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FIRST BOOK
OF
NATURE,

BY
JAMES E. TALMAGE.

PUBLISHED BY
THE CONTRIBUTOR COMPANY,
SALT LAKE CITY, UTAH.

1888.

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FROM THE PRESS OF
THE DESERET NEWS COMPANY.

PREFACE.

IN PREPARING this little volume, the author has made no greater pretension than is implied in its title. The matter here presented is designed to assist in the elementary study of the simplest objects of Nature; such as all people have more or less necessity of dealing with.

The order in which the topics have been treated, is the one that appeared most natural, and easiest to follow—animals, plants, and minerals of earth, and the most conspicuous objects of the heavens. No detailed classification has been attempted; nor have technical definitions or terms been employed; but it is hoped that the plan here adopted, will serve the reader as an introduction to a more thorough and systematic study of natural science, if to pursue such should be his desire.

The writer has sought in a sincere though humble way to demonstrate the meaning of “Nature” as defined in the introductory chapter; that Nature is but another name for the will of God as expressed in

His works. Many of the ideas presented are of necessity far from new—such facts have long been common property of the reading public; but wherever cullings have been made from standard works, credit has been given in the body of the book.

All the illustrations in Parts I, III and IV have been taken from “Steele’s Zoology,” “Geology,” and “Astronomy,” by the kind permission of the publishers, A. S. Barnes & Co. of New York and Chicago.

J. E. T.

SALT LAKE CITY, NOV., 1888.

“And this our life, exempt from public haunt,
Finds tongues in trees, books in the running brooks,
Sermons in stones, and good in everything.”

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FIRST BOOK OF NATURE.

CHAPTER I.

INTRODUCTION.

IN THE course of a single day, such a great variety of things comes before our view, that their names and definitions alone would fill a larger volume than this. Yet, they may all be classed in two clearly defined groups. Every object is either a *natural* or an *artificial* production; the former division including all those things that have not been in any way changed or operated upon by man; whereas, artificial things, are those that are made from natural materials, through human instrumentality. Wood, iron and stone are natural products of the earth; but a house made of such materials is an artificial thing. The horses that draw our vehicles are animals, and animals constitute one of the largest divisions of natural objects; but the wagon, which they pull, and the harness, by which they are attached, are artificial products,

having been manufactured through the agency of man.

In the course of this little book, we hope to devote some attention to the first class of things, or *natural objects*—those that are produced without human intervention, through the operation of the laws of Nature. *Nature*, in our present sense, means that system and order of things about us which is independent of, and, indeed, superior to human action.

Before man was placed on earth, there was day and night, summer and winter; the sun shone, and the rains fell; seeds sprouted, and flowers and fruits appeared in their proper season—these things are not controlled by man; they operate under the laws of Nature. Such laws have been in force since the far distant days of creation, when Jehovah spake, and as a result of His Almighty word, land and water were formed, the grass, and the herb and the fruit tree grew, and each yielded seed after its kind; the sun became visible in the heavens by day, and the moon and stars shed their inspiring rays over the sleeping earth; the fowl, the fish, creeping things and beasts came forth to enjoy the life allotted to them, and to accomplish the object of their existence. Such mighty deeds were done through the word of God, in accordance with His righteous will; yet man says these things were natural occurrences,—taking place in obedience to the laws of Nature. *Nature* then is but another name for the will of God; that which He decrees is done; His will is the law of existence. Look around the world and behold the uncounted

results of His omnipotent labors;—the things of Nature have been called the thoughts of God—they are indeed an embodiment and a realization of His all-wise designs. By learning the use and purposes of things, to a small degree, at least, we grasp the idea of their Creator; and to do this is to become truly wise. From the simplest objects, oftentimes the deepest lessons may be learned:

“The waves that moan along the shore,
The winds that sigh in blowing,
Are sent to teach a mystic lore
Which men are wise in knowing.”

The broad pages of Nature's book are open for us all to read; but, like the schoolboy, poring over his simple lesson, we can study best with the assistance of a skillful teacher; and the wisest instructor is the Author of that great volume. Careful thought and prayerful study, are the mystic raps, before which the doors of Wisdom's temple swing, and by which that sacred edifice is opened for our use. Let us knock and gladly enter, remembering ever the sanctity of the place, and the holiness of our surroundings.

Confining our attention now to the class of *natural things*, as distinguished from others which are the products of human art, the objects of interest that present themselves for our study, are so numerous, that they bewilder us by their variety. It is best, therefore, that we follow some system or method of classification in our dealing with such a multitude of things.

We are all familiar with the sight of horses and

cattle, of dogs, butterflies and bees, and many other creatures which resemble, to some degree, one or the other of these; all such are called *Animals*. Besides these, we see trees and shrubs, grasses, flowers and weeds, all springing from the soil, and these we know under the name of *Plants*. And again, there are pebbles, and boulders, sand, gravel, and clay, all of which are called *Stones*.

Every natural object belongs to one of these three groups, which, indeed, have been called the *Three Kingdoms of Nature*:

1. The Animal Kingdom.
2. The Vegetable or Plant Kingdom.
3. The Mineral or Stone Kingdom.

Animals all live, grow, and move, though some much more freely than others, and all feed on plants, or other animals. Plants live and grow also, deriving their nourishment from the soil, water, and air. Minerals, however, do not live or grow at all, as do animals and plants; they need no food; the summer's heat does not cause them to fade or faint; the frosts of winter do not kill them, for they are dead. A stone can be cut or broken in any shape, but the nature of the rock itself, is apparently unchanged thereby; while any such violence executed on a living thing would result in its death.

PART I.

The Animal Kingdom.

“He prayeth best who loveth best
All things both great and small:
For the dear God who loveth us,
He made and loveth all.”

CHAPTER II.

ANIMALS.

HE Animal Kingdom comprises so many different forms and kinds, that we could not hope to learn even the names of all of them, though we should study for a very long time. For convenience, those who have considered the subject before us, have classified animals according to their likeness or difference; all those that most closely resemble each other being said to belong to the same class.

Some animals have hard, solid bones within their bodies, upon which the softer parts, such as the flesh, blood vessels, etc., are supported, as is the case with the cow, rat, snake, frog and fish; while others, like insects, worms, and the like, have no bones at all.

All the bones of an animal's body form what is called the skeleton.

Fig. 1.—Bony Skeleton of a Cow.

Figure 1 represents the skeleton of a cow; all the flesh having been removed from the body of the animal before the drawing was made. Examine it carefully, and compare it with the skeletons of other animals such as frogs and fishes, shown in figures 16 and 17. If we look closely at such a bony skeleton, it will be seen that all the bones seem to be connected with the back bone or spine, which is in fact a long chain of bones extending from the head throughout the whole length of the animal's neck and back. Such animals are called *Vertebrates*, a word meaning "back-boned;" other animals are called *Invertebrates* or "non-back-boned."

It is remarkable, too, that all vertebrates have red blood in their bodies, while the invertebrates have none. Think for a moment of this difference as it exists between a cat and a butterfly; the body of the former bleeds even if the skin be but just cut through; but if the latter be accidentally crushed, only a colorless watery juice is found within its body.

Vertebrates, then, are animals with bones and red blood in their bodies; and invertebrates are animals having no bones within, and no true blood.

But vertebrates are not alike in all particulars. Some of them, as cats or fowls always seem warm to us when we touch them; and such, in consequence, are called *warm-blooded animals*; while others, as the snake, the lizard and the toad are almost repulsively cold to the touch, and may be appropriately named *cold-blooded animals*.

CHAPTER III.

APES AND MONKEYS.

MOST of us are somewhat acquainted with these peculiar and interesting creatures, from having watched them in their playful gambols and funny tricks in the menageries. A common variety living in Western Africa is the *Chimpanzee*, a monkey measuring about four feet high when standing erect. Another monkey, with a very peculiar name, and really the largest of the whole tribe is the *Orang-outang*, some specimens reaching a height of six feet if measured while standing on the hind legs.

But the strongest and fiercest of the whole monkey tribe is the terrible *Gorilla*, also an African animal. A good representation of this creature is given in figure 2. The gorilla is of a savage, cruel disposi-

tion; and travelers are anxious not to disturb it in its haunts, unless they are well prepared for fight. Its strength is so great that the creature can break off,

Fig. 2.—Gorilla.

with apparent ease, large branches from trees; and it is recorded, by good authority, that a gorilla has

been known to kill a hunter with a single blow from its powerful paw; and then to twist and flatten the rifle barrel of its fallen victim as if the weapon were made of wax. Note in the picture (figure 2) the savage expression; the low, retreating forehead, and the large protruding mouth with its sharp teeth. Look carefully at the animal's feet; the inner toe on each is apart from the rest, very much like a thumb. This feature is of great service to the beast in climbing, as it can grasp the boughs of trees more firmly.

The monkeys already named, are among the most remarkable of this peculiar tribe of animals. Those mentioned, are all tail-less; and are sometimes called by the general name of *apes*. They usually live together in small families, each little company appearing very selfish and unsociable, in permitting visits from others, upon its own domain. They live mostly on nuts, fruits, and various kinds of vegetable food, which their native forests produce in abundance.

Many other varieties of monkeys, smaller than the apes, are to be found in the warm parts of both hemispheres, living mostly in trees, and feeding upon fruits, nuts, and insects. Unlike the apes, these smaller monkeys usually congregate in large herds. They seem to be of a jolly disposition—leaping and playing among the branches, and all the time chattering in a truly ludicrous and noisy manner. In some species, as for instance, the spider monkey of South America—named from its long, sprawling legs and slender body—the tail is so long that it can be

twisted round the tree, and thus serve as an aid to the animal in climbing. The end of the tail is destitute of hair, and so sensitive, that it is used to hold small objects, such as fruit and eggs.

On each of the monkey's feet, the inside toe, which we may call the great toe, is spread apart from the others, somewhat like our own thumbs, for which reason, monkeys are sometimes called *Quadrumanous*, or four handed animals. They can grasp objects with the toes of the hind foot almost as well as with those of the front; but such motions are extremely clumsy, when compared with the almost perfect, action of the truly wonderful and graceful human hand. Some people claim that monkeys resemble men in many respects, and have even gone so far as to say that monkeys and men belong to the same family. Such extravagant statements as these are without doubt entirely unfounded. It is true that some monkeys stand on their hind feet at times, but none do so as a natural and common thing; and when they try to walk in that position, their movements are very awkward and unsteady. The gorilla stands erect when striking at an enemy; but this is no characteristic resemblance to human habit, for bears frequently assume a somewhat similar position when fighting. An ape's natural walk is on all fours, the front paws being clenched, so that the knuckles rest on the ground, and the soles of the hind feet in most cases, partly turned toward each other. No comparison of close resemblance, therefore, is admissible between such positions and the stately

posture and graceful bearing of a human being. Man alone naturally and uniformly walks erect—his head nearest heaven, and his eyes, embracing within their vision, the sky with its countless glittering worlds, as well as the ground, with its soil and flowers. The bones of the monkey's body—especially the hip bones—are of such a shape that an upright position would be positively painful to the animal, if prolonged. The skull is so different in each case, that no one could mistake a human head for that of an ape.

What connection is there between the clear intelligence of the human countenance, and the dog-like face of the baboon; between man with his heavenly gifts of speech and song, his buildings, railways and ships, and the chattering gambols of the monkey, or the savage strength of the gorilla! We are the children of God, and bear no relationship with the animals, except in the common features of mortality. Our bodies, while in this earthly state, need food, and air, and water, as do theirs, and we are subject to disease and death as are they; but the soul of man is the direct offspring of Deity; our Father has told us so; but sacred writ does not record such parentage of the ape. Words of inspired truth declare that in the eyes of the Lord, a righteous man, though mortal, is but little below the angels. Then let us not assert that our Father's children are scarcely above the monkeys; for such is not true.

CHAPTER IV.

INSECTIVOROUS ANIMALS.

IT is common to classify animals according to the food of which they seem to be most fond. Among quadrupeds, such as feed largely on insects are called *Insectivorous Animals*; those whose principal diet consists of the flesh of other animals are said to be *Carnivorous*; while plant eaters are called *Herbivorous Animals*. We shall speak of some members of each of these classes.

