exists in the *Sertularia*. Each is enclosed in a horny transparent sheath, the upper part of which is so flexible as to be capable of being drawn inwards by the action of muscles, thus closing the mouth of the cell.

927. The polype itself has, when protruded, the general form of the hydra, the mouth being surrounded by ten long and slender tentacula. There is this important difference, however, that in the *Bowerbankia* and all the other polypes of this order, the arms are fringed with *cilia*, or little hair-like filaments; whilst in the *Hydraform* Polypes no such appendages exist. This difference is more important than it would at first sight appear, being connected with the whole economy of the animal. This hydra only obtains its food by grasping with its arms that which comes within their reach; but, in the animals under consideration, the rapid vibration of the filaments, which seem to take place at the will of the polype, produces currents in the water by which a regular stream is brought to the mouth; and this stream contains many nutritive particles, from which a selection, adapted to the highly organized digestive apparatus, may be made.

928. The mouth opens into a wide tube, which may be regarded in the light of the œsophagus or gullet of higher animals; and this terminates, at its lower end, in a narrow orifice, leading to a globular cavity, which seems analogous to a gizzard, having thick muscular walls, lined with tooth-like processes. Here the food seems to be ground down before being transmitted to the true stomach, a much larger cavity situated below it. The walls of this cavity are beset by a number of yellowish-brown spots; and there is reason to believe that these are organs for the secretion of bile—a fluid of that aspect being poured from them

Bowerbankia; a, œsophagus; b, gizzard; c, stomach; d, orifice of intestine.

into the stomach, whilst the digestive process is going on. From the upper part of the stomach, not far from the first opening, an intestinal tube passes off by a distinct orifice; and this terminates on the outside of the ring to which the tentacula are affixed.

929. The whole of this complicated digestive apparatus seems to float in the cavity of a membrane which lines the cell, and from the outer layer of which, indeed, the cell is formed (by the deposition of horny matter in it), and the interspace is filled with fluid. In order to retract it within its sheath, and to draw down the upper portion of the latter as its protection, a very curious set of muscles is provided; and the succession of movements by which this action is effected, is very interesting. The polypes of this order are very easily alarmed, and will withdraw themselves at the slightest intimation of danger, and they exhibit great caution in putting themselves forth again.

930. The whole process of digestion may be distinctly watched in this beautiful little animal. The food obtained by the motion of the cilia passes into the mouth, and is propelled downwards to the first stomach or gizzard, by the successive contraction of the walls of the tube, as in the highest animals. After being subjected to a brief trituration there, it is passed onwards to the principal stomach, where it remains a considerable time for digestion, being sometimes regurgitated, for a second trituration, to the gizzard. The matter to be rejected does not return, as in the lower Polypifera, by the mouth, but passes, in the form of little granules (no large substance being ever swallowed), into the intestine, where it accumulates into small pellets, which are gradually propelled to its outlet by the successive contractions of the tube. When they have been ejected from it, they are carried to a distance by the reflux of the current, which is constantly being driven by the action of the cilia to the mouth. No nervous system can be detected in these animals, yet its presence may be inferred from the existence of distinct muscular structure, of which different parts have to be put in action at the same time.

931. There is considerable variety in the structure of the Polypifera which have been associated into the group of which this is a specimen, some being more and others less complex; but they all agree in these two essential points, the possession of a second external orifice to the digestive cavity, and the presence of cilia on their arms. By these they are distinguished from all the other Polypifera. The latter of these characters has been embodied in the term *Cilio-brachiata* (ciliated-armed), which is very

957. Describe the structure and habits.

958. What of the varieties?

appropriate. They have also been called Bryozoa, from their fancied resemblance to mosses, and Ascidioida, from their affinity to the *Ascidia*, a group in the lowest class of Mollusca.

932. The polyparies formed by the animals of this group differ considerably from each other in the structure and arrangement of their parts. Frequently they have but a horny texture. Sometimes, however, stony matter is deposited in the cells, and fills up the interspaces between them. This is not a mere excreted layer, formed for the habitation of the animal on the surface of the gelatinous pulp, but is deposited in the substance of its own tissues. For if one of these structures be submitted to the action of a dilute acid, its form is not destroyed, but a flexible membranous substance remains, which completely retains the original form, unless submitted to pressure. A very common kind of compound structure is the *Flustra*, which grows in flat expanded surfaces, often encrusting sea-weeds and other marine bodies, but sometimes without any such attachment. This may be picked up on almost any of our shores; it is often mistaken for a sea-weed, but is distinguishable from it by its greater crispness and firmness of texture, and by the cells which may be observed to cover its surface. These cells are extremely minute, and are set closely together, so that a very large number, each when alive containing a polype, exists in each specimen. New cells and polypes are formed from the sides of the old ones, by a process resembling the budding of the hydra; and it not unfrequently happens that those at the exterior of the specimen are in active life, whilst those of the centre are dead.

933. The polypes of this order are also reproduced by the formation of *gemmules*, somewhat resembling those of Sponges and Sertularia, but endowed with greater activity, and with apparently greater power of directing their movements. These are developed from the inner membrane of the cell, and gradually increase so as to fill up its cavity, and to cause the death of the contained polype. When they at last escape, they swim, like animalcules, with a great variety of movements, and seem to have a perfect control over the vibrations of the cilia with which they are covered, and by which all their motions are produced. When they at last fix themselves, they spread themselves out, each into a gelatinous film, in the substance of which the outline of cell soon shows itself; and the polype, with all its complex parts, is developed by degrees. To this first formed cell others are soon added.

934. The Polypifera of this order seem to attain their full development under a less constantly elevated temperature than

959. What compound structure is cited?

960. What of their reproduction?

that required by the *Helianthoida*. Stony corals are formed by them in many seas of the temperate zone, and the more delicate species abound on our own coasts. This fact is interesting, when we compare the fossil with the recent corals, as will be presently done.

935. When we consider the vast extent of the coral formations, which are at the present time effecting a change on the surface of the globe that has been a fertile theme of astonishment and admiration, we cannot but be struck with the enormous amount of animal existence that must be concerned in producing them. Much error has prevailed on this subject, however; and in some points exaggerations have been produced, through superficial observation. But here, as in almost every department of nature, the truth, as disclosed by a more careful examination, is far more wonderful than the showy covering in which the common love of the marvellous may have enveloped it.

936. It is generally stated that the coral masses, forming reefs or islands, are built up from the depths of the ocean. This is not strictly true, for it is well ascertained that none of the species which form the massive stony structures of which these are composed, can exist at a greater depth than from 80 to 120 feet. It is evident, then, that supposing the relative level of the land and sea to have been always the same as at present, these coral structures must be based on the summits of submarine mountains, or ridges of hills, which rise from the bottom of the ocean, like corresponding hills and ridges upon the dry land; since deep water is almost always to be found in their neighbourhood. This is probably true to a certain extent. There is reason to believe that solid rock exists at no great depth below the surface of some of the islands; and there are many in which it forms part of them, a cone of rock rising out of the water, incrustated with a terrace of coral. Moreover, it may be stated as a general fact, that there is no part of those seas in which the temperature, depth of water, and other circumstances, are favourable to the operations of the coral-polypes, in which they are not constantly at work; and thus channels are being continually rendered narrower and less deep, and harbours are being blocked up, which were formerly accessible. But this takes place with less rapidity than is generally imagined.

937. The coral islands of the Pacific and Indian Oceans constitute a large proportion of the groups with which that vast area is scattered. In some instances they are considerably

961. What inference is authorized in geology?

962. What of coral formations?

elevated above its level, but in general their surface is only slightly raised above it. As the polypes do not build above low-water mark, it does not become at once apparent how even this elevation is attained. It is to be remembered, however, that in the tropical ocean there is an almost constant succession of waves driven by the trade-wind from east to west. These, dashing against the windward side of the islands, break off blocks from the masses of coral, which they cast upon the summit. An accumulation of these blocks, consolidated by smaller fragments, and by the sand resulting from their constant friction, gradually produces a firm rocky superstratum. The surface of this, decomposed by the atmosphere, forms a sort of chalky soil, which is well adapted to the growth of many kinds of plants; and the seeds being drifted by the sea, or brought through the air by birds, take root in it, so as speedily to cover the island with a luxuriant vegetation. In the course of the growth and decay of successive crops, a thick layer of mould gradually covers the previous chalky soil; and this affords support to the most beautiful kinds of tropical plants, which the humidity of the insular atmosphere causes to flourish to a degree rarely seen on continents.