A common insectivorous animal with which we are familiarly acquainted is the *Bat*, often erroneously called *bat-mouse* or *flutter-mouse*. Because this peculiar little creature flies only at night, and loves to live in quiet, dark places, such as old and deserted houses and the like, and moreover, because according to our sense of beauty it is not particularly handsome, we are very apt to look upon it as an ill-omened creature, and to shudder at its mere presence. Let us put aside such prejudices for a time, and watch the little fellow with care and interest, and without doubt we shall learn something of value. Although the bat flies in the air, it has no real connection with the birds; it is not produced from an egg like birds; its body is covered with a kind of hair or fur, not feathers; and its so-called wings are very different from the true wings of birds.

Here is a skeleton of a bat (Fig. 3), which I prepared by placing the body of a dead bat near a

Fig. 3.—Skeleton of a Bat.

nest of large ants; those little insects very soon removed the flesh and left the bones clean and white. Look at the bones of the front limb, they are very much elongated; and in a living specimen a thin skin or membrane* passes from one to the other, and is attached to the side of the body between the front and hind legs forming a kind of web. By expanding and flitting this the creature is able to move quite rapidly through the air. The bat has no beak like a bird, and in its mouth is a full set of teeth, while birds have none.

It loves to feed on insects that fly at twilight; and to catch these it curves that part of the wing-membrane between the hind feet and the tail into a

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* If this membrane be spread out and carefully examined with the microscope while the bat is alive, a truly wonderful sight is revealed. Countless little blood vessels are seen filled with blood flowing steadily along like red wine through a pipe.

kind of net, which in the course of the animal's rapid flight collects the insects that come in its way. During the day-time, when the light would be altogether too bright for its eyes, the bat remains in its dark haunts, suspended by its hooked claws head downward. As the cold weather approaches, it seeks some sheltered nook, hangs itself up by its claws, and falls into a deep sleep, remaining dormant till the return of spring. Animals which thus sleep away the winter are said to hibernate.

Bats are very attentive to their young; a baby bat is often seen clinging by its claws to its mother's body while she is flitting through the air catching insects for supper.

Wherever insects are so numerous as to be troublesome, bats must be regarded as true friends to man; and as such they should be protected, rather than ruthlessly murdered by cruel boys, as is often the case, while elder ones look on with indifference, believing the animals to be but worthless pests.

A very large variety of bat called the vampire is found in the tropical parts of America, often attaining a spread of wings from three to four feet. This animal delights to dine on fresh blood drawn from the bodies of living animals; to obtain which it usually approaches its victims while they sleep; and after making a very small puncture in the skin, leisurely sucks the blood therefrom. Though the wound can scarcely be seen, the amount of blood drawn is often considerable. Without doubt, however, the stories so often told of vampires sucking the

blood from men and large animals until their victims expire are wild exaggerations.

A large bat called the Kalong is found in Java. Its wings when extended often measure five feet from tip to tip. Its head is shaped very much like that of a fox; and from this characteristic it is often spoken of as the fox-bat. This peculiar animal is not insectivorous in its habits; it feeds mostly on fruits, and makes its presence unpleasantly known among the people by plundering their winter stores of fruits and vegetables, if not carefully protected.

The *Mole* is also mostly insectivorous in its diet, though it feeds also on worms. By the aid of its broad snout and wide spreading feet it readily digs long underground passages leading from its dwelling place in different directions. It constructs its home in the most ingenious manner, there being three passages leading from the nest proper to the main run; so that the animal has several avenues of escape if attacked in its stronghold.

Fig. 4.—Plan of Mole's Dwelling.

In figure 4 the plan of a mole's home is sketched, showing the central castle and the passages connected therewith.

Mole-skins are prized on account of their soft, fine

fur, and in consequence these little creatures are killed in great numbers. This is to be regretted; for without doubt the mole is of far greater benefit than detriment to farmers, feeding voraciously as it does on the larvae or grubs which would eventually develop into destructive insects. The skillful manner in which the animal burrows through the ground, has probably furnished man with valuable hints regarding the shape of his shovels and plows.

Pope says:

“Learn of the mole to plow, the worm to weave.”

Many of the smallest among the so-called *field-mice* are in reality *shrews*—useful little insect hunters, frequenting our meadows and fields. The true field-mice are, however, destructive animals and very injurious to the farmer, devouring, as they do, grain and roots in large quantities. Of these something will be said in another chapter.

CHAPTER V.

CARNIVOROUS ANIMALS.

NIMALS that devour others are called *Carnivorous* or *Flesh-eating Animals*. The class is a very large one, including some of our domestic pets as well as many of the most ferocious of the whole animal kingdom.

THE CAT FAMILY.

The common house cat is the domestic representa-

tive of a very distinguished family. Most of pussy's kindred, however, are larger and more to be feared than herself; such as the wild cat, jaguar, leopard, panther, tiger, and lion. All of these have their paws soft and cushioned, so that they can steal, with noiseless step, upon their victims. Their claws are sharp and curved, well adapted both for holding and tearing their prey; and when not in use, these weapons are kept carefully enclosed in sheaths within the foot, by which means their sharpness is preserved. The tongue is covered with many rough points, almost as hard as horn, by the aid of which some of the family, such as the lion and tiger, are able to lick clean the flesh from the bones of the animals upon which they feed. They use their rough tongues also as curry-combs for smoothing and cleaning their skins. Let us observe, carefully, the sly and silent manner in which a cat steals upon a mouse or a bird, the patient way in which she watches for hours beside a mouse-hole—then notice the swift leap—meaning in nearly every case death to the unfortunate victim—and we will have a fair idea of the manner in which the fierce lion, and the dreaded tiger, the savage leopard and the cruel panther hunt and kill their prey.

The *Lion*, though usually measuring less than ten feet in length, is so powerful as to be able to treat a cow or a man, as a cat does a rat. A heavy, shaggy mane covers the neck of the male, giving the animal a most dignified and stately appearance, from which circumstance he has been named "King of Beasts."

The lioness is smaller than her mate, and is destitute of a mane.

The *Tiger* is found only in Asia, and chiefly in India. It grows usually about three feet in height, and eight feet in length, and its body is beautifully striped in dark-yellow and black. When disturbed in its native haunts, it is a ferocious beast. In one year nine hundred and seventeen men are said to have been killed by tigers in British India alone.

THE DOG FAMILY.

The ordinary dog owns many relatives among wild animals, such as wolves, foxes, hyenas, and others. The teeth of these animals resemble to a certain extent those of the cat tribe; but the so-called *eye teeth* are very long and sharp, so much so that some people call the corresponding teeth in other animals, especially if long—"canines" or "dog teeth." The claws in all of them are much thicker and less sharp than among the felines, and cannot be retracted or drawn into the foot.

Even among tame dogs there are many and widely different kinds. Compare, for instance, the majestic Newfoundland, with the frisking little terrier; or the thick-set bulldog, with the slender and swift-footed greyhound; look upon the broad face and rounded head of the mastiff, and then upon the long cranium and pointed nose of the fox-hound. The dog is in truth a companion to man. Wherever man has gone—to the frozen regions round the poles, as well as through the burning wastes and tangled forests of the tropics, the dog has followed and served his mas-

ter. The attachment of the dog to man amounts to a true passion. Many a noble hound has lost his life rather than suffer injury to come to his charge. He considers a kind word and a friendly caress full reward for almost any sacrifice or exertion.

The *Wolf* is in size about equal to a large dog; and of a savage and ravenous disposition. Wolves generally hunt in packs or companies, and so frequently kill and devour larger animals than a single wolf would dare attack. They wage great destruction among sheep, calves and other farm animals. The Grey Wolf is widely distributed over the thinly settled parts of Asia, Europe and America. The Prairie Wolf or Coyote is much smaller and less ferocious, and is found on the plains and prairies west of the Mississippi.

The *Fox* is readily distinguished from the other members of the dog tribe by its long bushy tail and pointed nose. It is a typical farm-yard thief, seeming to look upon all chickens, turkeys, ducks and the like as if created for its own special use. Though decidedly carnivorous in habit, it seems to enjoy a meal of ripe fruit occasionally. For craftiness and cunning it is proverbial. In many parts of Europe fox hunting is regarded as a fine sport, in spite of its cruelty. Dogs are trained to hunt the fox—mostly by scent; and in eluding its pursuers the crafty creature resorts to many pretty tricks. When closely followed it will often double on its track, so as to baffle the hounds by throwing them off the course; it has been seen to leap to the top of a fence or hedge

and run along for a considerable distance, thereby leaving no track which can be followed by the dogs along the ground; it will sometimes run through a flock of sheep, apparently thinking the dogs will fail to follow the track among so many. When the hounds are close upon it, the fox will often drop flat behind some fallen tree or large rock while the dogs, unable to check their headlong flight, rush past. Some observers say that if caught alive the sly creature will lie as if dead, and even allow itself to be severely treated without betraying the trick; but as soon as a chance of escape offers itself, it scampers away. The cunning of the fox is a gift to it from the Creator, whereby it may escape from its cruel and bloodthirsty foes.

Jackals and *Hyenas* are met with in the warmer parts of the Old World; and are of great good as scavengers, devouring large quantities of offal and other decaying and offensive matter. They seem to possess a little of the fox's cunning, with much of the wolf's savageness, and the lion's daring.

THE WEASEL FAMILY.

The Weasel family, including weasels, pine-martens, otters, skunks, minks and sables, are all small slender animals, and mostly nocturnal, or night-roving, in their habits. Some of the most valuable furs, as the Siberian sable and ermine are obtained from these graceful little creatures. *Weasels* furnish the ermine—long used in England to decorate the official robes of judges. The fur of these animals undergoes remarkable variations in color at different seasons; being

brownish on the upper parts and white below during the summer months, but turning uniformly white as winter approaches, and resuming its dull hue again in the spring. The hair is not shed to produce these

Fig. 5.—The Weasel in its winter dress.

alterations, but actually changes color. In warm countries, where winter cold is scarcely known the weasel retains one color throughout the year.

Figure 5 represents this slender and beautiful creature, bedecked in its snowy winter costume.

The sleep of the weasel is so deep that the animal may be readily caught if surprised in slumber, and hence the comparison so often used when speaking of an easy task—"like catching a weasel asleep."

Otters feed mostly on fish and as we would naturally expect, they live generally near the water. They are attractive little animals, though but rarely met

with in these parts. It is amusing to watch them engaging in their favorite sport of coasting,—down a steep snow bank in the winter, or a slide of slippery clay in the warmer seasons; seemingly with all the gusto of a crowd of merry boys with sleds. Animals appreciate fun as well as we.

The otter's eyes are tolerably close together, and are located low on the head so that with a very slight movement it can see in any direction. This wise provision assists the animal greatly while fishing.

The *Skunk* is found only in North America. Its skin is singularly striped lengthwise in white and black or dark-brown; but the creature is most remarkable for its power of emitting, when disturbed or angered, a most offensive odor, absolutely unendurable by other animals. It retires to its burrow fat and sleek as the winter approaches, and remains there till spring, when it reappears in a pitifully gaunt and hungry state.

THE BEAR FAMILY.

There are many varieties of bears of which the *Grizzly Bear* of the Rocky Mountains is the most powerful and ferocious. Its stout and non-retractable claws often measure six inches in length, and its strength is so great, that the animal has been known to carry off the carcass of a buffalo weighing over a thousand pounds. When hungry or attacked, the grizzly bear is regarded as the most formidable of North American wild beasts. The Indians consider it a great feat to kill a grizzly; and the successful

hunter usually wears the claws around his neck as a mark of honor.

Fig. 6.—Grizzly Bear.

Fig. 6 shows the general appearance of this beast. It has derived its name from the peculiar color of its hair, which is a mixture of black and grizzly gray. As seen in the picture, the animal walks on the flat part of its foot, leaving the impression of its broad sole, together with that of its long claws in soft ground, the imprint looking not unlike that of a very large human hand.