938. Several of the coral islands take the form of rings, containing large basins of water communicating with the sea, which are termed lagoons. These were probably erected on the craters of submarine volcanoes, of the existence of many of which beneath the Pacific Ocean there can be no doubt. They first rise to the surface in the form of circular reefs; the windward side is gradually raised above the sea level by the process already described; but an opening usually remains at the leeward side, through which the water that washes into the central basin may flow out. As the whole ring is gradually elevated, however, the source of this overflow diminishes, and gradually ceases; the leeward channel is filled up by the growth of coral, and the lagoon is cut off from the sea. This basin, also, is at last filled up by the accumulation of fragments of coral, and by the growth of the more delicate species in its interior; and at last one nearly uniform surface is produced.

939. There is reason to believe, however, that in many instances the coral extends to a much greater depth beneath the surface than that in which the animals are known to live; and the question then arises, in what manner was it formed? A careful examination of the islands of the Pacific Ocean shows us that many of them, which rise considerably above the surface, are entirely composed of coral. Now, as the coral-polypes

963. How are islands of coral accounted for?

964. What of lagoons and their formation?

never build above the level of the sea, it is evident that some subterranean movement, probably of a volcanic nature, must have lifted these islands from the bed of the ocean. In some instances the height at which coral may be found is very great—not less than eight or nine thousand feet. It is not improbable, then, that as the bottom of some parts of the ocean is rising, that of others should be falling. If a coral island had been originally formed in the usual way, and had then gradually sunk in the water, the polypes would have continued to build it up to the surface; and thus almost any amount of thickness may be produced, by a corresponding slow subsidence.

940. One of the most extraordinary coral growths known, is the barrier-reef which stretches along the shores of New Holland, at a distance of usually more than a hundred miles from the coast. This is above a thousand miles long, and for several hundred miles has no break wide enough to give passage to a ship. It is scarcely conceivable that a submarine ridge of hill should exist, a thousand miles in length, and approaching everywhere within one hundred feet of the same elevation; for such a ridge is nowhere seen on the dry land. But it is easy to account for this remarkable structure, if we suppose that the ridge was formerly more or less elevated above the surface, and that its different parts gradually became encrusted and capped with coral as they were submerged, after which the growth would continue upon the same parts, until the whole, being thus depressed and covered, became the continuous mass which is now witnessed. That such depressions are taking place in some islands of the Pacific, is a fact substantiated, not only by the traditions of the natives, but by observations made since they have been visited by Europeans.

941. There are many instances in which the coral structures of comparatively recent origin have undergone a metamorphosis, which causes them to lose in some degree their original aspect. Large masses, when long exposed to the air, become changed into a solid, often somewhat crystalline, rock, in which the traces of organic structure are very indistinct, and with which the *mountain* or *secondary limestone* closely corresponds. This is observed in the Bermudas. Moreover, the coral sand often becomes agglutinated, by the percolation of water through it, into a very hard stone; it is in such a mass that the human skeleton, found on the shore at Guadaloupe, and now placed in the British Museum, is imbedded. This stone, when minutely examined, is seen to consist of a number of rounded grains, cemented, as it were, together; and it closely

965. What other volcanic phenomena are cited?

966. What of depression and submerging of land?

resembles the rock known to the geologist as *oolite*. Further, where shallow water exists around coral islands, the bottom is found to be covered with a layer of white mud, which is formed by the decay of the animal matter which held together the particles of carbonate of lime in the stony corals; and these are consequently set at liberty in a finely divided state, and fall to the bottom in a form which, if dry, would constitute *chalk*. Thus we may trace, very distinctly, the mode in which the three principal kinds of limestone rocks may have taken their origin in coral formations.

942. Now the mountain limestone, as it is termed—a rock very abundant in Britain, extending over large areas beneath the coal-fields, and sometimes exhibiting a thickness of nearly 3000 feet—is in some parts evidently composed of accumulations of shells, stems of encrinites, &c. But in many others the remains of corals are very distinct; and these are so blended with the neighbouring rock as to make it appear probable that the latter also was once in the state of coral, but was gradually changed by the process just described. Further, the collections of other animal remains are just such as we should expect to find on the margin of a coral reef or island existing at that epoch; and a similar process of fossilization is taking place on the shores of those existing at the present time; the imbedded series of animals only being different. The great thickness of the beds of this rock may be very well accounted for, in the same manner as the depth of the coralline masses of recent formation.