The *American Black Bear* is a much smaller animal than its fiercer brother already described; but if compelled to defend itself or to protect its young it will fight desperately. Though classed among carnivorous or flesh-eating animals, it feeds largely on fruit if such be obtainable. It is especially fond of honey, and will frequently venture to assail the nests of wild bees to satisfy its taste for sweets.

The grizzly bear shows these same traits to some extent.

The *Polar Bear* of the frigid regions is the largest of the bear tribe. The soles of its broad feet are covered with long coarse hair, by which the animal gains a firmer footing on the ice fields and plains of frozen snow of its arctic home.

The *Raccoon* or "coon" as it is sometimes called, is an American animal, about the size of an ordinary dog, and in general appearance suggestive of a small bear, if its long tail be not taken into account. It is not wholly carnivorous, feeding on roots and fruits as well as birds, eggs, small quadrupeds and fish.

CHAPTER VI.

HERBIVOROUS ANIMALS OR PLANT-EATERS.

THE perfect manner in which every part of the body of these animals is adapted to their habits of life, is another proof of the infinite wisdom of the Creator. Instead of long, pointed teeth, like those of the dog and the lion, suitable only for holding their struggling prey while writhing in death agony, the plant-eating animals have wide chisel-like teeth in front, and broad, flat grinders behind, fitted admirably for cropping the herbage, and grinding the grass and seeds which form their food. Their feet are clad in hard, tough hoofs, either solid as in the case of the horse, or divided

evenly into two toes, as with oxen, sheep, goats, deer and camels, or formed in a greater number of toes as in the case of the gigantic elephant, rhinoceros and hippopotamus.

THE HORSE FAMILY.

The *Horse* is thought by some to be the most graceful of all quadrupeds. It has become indispensable in the service of man. Wonderfully sagacious, and closely attached in its feelings to those who care for it, it is at once a companion and a servant. For such a trusty follower, man may well be thankful; and he should show such thanks by treating the animal with due kindness and consideration. A properly trained horse can always be governed more easily by a gentle word than by the lash. There are many kinds of horses, with very different appearance, as will readily be believed by comparing the large, heavy-set cart horse with the slender racer and the pretty little Shetland pony. The digestive organs of the horse are arranged so as to allow the process of digestion to go on in an uninterrupted manner, thus fitting the animal for more continuous movement.

The *Ass* or *Donkey* is in general form and habit related to the horse, though smaller and more hardy. It feeds upon the coarse forms of herbage, and is of an extremely patient disposition, fitting it for long continued work. As a pack animal it is of great service, and can carry with apparent ease a surprisingly heavy burden; but drivers are too apt to overload the poor beast, and cause it suffering.

The *Zebra* runs wild in Southern Africa, and though greatly resembling the horse is readily distinguished by the beautiful stripes of white and black with which its body is covered and by its wild and fractious disposition. It is said that no zebra has ever yet been tamed.

THE OX FAMILY.

The animals included here are the ox, sheep, goat deer, camel and their relatives, and among the whole range of the animal creation, these are of the greatest value and service to man. From them he obtains milk and meat for his food, leather for his shoes and hair and wool for his clothing; besides tallow, horn and bones. Many of them, too, are his willing and efficient beasts of burden. All of them subsist exclusively on vegetable food and have cloven hoofs.

They are frequently called *Ruminants* or *Cud-chewers*, from a peculiarity which they show in eating. To understand this more readily, let us examine the stomach of an ox or a sheep, as an illustration of the strange digestive organs of the whole family.

The appearance is well represented in figure 7, the upper picture showing an external view, and the lower one the appearance after partial dissection. As is there shown, the stomach consists of several cavities, looking, in fact, like separate stomachs. When the animal swallows, the half chewed food passes through the gullet, or œsophagus (*o*), into the first stomach or paunch (*p*); and after becoming moist and soft it passes to the second cavity (*b*),

called from its complicated structure the "honey-comb stomach." Here, by the movements of the stomach the food is rolled into balls, which are then passed one by one again into the mouth after the animal has ceased feeding and is at rest. The food is now thoroughly masticated and then swallowed again, passing this time through a valve near the end of the œsophagus tube, directly into the

Fig. 7.—Stomach of a Sheep.

third stomach (*f*), called by some the "manyplies," because the inner surface is roughened by numerous folds of the lining membrane; and thence after a short interval into the fourth cavity (*c*), each process more completely effecting the digestion of the food.

The ability to eat rapidly, depending for complete mastication upon subsequent chewing is of great practical use especially to the wild animals of this order. Nearly all plant-eating animals are eagerly hunted for food by the bloodthirsty, carnivorous creatures already spoken of; most are also of a shy and timid disposition, unfitted to defend themselves against their savage foes at close quarters, and therefore relying mostly in flight for safety. Beside this, they are certainly more exposed to attacks while feeding in open glades and pastures, than while hid-

den in their coverts and retreats. It is well, therefore, that they can eat rapidly and hasten back to places of comparative safety. And yet, the food upon which they live requires thorough mastication before digestion can go properly on—and this is secured by the ruminating process.

The interesting habits of the many species of deer, including the moose, reindeer, elk, red-deer and antelope, as well as the musk ox, bison, hump-backed camel and dromedary, and the longnecked giraffe, will form very interesting subjects for further reading and study.

Beside those already named there are many other well known herbivorous animals worthy of our notice.

The *Elephant* is represented in figure 8, and a good idea of the animal's size is to be gained by a comparison with the picture of the man standing alongside.

Fig. 8.—The Asiatic Elephant.

This creature is the largest of all living quadrupeds, sometimes attaining a height of ten feet, and a weight of twelve thousand pounds. The head is extremely large and heavy, and to support it the neck is of necessity short and stout. When in a standing position, therefore, the animal is unable to reach the ground with its head; but to make up for this apparent inconvenience, it has a peculiar organ called the trunk, looking much like a long and very flexible nose. It serves in fact as a nose, as well as for numerous other purposes. By its means the elephant picks up food and conveys the same to his mouth; by suction he fills the trunk with water, and pours it down his throat. This simple organ is said to be composed of over forty thousand separate and distinct muscles, by the action of which the trunk can be placed in almost every conceivable position. It is so strong that by its aid the animal can root up large trees; and so sensitive at the point as to easily pick up a single grain of wheat or rice. The elephant is very intelligent and can be trained to be of great service to man. He can be taught to carry logs and stack them in order; or to lay stone or bricks in a wall as orderly as a mason could. Two large overgrown teeth called tusks, project from the upper jaw; these are the ivory so highly prized for ornaments. A pair of tusks often weigh two hundred pounds.

The Rhinoceros, the Hippopotamus and the Tapir are large animals inhabiting only tropical regions and extremely interesting and instructive in their habits.

THE HOG.

Our common pig has a peculiarly shaped skull, adapting it for rooting in the ground. The skin is covered with long bristles, so stout as to be useful to the shoe and harness maker in sewing leather. The uncleanly habits of the animal are proverbial; and these are made the worse by the filthy surroundings among which pigs are usually confined. The flesh of the hog is used as an article of human food; though observation, experience and revelation unite to declare it unwholesome. Learned physicians and scientists of the day say that swine's flesh causes many disorders, and much sickness among those who use it. The food upon which the creature lives is very varied, and much of it is of a most unhealthful kind. It would seem that one object for which the hog was created, was to fill the office of a scavenger; devouring, as it does, large quantities of decaying matter, which otherwise would taint the air, water and soil, and thus favor the spread of disease.

The wild boar, an untamed species of hog, is still found in the forests of Europe. Its chase and capture have always been considered as agreeable sport. Another of the hog tribe, and a truly remarkable one at that, is the Babirusa Hog, or Hog Deer, a native of Java and Borneo. Its upper canine teeth are greatly prolonged, and curved backward, so as to form a protection to the eyes when the creature is running through the bushes.

CHAPTER VII.

RODENTS OR GNAWING ANIMALS.

S their name indicates, these animals are noted for their biting or gnawing propensities; and they may easily be recognized by the peculiarity of their teeth. In all of them, such as mice, rats, squirrels, etc., the two front teeth of each jaw are very long; the outer part of each tooth consists mainly of the hard white substance called enamel—the hardest substance to be found in the animal body in fact, while the inner or back portion is of a much softer material. The result of such an arrangement is that the teeth, though worn by constant use, always present a sharp edge, the hard enamel forming the cutting part. Unlike the case of most animals, a rodent's teeth grow as fast as they are worn away, and they are therefore in constant working order, unless an accident befall the animal and one or more of the teeth be broken out. In such a case the opposing tooth grows uninterruptedly, causing the animal serious inconvenience.

The writer has in his possession a rabbit's skull in which the lower front teeth have attained a length of nearly two inches, through the corresponding upper teeth having been broken out by an accident, so that there was no check to the growth of the lower gnawers. The body from which the specimen was obtained, bore every evidence that the rabbit had

died of starvation—most likely as a result of such unfortunate accident.

Mice and *Rats* exist in greater variety than any other class of quadrupeds, and include some of the smallest. House-mice, field-mice, harvest-mice, and jumping-mice are familiar acquaintances at home and on the farm. The last named, though less frequently seen than most of the others, is an exceedingly interesting and active little creature. Its body is not more than from two and a half to three inches in length, while its tail is more than twice as long. It moves by long and rapid leaps, and is so agile in many of its movements that the observer's eye is scarcely able to follow it.

Our domestic friend, the *House-Mouse* is a graceful and indeed a pretty animal, and could we but put aside our inborn prejudices for a time, we would indeed consider it such. Its slender build, smooth glossy skin, beautiful lustrous eyes, and engaging ways would commend it to favorable notice. It has been in many cases trained as a pet, coming at the call of its master, taking food from his hand and playfully submitting to his caresses. Contrary to common thought, mice are extremely cleanly in their habits; but as they indulge so unreservedly in attacks upon our pantry stores, we prefer them outside the house. With their chisel-edged teeth they can readily cut an entrance through the sides of cupboards and cases, and then they feast upon the contents at leisure.

Among rats the brown rat and the muskrat are

common with us in these regions; and occasionally the black rat is met with. This last was formerly the most common of all, infesting alike houses, barns and stores; but it seems now fast becoming extinct through the cruel and persistent attacks of the brown rat. It is an interesting creature, exhibiting great sagacity, a deep attachment for its young and a warm affection for others of its kind. It has been asserted by Dr. Franklin, whose trustworthiness as an observer will pass without question, that he once watched a company of rats migrating in search of a new home; and that among the party he saw a rat carefully leading a blind comrade by a twig held between its teeth. The muskrat is a common inhabitant of our brooks and ponds. It grows usually about a foot in length, exclusive of the tail, which is usually as long as the body. The animals very frequently prove annoying and injurious to the farmer by burrowing into the banks of his irrigating canals. They build their winter homes of rushes and sticks, oftentimes from three to four feet high, the entrance being below water and leading to a dry and warm apartment in the upper story. The skins of muskrats are valuable, the fur being used in trimming winter clothing, under the name of River Sable Fur.

The *Pouched Rat*, often called the *Pocket Gopher*, makes its presence known by its extensive underground burrows. On the outside of its face are large cheek pouches—not connected with the mouth, but in reality pockets in the skin; which in some cases

extend back as far as the shoulders. These are useful in collecting and carrying food.

The *Beaver* is among the largest of the gnawing, or rodent family; and was once to be found in almost all North American streams; but it has been hunted and trapped for the sake of its skin, so persistently, that it is fast becoming extinct. The fur is reddish brown in color, and of a very fine, soft texture. The tail is flat and scaly, and of great service to the animal while swimming. By means of their sharp and very powerful teeth, beavers can readily and rapidly cut down large trees, which they have the ingenuity to fell in such a way as to cause them to fall directly into the water so as to be borne by the current to the spot desired. Of these trees, together with rushes, sticks and earth, the animals build large and substantial dams across the streams; thereby forming deep water places, around which they build their dwellings—one story always being above water, with the entrance below.

Squirrels are extremely active and pretty creatures, with their long ears, bright eyes, glossy skins and superb bushy tails. They live mostly on trees, feeding on fruits and nuts, of which they are careful to lay up an ample store for winter use. It is an interesting sight to watch a squirrel perched on its haunches holding an acorn or a nut between its front paws, and all the while nibbling at the hard shell. After a time a clean-cut hole is made through the shell and the little fellow falls to work upon the kernel with evident relish. It is said that in collect-

ing winter supplies the squirrel takes each nut singly in its paws and judges from the weight whether the shell encloses a good kernel or is but empty; in the one case it is stored away; in the other it is rejected. If alarmed, a squirrel will run with wondrous agility up the nearest tree, and then leap from branch to branch, or even from one tree to another with surprising speed.

Flying Squirrels have a thin skin extending along the side of the body from the front to the hind legs. By expanding this while in the act of jumping they are able to make greater leaps than would otherwise be possible. Perhaps their large bushy tails are also of assistance in jumping.

The charming little *Striped Squirrel* or *chipmunk* of our hills, fields and bench lands is provided with cheek pouches connected with its mouth, in which it carries its food to its nest, either for immediate or future consumption.

The *Prairie Dog* is perhaps the quaintest little animal of the whole squirrel kind, and is to be found on our western plains and dry deserts, living in underground burrows. Usually large numbers congregate in the same locality, constituting what is called a *Prairie Dog Village*. They seem to be very inquisitive little creatures, frequently to be seen sitting on their haunches outside their burrows and watching with apparent concern the passers-by; but at the least sign of danger, with a rapid motion each little fellow dives into his hole, at the same time uttering a short, sharp bark or yelp, from which circumstance

the name of prairie dog has been bestowed. The members of a Dog Village seem to act in such perfect order and system as to lead many people to think that they are a regularly organized community.

CHAPTER VIII.

THE BIRDS.

MONG the most pleasing and interesting subjects of the whole animal kingdom are the birds. Their beautiful plumage, graceful actions, and, above all, their inspiring songs, combine to charm even the least susceptible among us. And then, what an infinite diversity in form and habit, they present to our view! Look upon the majestic eagle, soaring in dreamy state through the medium of the "upper deep," or standing in grave supremacy on a rugged mountain cliff; then contemplate, in contrast, the flitting, flashing, darting humming-bird, scarce larger than your thumb; yet presenting a wider variety of colors, and finer combinations and contrasts in tint, than could be brought together by the hand of a master artist, on a canvass many times its size. Does not Nature delight in true beauty and wide variety?

Watch for a moment, the wood-thrush, or the robin, mounted high, and greeting with joyous song, the sun's return. See its little breast throb as if about to burst with melody; its whole body intoxi-

cated with the harmony of its hymn. Is it not to us a fair example of thankful prayer for all the blessings of light and warmth, of happiness and of life?

Who taught these birds to sing? Surely one who rejoices in the musical mysteries of those happy songs, who knows the deep import of every note, and takes delight therein. What unbounded trust and implicit faith that little bird possesses, relying with full confidence, upon the providing care of its Maker; as if knowing well that without His knowledge, not one of its family falls to the ground. Surely this world is a much better and more cheerful place for the presence of birds. Then, let the happy songsters be protected among us. Boys, check your reckless love for the slaughter of such innocents as these; never set your target-gun or catapult against one of them; it is a barbarous nature that can be satisfied only by blood. Life is a mysterious and God given power—a power,

“Which all can take, but none can give,”

and everything possessed of life, should be sacred to us all.

Observe the great care and the provident concern with which the Creator has fashioned the bird's body in all its parts. Being intended primarily for flight, the structure combines muscular strength with small bulk and great lightness. The air taken into the bird's lungs spreads itself throughout the body, and even enters the bones, which are made hollow for this purpose; so that when a bird takes a full breath

its whole body is inflated and thus well prepared for aerial travel. The muscles operating the wings are comparatively large and remarkably strong; and this is especially true of birds that fly much. Compare for instance the pectoral muscles on the breast of the wild duck with those of a domestic fowl—in the former case the flesh is dark colored and well supplied with blood to nourish those much used parts, whereas the chicken's breast is white and comparatively bloodless through disuse.

Look now at the feathers covering the bird's body; a moment's careful study of these simple appendages will not prove to be entirely without value. A large quill feather from the wing, for instance, is seen to consist of a central tube or shaft, attached to which on either side is a blade-like expansion called the vane. If we provide a small magnifying glass and by its assistance look steadily at the feathery vane, we will find it to be composed of a great many separate branches, each of which consists of still smaller ones; and the edges of the finest are covered with little barbs, which hook themselves together so as to form a continuous blade. As the bird flies, the feather strikes the air with its broad surface as a boat-oar does the water, but in the return stroke only the sharp edge is presented. Beside such large and compact feathers, there are many smaller plumes to be seen; these have not the barbed edges, and consequently the fibres are loose and separate, seemingly designed as a protection against cold.

In comparison with the size of its body, a bird's

head is extremely small, and very light—an admirable adaptation to easy flight. Instead of a large mouth filled with teeth, birds have beaks, some short and stout as the robin's and sparrow's, others hooked and sharp-pointed, like those of the hawk and eagle, and still others like the duck's, flat and spreading. Birds swallow their food whole; it passes first into a small sack called the *crop*, thence into a second receptacle, becoming continually softened by the action of the digestive fluids, and then into the *gizzard*—a very thick walled stomach, usually containing sand, gravel, and other hard substances which the bird has swallowed. By the movements of the gizzard, and the grinding of the hard bodies therein contained, the food soon becomes reduced to a finer condition, and is ultimately absorbed.

The young of birds are produced from eggs, previously laid by the hen, and each covered with a hard shell. Reptiles, such as the tortoise and serpent, also produce eggs which in shape and size greatly resemble birds' eggs, but these have a tough leathery skin instead of a hard brittle shell. Inside the shell, each egg is seen to consist of a white portion and a yellow part or yelk (sometimes called the yolk). If we examine the uninjured yelk of a freshly laid egg, there will be noticed a small whitish speck floating on the surface; this is called the *germ*, and under the influence of warmth it undergoes a strange development, and eventually appears as a living bird. The warmth of the parent bird's body is naturally employed in the hatching; but artificial heat may be

used with success. The ostrich, a large bird inhabiting the sandy deserts of Africa, frequently leaves its eggs uncovered during the warm parts of the day, knowing that the heat of the sun will be sufficient to continue the incubation. A peculiarly ingenious habit is practised by the Mound Birds of Australia. Instead of sitting upon the eggs, they place them in large heaps of decaying vegetable matter, which they have previously collected and prepared for the purpose; the heat generated by the decay proves to be all that is requisite in the process.

The period of incubation varies with different species of birds. The eggs of the humming-bird hatch in twelve days; canaries, from fifteen to eighteen days; fowls, twenty-one; ducks, twenty-five and swans, about forty-five. When the young bird is developed, and ready to escape from the shell, it makes a hole in the latter by means of a hardened appendage on its beak, which Nature seems to have provided especially for this purpose; for soon after the bird leaves the shell, the hardened point, being of no further use, falls off, furnishing another and strong illustration of Nature's tendency to do away with all superfluities.

The size of the eggs produced is in general proportionate to the size of the birds. The largest eggs are those of the ostrich and the emu, a single one weighing as much as do three dozen eggs of the barn-yard fowl. They are used as food, and the shells being very stout and strong make admirable water vessels. In contrast, the eggs of the fairy-like

humming-bird may be named, in size about that of a pea and of a pure white color. Generally the larger birds lay but few eggs; the eagle for instance lays two, while the little wren occasionally deposits twelve in a nest.* To this also there are exceptions, which, however, cannot fail to do as much to strengthen our belief in the divine foresight which has planned all, as the rule itself. The ostrich, already referred to, frequently lays ten eggs, some of which are not produced until after incubation has progressed and perhaps not until the young birds from the eggs first laid are hatched. The extra eggs are destined to serve as food for the young ostriches, until they become sufficiently vigorous to digest the hard and uninviting fare of the desert, upon which their parents feed. The incubation process is one of surpassing wonder; man is powerless to explain, far less to imitate, the mystic changes in silent progress within the shell of a fowl's egg.

The great attachment of birds for their mates, and the unusually strong parental instincts, implanted for a wise purpose within their feathered bosoms, find fullest expression during the breeding season.

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* The most prolific egg-producers among birds are the domesticated varieties which have been bred and cared for by man for long periods. Tame ducks sometimes produce over a hundred eggs within four or five months; while the barn-yard fowl lays frequently 120 eggs during the year. The rearing of such birds for their eggs is now a profitable and an important industry. In 1876 there were imported into Great Britain alone 753 millions of eggs, valued at \$13,100,000.

After the nest is built and the eggs are laid, the long and tedious labor of incubation is begun by the female; while the male usually remains perched in some neighboring bush or tree, ready to defend his household charge against any foe; and, in the meantime, he enlivens the heart of his patient mate by giving voice to a joyous song, occasionally taking her place on the nest for a short time, while she enjoys her daily exercise and her meals. When the little ones appear, the duties of both parents are of a different, though very laborious nature, nearly all their time and attention being demanded to supply food to their eager offspring; and no amount of hardship and self-denial seems too great to be borne, if the babies can be protected and fed.

In defense of their eggs or young, even small birds fight most desperately, not hesitating to attack larger birds, animals, reptiles or men, who attempt to desecrate their homes. Some of our smallest and sweetest of singing birds, ordinarily of so tender and timid a nature that we would scarcely think them capable of a daring deed, have been known to fearlessly dart on large snakes or even cats that seek to rob their nests; and many a man has been driven out of his own barn loft by a pair of owls who had established their home in that place. Yet the courage of birds seeking to protect their homes, is not of the blind, rash kind, so often seen among men who are terrorized and excited. No; they seldom lose their presence of mind; but often display at such times most cunning and ingenious devices to draw the enemy

away. A dove or a partridge on being disturbed on its nest by the approach of man or dog, will often flutter along only a short distance ahead of the pursuer, and sometimes under his very feet, acting as if lamed or injured, and thus tempting a chase—always leading the enemy farther away from the nest with its precious inmates.

Among the many foes which the sitting birds have cause to fear, we may mention reptiles, carnivorous quadrupeds, and birds of prey, and perhaps cruelest of all, children with uncurbed passions for destruction. It is disgraceful and wicked to molest an innocent bird; and in addition, cowardly and cruel to injure its nest or steal its offspring. The grief manifested by the parent birds on being deprived of their young, is pitiful to witness; and their cries of distress are not unheard by the kind Creator “who made and loveth all.” As we hope to receive kind treatment and mercy from our Father, let us be willing to show the same toward His humbler creatures, who are far more innocent in His sight than the man or boy with barbarous and wanton instincts of slaughter.

CHAPTER IX.

BIRDS AT HOME.

HE great solicitude of birds for their young is beautifully shown in the care bestowed upon the nest. Nests are built solely for the purpose of rearing the progeny, and not to form a home for the old birds at all; for in the winter-time

when shelter is most needed the nests are entirely discarded.

Many of the larger birds, such as the eagle family, content themselves with a somewhat rude nest lodged on a projecting crag, or between the branches of a tall tree, and consisting of such coarse materials as sticks and twigs, lined, however, very comfortably with hair, wool or feathers. But many smaller species of our feathered friends display wonderful skill and unbounded care in the construction of their children's homes.

Look at the pretty cradle-nest of the humming bird; it is a masterpiece of skill—in size not larger than a small blue plum, but shaped with all the care that an expert weaver could bestow. The materials of which it consists are soft mosses and delicate lichens, generally collected by the male, and artistically arranged by his mate; the crevices are closed by a kind of glue formed from the saliva of the bird; and the inside is lined and padded with the richest and softest of vegetable silk. Not less wonderful, though entirely different, are the nests of the wren, the hedge-sparrow, the finches, the blue jay and the magpie; all of them show the effects of a Master's teaching.