943. There are observed, in rocks of more recent formation, appearances which still more clearly indicate that they too were originally formed by coral-polypes. These are often found only within narrow limits, as if they had been reefs or islands of small size. Thus we find a stone called coral-rag in Oxfordshire; and very distinct coral beds in the crag of the eastern coast of England. It is interesting to remark that the remains of coral which are found in the older limestones, all correspond with those at present abounding near the equator and exhibit the *lamelliform* character; whilst they are gradually replaced in the newer strata by species more allied to those at present existing in temperate climates. This is one of the many facts which tend to prove that this part of the earth had at some former period a much higher temperature than at present.

944. We see, then, that vast as are the works of the existing species of this class, they are probably far surpassed by the accumulations of former ages, which constitute, in some form

967. How are the various rocks of limestone explained?

968. What instance of metamorphosis is cited?

or other a large proportion of the solid rocks of our terrestrial surface. And thus we see the exemplification of a principle which has frequently come under our notice—that in the economy of Nature nothing is insignificant; and that the most gigantic effects may be produced by the multiplication even of the humblest among the living inhabitants of the globe.

CLASS XXIII.—PORIFERA.

945. Of all the beings usually known under the designation of *Zoophytes*, the *Sponges* and their allies, constituting the class *Porifera*, appear to have the best claim to the title, since they present so complete an admixture of the characters of plants and animals, that it is difficult to say to which division they properly belong. Like plants, they are fixed to one spot during the whole of their lives—subsequently, at least, to their first development; they seem to possess no sensibility, for they can be torn or wounded in any way, without showing by their movements any indication of being affected by the injury, and they do not appear to have that power of executing voluntary motions, which must be regarded as the distinguishing characteristic of animals. On the other hand, they present a structure which is not analogous to any thing found in plants, but is similar to that of beings undoubtedly belonging to the animal kingdom; with these beings they are connected by intermediate forms, presenting a regular gradation of increasing complexity of structure and variety of function; and there are certain movements, both in the adult and in the undeveloped *Sponges*, which are more analogous to those seen in higher animals than to any observed in plants. On the whole, then, the evidence for the animal character of the *Sponges* seems to preponderate, and they will be accordingly considered here. Still there is no doubt that, if they are included in the animal kingdom at all, the lowest place in the scale should be assigned to them.

946. The common *Sponge* is a sufficiently characteristic form of the class, to serve as the foundation of a general account of the structure which prevails in it. On looking at its exterior, we observe that it is covered by a number of closely set and minute orifices; and that larger openings are disposed at intervals among these. The former are termed *pores*, the latter *vents*. On cutting into the substance of the sponge, it is seen to consist

969. What other coral productions are named?

970. What reflections are suggested?

971. What is the character of the twenty-third class?

of a sort of network of filaments, interlacing together in such a manner as to leave large channels and spaces of various forms, which communicate with each other. The large channels terminate in the vents; and, on tracing any one of them into the

External surface and sectional view of Living Sponge.

substance of the sponge, it is seen to divide and send off ramifying branches, which at last lose themselves in the spongy network that lies around them; and this communicates with the pores on the external surface.

947. The interlacing fibres, of which the walls of the large canals, and the spongy tissue between them, are alike composed, entirely consist (in the common sponge) of a sort of horny animal matter, as is shown by burning a small portion of them. But in other species we find *spicula*, or needle-like crystals, of silex or of carbonate of lime, disposed amongst these, giving to the structure much greater firmness, but depriving it, more or less completely, of that elasticity which is so useful in the common sponge.

948. The substance known as *sponge* is, however, but the skeleton of the being; when alive, this fibrous network is clothed, within and without, by a thin gelatinous substance, very like the white of an egg. This lines all the passages, and covers the exterior; but it drains away when the sponge is removed from the water. In this the peculiar vital endowments of the being appear to reside. These are manifested, not only by its slow but regular growth, but by a curious circulation of fluid, constantly taking place within the mass. When a sponge

972. Why are they included among animals?

973. What structure is seen in the diagram?

974. Describe the living sponge.

is examined in its living state, beneath the water, a constant current is seen to issue from the vents; being made evident by the disturbance of the water, and by the movement of particles floating in it. It may also be ascertained that a constant flow of water takes place inwards through the pores, for small solid particles upon their edges are occasionally seen to be sucked in. No intermission can be detected, during the life of the sponge, in these currents, which evidently have for their object to convey the nutritive matter contained in the water into the interior of the mass, and also to carry off the particles which are to be excreted, since thin films detached from the living tissue are seen to pass out from the vents along with the fluid ejected from them.