In the autumn, after the leaves have fallen and the trees and bushes are bare, much may be learned by a close examination of the empty and forsaken nests of the past summer's songsters. See with what care these little creatures have selected the locality and position best calculated to ensure the safety of their

homes—perhaps a forked bough deeply hidden in the heart of a leafy bush, or a crevice in some dried tree trunk, or a sheltered ledge of rock. Peep within one of these cozy cots, and see the provisions made for the comfort of the birdlings; here they were hatched and reared, learning from the solicitous care of their parents, their own future duty. Look specially at the nest of the tiny wren: from the outside it seems little more than a ball of straw, but within it is lined as soft as a lady's muff of costly fur and finest silk; there is an entrance *on the side* thus providing a roofed top to keep out the rain.

The Bottle-Tit is a small bird, found at the Cape of Good Hope, and remarkable for the ingenuity displayed in the forming of its nest. This is woven of cotton, somewhat in the shape of a bottle, and of such careful workmanship that a single loose fibre is rarely to be seen. While the hen bird is sitting within, the male keeps careful watch from his seat in a little pouch, built for the purpose, on the neck of the curiously shaped abode. When the old birds leave the nest, even for a short time, the opening is securely closed. But in elegance of construction, even this nest is surpassed by that of the Pendulum Titmouse, a bird no larger than a sparrow, and found chiefly in Africa and India. Its nest is in shape like a long-necked retort, such as is used by chemists, and is hung from a branch of a tree, with the opening downward. Nothing is employed in its construction but the finest moss and down, woven so compactly that it forms a kind of felt which is an admirable non-

conductor of heat, thus insuring the eggs and young good protection from the extremes of temperature.

The Tailor Bird is a well deserved title bestowed on a peculiar variety native in India. The nest is built in a large leaf, the edges of which have been sewn together to form a kind of sack. In this labor, the ingenious little seamstress employs a fine kind of flexible grass as thread, and her own sharp bill is an admirable needle. If a single leaf sufficiently large cannot be found, two smaller ones are sewn together. This forms but the casing or holder for the nest, which is then built within, of grass and fibre, and thoroughly lined. In this pendulous cradle, the young are reared, gaily rocked by every breath of air. What child can boast of so ingenious a bed?

Fig. 9.—The Weaver Birds' Home. .

Another feathered resident of the Cape of Good Hope claims our attention by reason of the peculiarity of its nest, viz. the Sociable Weaver Bird, or as some people name it, the Republican Bird. A picture of its strange dwelling is shown in figure 9.

A great number of these birds live together as a colony: sometimes as many as six hundred building in a single tree. They first construct a huge framework about the trunk of a tree, resembling somewhat an expanded umbrella in form, and beneath this great dome, each has its own apartment. An idea of the size and weight of such a nest may be gained from the statement of Levailant, that in moving one of them, he was compelled to employ a wagon and several men.

A peculiar kind of swallow is found on the coasts of China, Java and Sumatra, which forms a nest unlike that of any other bird. The little builder collects a soft, slimy sea weed, abundant in the neighborhood, and cements the same by the aid of its own glutinous saliva into a kind of isinglass. These are the *edible bird's nests*, considered by epicures as a great delicacy for the table. Soup made from these nests is among the most expensive of such luxuries, yet it is in such high favor with the wealthy, that the collection and exportation of edible nests forms a profitable avocation in the parts where they are found.*

The noisy magpie, so common about our copses and hills, is a phenomenal thief; and apparently

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* This peculiar kind of food is more widely consumed than is generally known. Figuier states that from the coast of Cochin China alone, over four millions of nests are exported annually: the proprietors of one cavern in Java, which is frequented by the Esculent Swallow, receive twenty-five thousand dollars per year rent for the place.

thinking that its own dishonest tricks may be imitated by others, it takes the precaution to surround its nest with a thorny hedge.

Some varieties of East Indian birds exhibit a most remarkable domestic arrangement during the hatching season. As soon as the eggs are laid, the male imprisons the female upon her nest by building a stout wall of mud about the same, leaving only a small opening for the supply of air and food. The latter commodity he supplies with assiduous care during the whole period, and as soon as the birdlings are hatched he joyously breaks down the barriers and liberates his patient spouse.

Many birds habitually hang their nests, as the golden-crested wren, orioles and humming-birds, and such find at times that their cradles are liable to be overthrown through the increasing weight of the thriving brood. In these cases they promptly provide an equipoise by loading the opposite side of the nest with small stones or mud. Is not this a mark of a high intelligence, looking, indeed, very much like reason? They do not weight the nests until the necessity for such a precaution is plain.

Not all birds exhibit the same degree of care and skill either in the nest building or any other duty of life. There are to be found good and bad, kind and cruel, skillful and careless, obedient and rebellious among birds as among men. Many birds are known to use the discarded nests of others rather than build themselves, and some have been known to forcibly dispossess the rightful occupants and appropriate their

homes. Such is not an infrequent trick of the pugnacious little house-sparrow, which easily drives the inoffensive swallow from its cozy nest of mud beneath the eaves. The Cuckoos of the Eastern Hemisphere and the Cow-Birds of the Western habitually deposit their eggs in the nests of other birds, and leave them there to be hatched by the owner of the nursery. The young cuckoo seems to know that its foster parents will never be able to keep its hungry mouth well fed, and care for their own legitimate offspring at the same time, so, being larger than the others, he manages to get them one by one on his back and soon pitches them out of the nest. As the cuckoo builds no nest, neither sits on her eggs nor nourishes her young she has been often referred to as the type of a careless mother and a truant wife. But she has a maternal instinct within her breast as have others, and a little study of cuckoo life will perhaps aid us in understanding such recreant tricks. Cuckoos do not pair like most other birds in the breeding season; and the hen bird does not lay all her eggs at one time. She produces eight or ten eggs during the course of a few weeks; in consequence of this, even if she did undertake to construct a nest, she would of necessity have to build it alone, without the assistance of a mate; but if the nest were completed and the first eggs hatched, she would have to provide food for her young while still trying to cover the eggs produced later. Apparently knowing that such a labor could not be performed with satisfaction and success, she declines to make the attempt. As soon

as an egg is laid, she takes it in her beak and flies to the nest of some small inoffensive warbler such as the lark, red-throat, robin-redbreast, hedge-sparrow or nightingale, and leaves it there. She seems to watch for the absence of the proprietor of the nest in making the addition. One observer tells of a red-throat coming home unexpectedly and finding a cuckoo at her nest; the little house-keeper at once began an assault and soon compelled the stranger to retire with her burden. If not interrupted, however, the cuckoo will safely deposit her egg; but it is said she is never known to bring a second one to the same nest. She visits the nests, in which her eggs have been placed, several times before leaving the neighborhood, apparently to satisfy herself that her progeny have been left in tender care. She is therefore not entirely free from parental anxiety regarding her offspring; but I do not seek to fully justify the creature in her truant and unsteady life, especially if the following be true. Louis Figuier, the French naturalist, states that the cuckoo, after depositing her own egg in a stranger's nest, frequently takes one of the other eggs from the nest, breaks it and scatters the shell; so that when the lady of the house returns she finds only the usual number of eggs and apparently is slow to discover the deception. Such an act would seemingly indicate a degree of careful thought and reason; but the intelligence so shown is used to assist the bird in its knavery. And such a condition of things is not without its parallel among the unfeathered bipeds of the world; too frequently men use their knowledge

and skill whereby to bring imposition upon their trustful and non-suspecting fellows.

CHAPTER X.

BIRDS OF PREY.

HE birds of prey, include some of the largest among the whole order of birds. Many of them are well known; though the links which bind them to the memory, are not associated with the grace and beauty of form and voice, so characteristic of the smaller and less pretentious birds. As their name implies, these birds feed habitually upon flesh; the bodies of other birds and small quadrupeds usually supplying their larders. They are, indeed, the scourge and terror of all the rest of the feathered tribes; and for the pursuit, capture, and killing of their prey, they seem to be specially adapted. The beak of a bird of prey is usually very strong and sharp, and of a hooked shape, with a characteristic naked membrane or skin, called the *cere*, at the base. The toes are very flexible, terminated by hooked talons, and operated by powerful muscles; even a hasty glance convinces an observer that such are terrible weapons, when vigorously used. Of this large class, we find in nearly all parts of the country, eagles, hawks and owls; and on the Pacific Coast, and in South America, several species of vultures in addition.

Among the last named division is the *Condor* of

the Andes, a vulture of the largest kind. It often shows a spread of wings of from eight to twelve feet, and the length of the bird from beak to tail, averages four feet. Its plumage is of a blue-black tint, contrasting strongly with which is a collar on the back and sides of the neck, of dazzling whiteness. The upper part of the neck and the crest, as with all vultures, is devoid of feathers; being covered with a tough, semi-cartilaginous coat. Like others of the vulture kind, the condor seldom kills its own prey, unless it be some animal rendered weak and helpless, from age or disease; usually the creature prefers to feed upon the dead and decaying bodies of animals, which, through the agency of wonderfully keen senses of sight and smell, it is enabled to recognize from a great distance.* It is extremely gluttonous in its habits, so much so, that after a full meal, it is so gorged as to be unable to fly. Taking advantage of this propensity, the inhabitants of the regions frequented by condors, often destroy great numbers of the birds, by setting out for them carrion flesh in abundance; after their meal is over, the capture of the greedy creatures is an easy matter.

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* The extravagant stories, related of the condors daring, seem, generally, to lack foundation. Those who have studied the habits of the bird most closely say that it will never attack large animals, except they be helpless, or unless it is compelled to fight in self-defence. Even men have been known to be attacked by these rapacious monsters, when famished and overcome from hunger, or fatigue; but, an observer, who has had good opportunity of judging, writes, that a boy of ten years, armed with a stick, can easily put a condor to flight.

Among *Eagles* we find in the United States, the *bald eagle*, more properly called the *white-headed eagle* and the rarer *golden eagle*.

Fig. 10.—White-headed Eagle.

The white-headed eagle is widely distributed over North America. This bird is the chosen symbol of our nation.* It feeds principally on hares, chickens, young lambs and even larger animals such as sheep, calves and pigs, and at times it betrays a special fondness for fish, though rarely taking the trouble to catch them for itself. The

osprey is a smaller species of eagle, with a great propensity for fishing, and it is usually successful in its sport. Of this fact the white-headed eagle seems well aware, and is ever on the alert to rob the osprey of its booty.

In the eagle the sense of vision is very keenly developed. When soaring in conscious majesty far above the highest mountain crags, so high in, fact, as to be almost imperceptible to the human eye from below, he sees a wild fowl or a hare on the plain, and,

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* Dr. Steele has made the somewhat humorous remark: "Equally indifferent to the extremes of heat and cold, as well as to a maritime or an inland life; now honestly pursuing an independent vocation, and anon acting the part of a freebooter, and robbing the fish-hawk of its well-earned food, it is not an altogether unsuitable emblem of the nation."

folding his wings, drops like a weight to within a short distance of the earth, then preparing his talons he seizes his prey and bears it away to a place of security. The swiftness of the eagle's flight is proverbially known; one naturalist claims that the bird is able to sustain a speed of forty miles an hour. Certain it is that its speed is wonderful, and its muscular power and strength still more so. . Eagles carry off even sheep and young deer to their aeries; and the sight of an eagle's nest, from the bones and other remains of their victims, might well suggest a charnel house.* The eaglets have an almost insatiable appetite; nevertheless they are able to exist many days without food. The great naturalist, Buffon, states that a young eagle was once caught in a trap and kept five weeks without food, but showed no signs of feebleness till the last few days.

Illustrative of the great physical power of eagles in their flight, instances of children being carried off by these birds have often been cited, and accounts of such cases have been recorded by some of the most trustworthy observers. The following are vouched for by the best authority:

"In the canton of Vaud two little girls, one three years

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* The following is recorded by Figuier: "A peasant in Ireland kept himself and the whole of his family for an entire season by robbing the eaglets in a neighboring aerie of the stores of food which were brought to them by the parent birds. In order to prolong this singular means of livelihood, report says, he endeavored to delay the moment when the loved ones would be driven forth, adopting the artifice of cutting their wings to render them incapable of flight."

old and the other five, were playing together in a meadow. An eagle swooped down upon the eldest and carried her off. * * * Two months having elapsed, a shepherd discovered the remains of the little victim horribly mutilated and lying upon a rock half a league from the meadow in which she was taken."

"In the Isle of Skye, Scotland, a woman left her child in a field. An eagle carried off the little one in its talons, and passing over a broad lake, laid it upon a rock. Fortunately the robber was perceived by some shepherds, who came up in time to succor the infant."

Another authentic case showing still greater muscular strength is the following:

"In the canton of Geneva a boy ten years old, who was robbing an eagle's nest, was seized by one of the birds and borne to a point six hundred yards from the spot. He was rescued by his companion, however, without having suffered further injury than some severe wounds inflicted by the bird's talons."

Hawks, are smaller members of the falcon family, and exist in several varieties. The American *Sparrow Hawk* is among the smallest of all—scarce larger than a robin. Hawks are powerful, for their size; though they do not approach the strength of the eagle family. Their flight, when in pursuit of prey, is very swift.

Closely allied to them, is the whole family of *Falcons* proper, perhaps the most rapacious, and certainly the most powerful of all birds of prey, in proportion to their size. In the Middle Ages, these birds, when tamed, were largely used in the art of *falconry* or *hawking*, which consisted in loosing trained falcons or hawks, to pursue and capture other birds. It was customary to keep the falcon hooded

or covered, while hunting, until the game was seen; then, being freed, the bird would immediately start in swift pursuit, very rarely failing to secure the prize. Falcons could be taught to capture herons, kites, crows, quails and pheasants; besides hares, and even gazelles. In Egypt, India, China and Japan, the sport is still practised.

All birds of prey seem possessed of wonderful tenacity of life; and if uninjured live to a great age; but such is specially true of the falcons. It is a matter of record that a falcon was captured at the Cape of Good Hope in 1797, apparently in full vigor, bearing upon its neck a golden collar, on which was an inscription dated 1610 and stating that the bird belonged to King James I of England. It must therefore have been over one hundred and eighty-seven years old.

Owls are nocturnal or night-roving in their habits, and in consequence have been always regarded with a sort of dread. In America there are upwards of forty separate kinds, varying from the size of a dove to that of a turkey. The plumage of owls is exceedingly soft and full; and their flight is so noiseless that they seem really to be borne upon the air itself without effort of their own. The eyes of the whole owl tribe are exceedingly large, and are directed forward, instead of sideways as is the case with most other birds, so that the owl must needs turn its head even to glance on one side; and this it does with such comical, quizzical movements, as to appear really ludicrous. The eyes are surrounded by

a large facial disc of slender and stiff feathers. But a more important characteristic of the eye is the excessive dilation of which the pupil is capable. This enables the bird to see more clearly in dim light; though of course the idea that the owl, or in fact any other animal, can physically see in absolute darkness is absurd. The brilliancy of day, however, seems to be almost insupportable to owls, and consequently they remain safely and snugly hidden in their dark abodes till twilight comes. If an owl be disturbed during the day and driven into the light, it is almost helpless. Many small birds, such as the saucy black-bird, and the mischievous sparrow delight to catch their common enemy in such a plight; they join forces and usually pick and annoy him without mercy, all the time chirping and chattering as if every one of them were giving the broad-faced gentleman a special lecture, with practical demonstrations on the evils of his ways.

Owls wage great destruction among mice, rats and other farm vermin, and in consideration of this alone they are entitled to protection and respect. Mr. Waterton, a very reliable observer, expresses as his opinion, that a pair of Barn Owls while rearing their young, bring to the nest four or five mice every hour during the night. He domesticated a colony of owls, and was rewarded for his pains by the disappearance of rats and mice about his premises.

These birds are far more effectual than cats as vermin destroyers on a farm. As is the case with all birds which subsist on living or freshly-killed prey,

the owl devours its food entire, swallowing alike the flesh, bones and hair—usually rejecting the feathers, however, if birds have been captured. The digestive organs are so constructed as to readily separate the digestible from the non-digestible portions, which latter are formed into a ball within the stomach and then ejected by vomiting.

An observer has thus described the barn owl's style of dining: "The mouse is first bitten smartly across the back so as to destroy all life, and when it hangs motionless from the bird's beak it is tossed into the air very adroitly so as to fall with its head downward. The owl then catches the head in his mouth and holds it for a few seconds; then a sharp toss sends it down his throat, leaving the tail hanging out usually at the left side of the bird's beak. The bird rolls this about for a bit, as a boy would a stick of candy, and then another jerk puts all out of sight."

CHAPTER XI.

CLIMBING BIRDS.

ALL climbing birds have their toes equally divided, two in front, and two behind; and so arranged as to firmly grasp the branches and trunks of trees. Among our common birds of this sort are woodpeckers and cuckoos; but in warmer parts, many other varieties are found comprising the parrots and all their kindred.

The *Woodpecker* is finely adapted to the habits of its allotted life, which are in many respects peculiar. The busy little bird may readily be observed about our woods and orchards, plying its avocation with enthusiastic ardor. Its principal food consists of insects and their larvae, in search of which it goes from tree to tree, examining every crevice in wood or bark, and occasionally sounding the tree by repeated blows from its stout bill to ascertain if the trunk be in any part unsound; in which case, it would most probably secrete insects. The bird easily cuts holes in tree and post to reach its prey; its tongue is very long and barbed at the tip, and by its aid the bird readily secures any insect within reach. This interesting little creature also bores in wood to form secure places for its nest. In many places, the woodpecker has been cruelly treated, under the mistaken notion that it is injurious to trees. On the contrary it is of very great benefit in the orchard and the forest, by ridding the trees of destructive insects in great numbers. The woodpecker never bores a sound limb; insects do not hide in any but dead wood, and stories about the bird's injurious carpentry are unconfirmed. As already stated, the cuckoo belongs also to the class of climbing birds; many of the peculiar habits of the European cuckoo have been already dwelt upon at some length.

Parrots are to be found native only in the warmer parts of the earth, where they live amid the surroundings of a perpetual summer; but they are com-

mon in a state of captivity nearly all over the world. Only one species, the Carolina Parrot of the Southern states, not larger than a dove, is to be met with in our country.

All parrots are characterized by a stout, thick bill, the upper mandible of which far overlaps the lower so as to form a hooked beak, which proves of as much use in climbing and grasping small objects as the claws. The colors of some species are most gaudy and gay; all the tints of the heavenly bow seem to have been appropriated to adorn their dress. They are proud, too, of their flashy apparel, and take great pains to preserve their finery in an unsullied state. Bathing is a delight, and in the warm weather, they splash about in the water, with keen enjoyment. Then they smooth and stroke their plumage, till every fibre is laid aright.

Parrots are especially remarkable, on account of their varied powers of voice. They readily learn to pronounce distinctly, any word or sentence they may hear; and frequently, they imitate familiar voices, so perfectly, as to deceive even intimate acquaintances. They may be taught to speak in any ordinary voice, to shout, to sing, and to laugh, with all the perfection of a trained actor. In consequence of such extraordinary powers, parrots have been widely adopted as pets, and many and strange are the stories told of their loquacity. It is not to be supposed, however, that these birds partake of the spirit of true language, so as to form new and independent sentences themselves, from the words they have heard.

They learn to imitate known sounds and to repeat what they hear; frequently, also, gaining an idea of the meaning, from the actions that accompany the speech; but this is only a highly developed act of imitation. Articulate speech, that is, language consisting of separate sentences and definite words, seems to be a gift to the human family alone. All birds and beasts, it is true, possess some system of communication between themselves, which, indeed, we may call their language; but this consists usually of disconnected sounds, and inarticulate cries, often associated with expressive gestures, serving, however, the purposes of their sphere of thought and action, as fully and as well as does the heaven-born speech of man fit him for his mode of being. The language of man differs from that of the animal creation, over which he rules, in kind, as well as in mere degree of perfection; and his speech is as far above theirs, as are his spirit and his mind superior to them. Parrots, however, and some few other birds, learn to reproduce the words of man, oftentimes with strange effect.

The author knew a fine gray parrot once, which had been taught to stretch out her foot when told so to do, and each time she did this her master rewarded her with a piece of sugar. She heard him say, "Polly, hold out your claw," so often that at length she learned to repeat the words in a very perfect imitation of his voice and manner. Frequently she would call out herself, "Polly, hold out your claw;" and at such times she would invariably stretch out her foot,

as if someone else had told her to, and then she would appear extremely disappointed because the sugar was not forthcoming. The bird seemed not to recognize the difference between her own voice and that of a person by her. Her performance then was purely an act of imitation.

I remember making the acquaintance of another parrot under somewhat peculiar circumstances. Calling once at a gentleman's house on business, I was left alone for a time in the sitting-room—at least I thought I was alone; but soon I was very much surprised to hear in a pleasing tone the words, "Please scratch my head." Looking around with no common interest to discover the person asking such an unusual accommodation at the hands of a stranger, I saw, in a corner of the room, a large cage containing a magnificent green parrot. As I approached the cage, the pretty prisoner repeated the request and in exactly the same tones of voice, at the same time bending her poll forward so that I could reach it easily through the bars. I complied, of course, rubbing her head for some time; in which process she seemed to take considerable delight, and at the conclusion, in a very distinct and pleasant manner she said, "Thank you, sir." I was inquisitive enough to ask the owner of the bird how she had acquired such an education. He told me, that finding the parrot enjoyed having her head rubbed, he made it a rule to do this for her every day, invariably repeating before beginning the process, "Please scratch my head," and at the conclusion always

saying "Thank you, sir," till the bird picked up the words and used them for herself.*

The many truly interesting species of macaws, parrakeets, love-birds and cockatoos, which we are always sure to find in any traveling menagerie, are all varieties of the parrot tribe.

Before forsaking our present subject of climbing birds, we must mention the truly wonderful *Toucan* of the South American forests. It has an enormous bill, almost as large as a boy's wrist, while the body of the bird is but little bigger than that of a tame pigeon. Though apparently clumsy, this wonderful beak is in reality very light, being of a spongy or honey-combed structure, and the bird seems to take great care of it—carefully hiding it in the feathers of its wing and breast when at roost, at the same time also curving its long tail over the back, and thus disposing of the two lengthened appendages, so that its whole body appears compact and inconspicu-

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* Goldsmith tells a story about a parrot owned by King Henry VIII of England. This bird was usually confined in a room overlooking the river Thames, in which abode it had learned many phrases from the boatmen and others passing on the river. One day it fell from the window into the river, when it cried with a powerful voice; "A boat! a boat! twenty pounds to save me." A man on the bank, hearing the cry, and thinking some one was drowning, sprang into the water without delay, and was considerably surprised to find it was only a bird. Recognizing the king's pet, he carried it to the royal palace and claimed the reward promised by the bird when in distress. We are assured by the narrator that when the circumstance was related to the king, he laughed heartily and paid the money with a good grace.

ous. The tongue of this bird is long, straight and barbed on each side like a stiff feather. From this peculiarity the people of Brazil, where the bird is often found, gave it the name it bears. In their language *toucan* means "feather."

The toucan feeds mostly on insects and soft fruits, in eating which it tosses its head back so that the food falls of itself into the throat, appearing at first sight as if the bird really threw the morsel into the air and caught it again.

CHAPTER XII.

SCRATCHING BIRDS.

MANY birds seem to be adapted mostly for a life on the ground. Such are the doves, pigeons, farm-yard fowls, turkeys, prairie-chicken, etc.; all of them feeding mostly on seeds and grains. From their habits when searching for food they are called *scratching birds*. These are to man among the most useful of birds, furnishing him with some of his daintiest foods.