949. The relative position of the *pores* and *vents* differs much in the different kinds of sponge. Sometimes all the former are on one side, and the latter on the other. Not unfrequently the vents are placed on the summit of little conical prominences, which look like craters of a volcano; and the stream issuing from them, when seen under a microscope, may be likened to a miniature eruption. Sometimes the sponge assumes the form of a hollow cylinder, which hangs at one extremity from a rock; the pores are all upon the exterior surface, whilst the vents open into the interior cavity, and their united stream rushes out with considerable energy from the lower end of the cylinder.

950. Sponges may be multiplied, like plants, by artificial division, each portion becoming a new individual, but it does not appear that this is their natural mode of increase. They propagate by detaching little round gelatinous bodies, termed *gemmules*, from their living tissue, which in time develop the original form of the parent. These are produced in the network between the large canals, into which they find their way; when mature, they pass out of the vents in the current which sweeps through them, and by which they are conveyed to a distance. In these *gemmules* a peculiar motion, like that of animalcules, may be seen for some time; they swim hither and thither, apparently with a consciousness of the most advantageous direction; at last they fix themselves, and begin to deposit the horny or earthy particles which are to form their skeleton; and the system of canals gradually shows itself in their substance. When once they have fixed themselves, they seem to lose all power of further movement, and remain during the rest of their lives attached to the same spot.

951. Some kinds of sponges are found on almost all shores;

975. What varieties are described?

976. How do they increase?

and some frequent deep water, whence they can only be obtained by dredging. It is in this manner that the common sponge is procured from the Mediterranean, the Grecian archipelago, and the other localities it frequents. Sponges are not confined to the sea, however, for there is a species which inhabits fresh water, the *spongilla fluviatilis*, or river sponge, and which is different in several particulars from the rest. One of the most interesting of these is its green colour, which it acquires under the influence of light, in the same manner as plants. But though this character would seem to show its nearer affinity to the vegetable kingdom, there is another which as strongly favours the view of its animal nature; for it shows more power of movement, altering the form of the vents from time to time. There is a very interesting genus, inhabiting the shores of Britain, and chiefly found attached to oyster-shells, which it seems to have perforated by some means peculiar to it. In this, the *Clione*, may be observed the general characters of the sponge, and the constant circulation peculiar to it; but small polypes are occasionally seen to protrude from the vents, indicating its affinity to the Polypifera.

952. The knowledge which the naturalist possesses of the structure and habits of the inferior tribes of Animals is extremely imperfect, and it must be long ere it can be rendered complete. Although it might be supposed that the united efforts of so many collectors had brought together specimens of all the principal groups (to say the least) of the Animal Kingdom, this is far from being the case; for even an ordinary voyager can scarcely fail to meet with beings previously unknown, or at any rate undescribed; and any one who makes it his business to seek for such, will be most certainly rewarded with ample success. Even on our own coasts, new species are being continually discovered by naturalists who only visit them occasionally; and residents in their neighbourhood are almost sure of being able to add to the general stock of knowledge, by the exercise of but a moderate amount of patient industry. Those whose taste leads them rather to the observation of the habits and economy of living animals than to the collection of specimens, may find abundant opportunities of contributing to the general stock of information on such subjects; for it may be safely said, that there is scarcely one of the marine Invertebrata whose habits have been fully investigated. Of the beneficial influence of such pursuits little need be said, for they must be

977. Name the varieties.

978. What of the perfection of this science?

obvious to every person of ordinary reflection. We think that we are improving our minds when we make ourselves acquainted with the thoughts of other men, whom we reverence for their superiority, though they are fallible and erring like ourselves. How much more may we learn from that Infinite Mind, which displays itself in the Creation, whose thoughts of wisdom and love present themselves at every step, and whose glorious attributes are revealed to us in the exact proportion in which we rightly seek to comprehend them ?

979. What encouragement is given to research ?

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