But few of this class are adapted for long continued flight; but to this a notable exception is found in the *Wild Pigeons*, which are really among the strongest and swiftest of flyers. Audubon, the great Ornithologist (one who studies birds) states that he has killed pigeons in the vicinity of New York City, having their crops still full of rice which must have

been gathered on the fields of Georgia and South Carolina—places from six hundred to seven hundred miles away. As it has been proved that the digestive organs of a pigeon will decompose a grain of rice in less than twelve hours, these birds must have traveled that distance with the speed of a fast express train. A mile a minute is said to be common flight for such birds. Wild pigeons live together in large numbers, and frequently migrate in a body when the supply of food runs short. A flock of such travelers on the wing is an imposing sight. The light of the sun at such times is obscured, as if a solar eclipse were in progress, and the sound of their wings can be compared only to the rush of a tornado. When they alight, they frequently pile upon each other to a considerable height, and the whole region is speedily cleared of everything edible to them; while their weight frequently breaks down the trees upon which they seek to rest. The same authority already referred to, Audubon, estimated that a single flock of these birds which he viewed in flight, comprised about eleven hundred and fifteen millions; and that the food required for such a host would be nearly nine millions of bushels per day.

Pigeons have been domesticated by man for many years; and at present a very great number of varieties are known. The *Carrier Pigeon* has proved itself of great service in bearing messages from place to place; and especially was this benefit felt before the invention of the electric telegraph. Knowing that these birds would always go straight to their

homes when liberated at a distance, travelers used to take several with them on their journeys; and after having fastened a small note to a carrier's wing or foot, would set the bird free. It would be seen immediately to rise in the air, and, having made several circular sweeps as if to ascertain the direction of its home, it would dart off on a straight line for its destination almost with an arrow's flight. Carrier pigeons have been known to make an exceptional speed of over one hundred miles in an hour, such, however, could not be continued for any considerable length of time.

The *Domestic Fowl*, another familiar example among the scratchers, and fully deserving of the class title, becomes readily attached to its home. These birds are poorly fitted for flight, and seldom attempt to rise in the air, except as a recourse of safety in time of danger, or to reach some elevated place to crow or to roost. At such times they seem so awkward in their attempts, and accompany the effort with such a noisy cackling and fuss, that one must think them engaged in an unusual undertaking. The male fowl, called the cock or rooster, is a magnificent bird, carrying himself with a dignity scarcely to be surpassed; but he is an aristocratic ruler, if not indeed a tyrant at times, in his dominion, and so jealous is he of his authority and rights, that the introduction of another rooster within his kingdom is a signal for battle: this will be continued between the rivals until one is vanquished. After the victory is decided, the defeated hero scarcely ever ventures

to meet the victor in combat again, usually fleeing even upon his approach. The fighting propensities of these birds used to be taken cruel advantage of to furnish barbarous sport for depraved people. The trained birds, pitted against each other, would usually fight to the death, in a determined manner, with both beak and spur. The spur can be seen on the back of the rooster's leg, just above the toes; it is a stout and sharp projection of a horny nature, and the owner knows how to use it to good advantage.

The flesh and the eggs of tame fowl are highly prized as food, and man bestows great care and makes ample profit in their breeding. As with all other domestic animals, chickens must be kept among clean surroundings if they are to be healthy in body and wholesome for food. Too often, however, their coops are allowed to become filthy, and in consequence the birds sicken and die.

RUNNING BIRDS.

There are some birds that live naturally upon the ground, being entirely devoid of the power of flight. Such is the case with the ostrich and its relatives, in all of which the wings are so small that they are entirely useless as organs of flight, whereas the legs are extremely stout. These have been called by naturalists, *Running Birds*.

The true *Ostrich* is found native in Africa, and occasionally on the plains of Arabia. It is the tallest of all birds, frequently attaining a height of six feet, and sometimes even eight feet; and weighing

upwards of a hundred pounds. It is the swiftest of all animals. A hunter mounted on the fleetest horse could not overtake the bird in a line of direct pursuit; but the ostrich always runs in a curve, and the pursuer follows along a straight line in the same main direction so as to intercept the creature along its course. Dr. Livingstone says: "The legs of an ostrich running at full speed can no more be seen than the spokes in the wheel of a vehicle drawn at a gallop."

Various artifices are resorted to in hunting the ostrich. Beside the method of chase and capture already described, the hunter sometimes hides himself in a hole in the sand, near the bird's nest. He takes his position while the owners of the nest are away in search of food, and usually succeeds in killing both the male and female birds when they return. Among the negroes, some hunters dress themselves in ostrich skins and in this disguise are able to approach the birds within bow shot. The ostrich is hunted mainly for its plumage. If taken young it may be tamed and even trained to carry burden. The negroes in Africa ride this bird as we do the horse.

The ostrich has a voracious appetite, though capable of enduring hunger and thirst for long periods. It swallows at times, gravel, and even large pebbles, and other hard substances probably to aid in grinding its food, as fowls swallow sand. Its senses of taste and smell seem extremely imperfect, and this renders the creature less particular than it would otherwise be, as to the things it swallows.

The *Rhea* is a running bird of South America, and from its general form, is frequently called the "American ostrich." It is usually not more than half the size of its African brother.

Besides the peculiarities of structure before noted, as fitting these birds for life on the ground, instead of in the air, the plumage of the Runners must be mentioned. The blades of the feathers are not joined compactly, by means of barbs, as in the case of flying birds. The wings are not used in beating the air, and there is no need of a continuous feather-vane; in such feathers, therefore, barbs would be useless, and consequently they are not provided.

CHAPTER XIII.

PERCHING BIRDS.

BIRDS that habitually build and dwell in trees, and that do not belong to the other orders already named are called *Perching Birds*. The class is so large, presenting such great variations and wide extremes that it is difficult, if not indeed impossible, to give any distinctive features of the whole tribe. We find included here most of the common birds of our orchards and fields, the happy songsters whose pleasing music imparts such a charm to both hill and valley, as well as others whose voices are by no means entrancing to the ordinary ear.

In this respect let it be noted that the gifts of Nature, even among birds, are distributed upon a plan

of equity if not indeed of exact equality. Favorites are difficult to find. 'The Father's preserving care and kind concern is exercised over all alike. 'The birds most famed for song are generally dressed in the plainest garb. Look at the lark, the mocking-bird, the nightingale and the thrush—they all are clothed in simple unostentatious colors, though they charm the hours of sunrise, and even rob midnight of its dreariness by their songs; then glance at the humming-bird bedecked in its robes of crimson and of gold, but with no power of voice above a chirp; and at the elegant bird of paradise—so proud of its gaudy attire that it will not touch earth with its feet unless of necessity—then listen to its comparatively inharmonious notes; think too of the gorgeous peacock with the eyes of Argus upon its train, but no nearer approach to a song than a discordant scream. Thus it is among birds as among men, the endowments of Nature are not all bestowed on one. The eagle excels in majestic strength, the nightingale in soul-inspiring notes; the pigeon and the swallow tax our belief in their feats of endurance and speed; the paradise bird has gained its name out of our homage to its almost heavenly lustre. So it is that each surpasses all in the special gift to which he is the lawful heir, everyone superior and at once inferior to all others, and—

“Thus all enjoy the power which suits them best.”

Here also is a lesson for us.

Among the Perchers, belongs the *Humming Bird*, the tiniest of all the feathered tribes—the flying

gem, as it is called. There are many species of these remarkable little creatures, though all native to the American Continent. The gayest in color are to be found in the warmer countries. Their long beak and flexible tongue, are admirably fitted for draining the honey cups of flowers—and such dainty food forms their chief support; though, indeed, they relish a meal of insects, occasionally. But it is the sad fate of these fairy-like creatures, to suffer for their beauty. The humming birds are eagerly caught to adorn the dress of those who aspire to a beauty not their own. The sacrifice of such innocent lives, for the cruel requirements of fashion, is both unnatural and wicked. Who sees aught of true beauty in the stuffed body of a bird, sewn on a head-gear? Are not the observer's feelings of sympathy and pity aroused to the exclusion of admiration; except, indeed, for the dead glories of the tiny creature? True beauty and proper taste are opposed to cruelty in any form; and will never countenance such barbarous practices, as are here referred to, by any act of encouragement.

The *Mocking Bird*, though common only in the Southern States, is a bird whose praises every American is proud to spread. It is in reality a member of the great family of thrushes. In size, it is about that of the meadow lark, of a dull ashy color, with a long tail; but in no manner remarkable either for brilliancy of plumage or beauty of form. It is a matter of surprise that such powers of song are concentrated within its little throat. But its music

is beyond description; it will never be forgotten by one who has once listened to those notes with all their wealth of inexpressible melody. It has a wonderful faculty too of imitating the voices of other birds or even quadrupeds; and this feat it accomplishes with such perfection as to deceive the animals themselves, who move about with evident concern thinking they heard the call of their mates. The Indians call the mocking-bird the "bird of four hundred tongues." Many of its admirers declare its voice to be superior even to that of the far-famed nightingale.

The class of birds known as the Perchers include also the numerous varieties of night-hawks, kingfishers, fly-catchers, warblers, thrushes, sparrows, larks, black-birds, crows, jays and many others.

WATER BIRDS.

In our mention of the chief classes of birds, we must not fail to speak of the *Water Birds*, both *Waders* and *Swimmers*.

The former are provided with very long legs; so long in fact, that some naturalists call them stilt-walkers. Through this peculiarity of their shape, they are able to wade into the water in search of food, consisting of worms, fish, or in fact any small aquatic animals. Herons, cranes, bitterns, snipes and plovers are common around our lakes and big streams. The largest ones are very dignified and imposing in their bearing. The snipes and plovers (the latter sometimes called "pee-wits" from the peculiar cry which they utter when disturbed) are the only ones commonly used for food.

The swimmers, including our common ducks, geese, swans, pelicans, divers and gulls are fitted for life in the water. They all have webbed feet, and swim and dive with skill. Their plumage is heavy and thick, and is kept well oiled from certain glands of the skin, so that their feathers are not saturated and their bodies moistened by the water. Every thing is arranged, it seems, to cause the water to slide off the polished surface of the outer feathers, while the thick undergrowth of down furnishes an admirable protection even from the severe cold of winter. None of these birds build very complicated nests; being usually content with a simple hollow among the rushes, always lined and carpeted however with the softest down, often obtained from their own breasts. The celebrated eider-down, of which the most expensive pillows and beds are made, is procured from the nest of a northern species of duck called the eider-duck.

Many swimming birds are able to remain under water for a surprising length of time; while others, as the tern and gull, do not dive at all. The family of the last named, the *Gulls*, are of peculiar and affecting interest to the inhabitants of this Territory; from the way in which they were brought by Divine power, in vast hosts in answer to the prayers of the people, to devour the ravenous locusts, which were producing such terrible destruction among the crops. Gulls have shown themselves to be veritable scavengers; and the good they accomplish by this propensity is extremely great.

CHAPTER XIV.

REPTILES.

HE word Reptile is derived from a Latin term meaning "to creep," or "to crawl," and is applied to a large class of cold-blooded animals characterized by such actions. Some of them, it is true, have limbs, but these are so short that part of the body is drawn on the earth. Turtles, lizards and serpents constitute our commonest classes of reptiles, and to these should be added the crocodiles and alligators, which though practically unknown in a wild state among us are unpleasantly common in the warm regions of both hemispheres.

Turtles or *Tortoises* are reptiles of a flat sprawling form, but particularly noted for their strange covering. This consists of a shell of bony and horny matter, made up of two parts, an arched roof-like upper part called the carapace; and a flat plate below called the plastron. The carapace, though composed largely of bone, is covered on the outside by a great many plates or scales of horn, fitted one to the other as accurately as are the ornamental tiles in a figured floor; and frequently of very varied colors. It is from this that the highly prized tortoise-shell ornaments are made. In most of the species, the two parts of the shell are immovably fixed to each other; the animal being able however to withdraw the head and limbs completely within as a plan of defense in case of threatened injury. But the

Box Tortoise has a movable plastron or lower plate fixed to its hard covering, by which it so effectually closes its shell, that a knife-blade can scarcely be forced into the joints.

Fig. 11.—Box Tortoise, with closed shell.

Figure 11 is a very good picture of the box tortoise, with its shell closed, as has been described, and lying upon its back. The tightly-fitting plastron is well shown, and the curiously-marked sections of which it consists, are very distinct. Dead and empty shells of these reptiles, are often used as boxes and trays. The senses of these creatures, seem, as a rule, to be extremely dull; and many injuries that usually prove fatal to the water-blooded animals, are borne by them with but few signs of discomfiture. They are said to live, under favorable circumstances, more than two hundred years. Many varieties of tortoises are known, of which, the land tortoises, fresh-water tortoises (the last named more precisely called turtles), are the chief.

From a hasty glance, it would seem impossible for an animal so heavily laden as the tortoise, with its cumbrous shell, to move at all readily, on land

or in water; but, contrary to such superficial appearance, those tortoises that frequent the water, are expert swimmers and divers; the whole internal structure being an admirable adaptation to such actions. The lungs are connected with numerous air-cells, looking much like small bladders, and situated in many parts of the body; so that when the creature inhales, all these air-bags become inflated, and the whole body is made specifically light.

Land tortoises, though seldom larger than a dinner-plate, and usually very much smaller in temperate countries, grow to great size in warm parts; some specimens weighing over two hundred pounds each. They live almost exclusively on vegetable food. The flesh of some kinds of land tortoises is eaten and considered a luxury; the animals being fattened for the purpose as we would feed a fowl or a tame duck for the table. Fresh-water tortoises are to be found in the marshes and rivers of heated regions. Their feet differ from those of land tortoises in being webbed, thus enabling the animals to swim easily. They are in general carnivorous in habit, feeding largely on fish, frogs and toads, small birds and insects.

The *Snapping Turtle* of many American rivers is represented in Figure 12 and deserves special mention. It is larger than other fresh-water species, measuring over three feet, and in exceptional cases four feet from the tip of the nose to the end of the tail. The head of this turtle is comparatively large and is terminated by a pair of strong hooked jaws,

which it can fasten with wonderful strength upon an enemy in case of molestation.

Fig. 12.—The River Tortoise, or “Snapping Turtle.”

Sea Turtles are in general very large. Their feet are shaped like fins or flippers, which are admirable organs of locomotion in the water, but give to the animal a very awkward appearance when it tries to make progress on land. These appendages, however, are of great service in scooping holes in the sand on the shore, in which to deposit its eggs. When laid, these eggs are carefully covered with sand and then abandoned, the heat of the sun being sufficient to effect the incubation.

Although turtles are strong for their size, some of the largest being indeed possessed of a muscular vigor little less than marvelous, yet they are entirely helpless when turned on their backs. Hunters take advantage of this in capturing large sea turtles, by rushing suddenly upon the creatures when on the shore, and turning them over before they are able to regain the water. After having disabled as many as possible in this novel way, the captors return and kill their game at leisure.

CHAPTER XV.

SNAKES.

SNAKES are characterized by very long bodies, covered with scales, but without external limbs of any sort. Even a hasty examination, however, shows their scales to be materially different from those of fishes, being formed really as wrinkles or folds in the skin, and covered with a thin delicate membrane, which is sloughed or shed at intervals, once a year, or oftener. Though devoid of limbs, snakes are able to move over the ground with great rapidity by a sliding or telescoping action of the scaly rings around their bodies. Their teeth are sharp and well fitted for holding their prey; for such purpose, indeed, the teeth are intended to serve, rather than as organs of mastication, as serpents swallow their food whole. The mouth and throat are capable of distension, in consequence of which, a snake is often known to swallow animals many times larger than itself. Some of the largest of snakes, such as the boa constrictor and anaconda reach a length of thirty or forty feet. As a proof of their great muscular strength, it needs only be stated that either of them can easily crush the bones of a sheep or a deer by the embrace of its powerful coils.

The ordinary black, striped and water snakes of America are harmless in their bite, though usually held in great dread. Their chief food consists of small animals such as mice and rats, frogs, toads,

and birds, which seem to be overcome with fear at the presence of a snake, and so become a ready prey to the devourer.

The rattlesnake on the other hand is of so venomous a character that its bite is commonly fatal to large animals, and even to man.

An examination of figure 13 will aid in gaining a clear idea as to the manner in which the poisonous bite is inflicted.

Fig. 13.—Rattlesnake's skull, showing the fangs.

In the upper jaw are two fangs or curved teeth which are hollow, and connected with a little sac or pouch containing the deadly poison. This is injected into the wound made by the two fangs whenever the animal bites.

The rattlesnake derives its name from a series of hard, horn-like rings on the tail, with which the reptile produces a peculiar rattling noise whenever disturbed. Were it not for this warning sound, the animal would be even more dreaded than it is. In color it is usually two shades, of brown with points of yellow. The arrangement of the rattles, as well as

the general shape and appearance of the rattlesnake may be fairly understood from figure 14.

The poison from any venomous serpent seems of little effect unless introduced into the blood of the body, which of course is the case whenever a bite

Fig. 14.—Rattlesnake.

from such a snake is received on the flesh; and in these emergencies, quick and efficient measures should be taken. If possible, let the wound be promptly and vigorously sucked; there is no danger of injury from drawing the venom into the mouth, unless sores or abrasions exist on the lips or within. The wound should also

be enlarged by a cut from a sharp knife—unless, of course, located where such surgery would be dangerous. If the bite be on a limb, a tight ligature should be bound on the side of the wound toward the heart so as to prevent as much as possible the spread of the poison through the medium of the circulating blood. The injured part may with great advantage be washed with hartshorn, or ammonia, previously diluted with twenty times its bulk of water; and

with alcohol. Small quantities of alcoholic liquor may very properly be taken inwardly at such time; but the common belief that the injured person's chances of recovery are in direct proportion to the amount of liquor drunk by him, is erroneous.

Lizards are reptiles, usually possessing a long, slender body and tail, and a comparatively large mouth, well filled with teeth. Many pretty and harmless creatures of this class are found in our Utah valleys, but none of a venomous kind. In tropical lands, lizards are met with, whose bite is dangerous.

The *Horned Toad*, of the Western plains, is a true lizard, the name toad, being a great misnomer; though its broad and comparatively short body, is an exception to the ordinary shape of lizards. The head is provided with spines and the body is covered with tubercles, suggesting the character of a mail-clad reptilian knight; this armor, however, is about its only means of protection. It is a timid, harmless little creature; and in the warm, Southwestern States, is tamed as a house pet. A very slight degree of cold causes it to become torpid and inactive.

Chameleons are peculiar and interesting lizards found only in the warm portions of the Old World, and possessing a number of strange distinctive features. The tongue is really a long tube, with an enlargement on the end, and can be darted out with unlooked-for rapidity, if a small insect comes within its reach. The chameleon's eyes can be moved independently of each other—a strange feature, and one that imparts to the animal a most remarkable appear-

ance at times. Then its tail is prehensile, that is, it can be used for grasping and holding branches of trees—and this is an unusual power among reptiles. The skin does not adhere to the body in all parts; spaces are left into which air at times enters, causing the skin to expand, and the whole body to appear enormously inflated; perhaps in less than a minute following one of such actions, the air cells are emptied, and the animal appears curiously lean and shrunken. In addition to these peculiarities, the creature is able to modify the color of its skin by expanding or contracting certain pigment cells situated just below the cuticle or outer layer of the skin, by which means the chameleon assumes the tint of the tree or ground upon which it happens to be, and so is in far less danger of detection by its enemies.

The largest members of the whole lizard tribe, often reaching a length of thirty feet, are the dreaded *Crocodiles* of Africa and India; then follow in order the somewhat smaller *Alligators* of the Southern States of America. The crocodile infests the rivers and sea shores, and surpasses even the fiercest of carnivorous mammalia in its powers of destruction. Its favorite method of attack is to remain concealed on or near the river shore till some animal or man draws near; then by a swift movement of its powerful tail the victim is stunned, and if not at once thrown into the water by the force of the blow, is seized and dragged beneath the surface, there drowned and devoured at the pleasure of its captor.

The alligators of America, though smaller than

their African relatives, are yet deservedly dreaded in their native swamps. As winter approaches, the alligators usually bury themselves in the mud, on the margins of their summer homes, and there sleep till the warmth of spring awakens them to a life of cruel rapacity. Travelers relate the thrilling concern with which they have sometimes viewed the heaving and swelling of a baked mud patch in the early part of the year; at such a sight they usually seek a place of safety without idle delay, knowing well that a hungry alligator is there throwing off the covers of its winter bed and getting ready for breakfast.

The Indians of the south usually capture the alligator by baiting a huge hook with meat, then securing it to a long stout rope, and placing it in a promising locality. When hooked, the huge game is soon drawn ashore and despatched with clubs. A method more ingenious and effective is practised on the banks of the Orinoco in South America. A bamboo, or some other elastic tree near the water is selected, the top is then bent down to the butt, and a baited hook is attached to the depressed top by a stout line. The tree is so arranged that its top is automatically released the instant a strain is felt upon the line; and consequently as soon as the alligator seizes the bait the tree forthwith straightens itself with great velocity and the victim is dragged from the water.

Alligators seem to hold dogs in high favor as food, and it is said the voracious creatures may be enticed from the water by the real or imitated bark of a dog.

CHAPTER XVI.

FROGS AND TOADS.

THESE strange creatures undergo such wonderful changes in the course of their life, that there is very little resemblance between the young and the adult. Their eggs may be seen during the early spring floating in the water of ditches and ponds, and looking like numerous black specks enclosed in a mass of jelly; those of the frog existing in large clusters, while the toad eggs are joined in long glutinous strings. Under the warm rays of the sun, these soon develop into small living structures, each looking much like a very little fish, with a disproportionate head and a flattened tail. These are called *Tadpoles* or *Pollywogs*. They live wholly in the water, are entirely destitute of limbs, and breathe by means of gills, as do fishes. These gills are seen as little feathery appendages on the sides of the head. In this stage of their existence they are extremely active, and grow with great rapidity; but soon, changes far more striking than mere increase in size manifest themselves. The legs are seen to grow, the hind ones appearing first. As these appendages become larger, the tail diminishes in size, and finally is entirely absorbed: the gills at the same time disappear, and to supply their place lungs are developed within the body. All traces of the fish-like tadpole are soon obliterated, and the mature toad or frog is the result. Originally a

thoroughly aquatic animal, it becomes in adult life of an aerial or air-breathing nature, though it is still able to remain for considerable time submerged in water; it can only breathe, however, in the air. In figure 15 are shown the principal stages in the wonderful development of a frog or toad.

Fig. 15.—Tadpole changes.

Figure 16 represents the skeleton or bony framework of the adult frog.

Fig. 16.—Skeleton of a Frog.

Frogs may be distinguished from toads by their stronger hind legs, their large horny ears seen just behind the eyes and the presence of teeth in the upper jaw. Both feed largely

upon insects, and to aid in capturing their winged prey the tongue is made very long and supple, and fastened at the front of the mouth, so that the greater part when inactive reaches down the throat. Yet the animal can dart this forward with surprising quickness and unerring accuracy upon any unlucky fly that may venture within range. Unlike most cold-

blooded animals the frog and the toad are endowed with powers of voice, and these too of no low order. The croaking bull-frog of American waters may be heard at the distance of a mile, in fact it has received its impressive name from the low, bellowing tone of its voice; while the gentle warbling chirp—it can scarcely be called a croak—of the festive toads, as they congregate in still ponds and quiet marshes on a summer evening and indulge in their mutual serenade, is known to all. Many people believe the toad to be of a venomous nature, whereas it has no means of wilfully injuring anything larger than a fly or a moth. Of insects, however, it destroys great numbers, and deserves therefore a more considerate protection than is commonly awarded to it. The toad's skin is frequently seen covered with drops of moisture even though the creature be at a considerable distance from water; this is a fluid which exudes from the skin under certain conditions, very much as does the perspiration of our own bodies. This fluid, which appears in greatest quantity if the toad be annoyed or frightened, is really of an acrid irritating nature and produces unpleasant and even severe smarting if conveyed to one's hand through touching a toad, and thence to the eyes. A dog is often seen to snap a toad in his mouth as if in a freak of sport; but he usually drops his plaything with a yelp of surprise, caused without doubt from the irritating effect of this exudation, upon the delicate lining membrane of the mouth.

During the winter frogs and toads hibernate in

large companies, having previously buried themselves deep in the soft earth.

Frogs and toads, and several other animals that pass through similar peculiar changes of growth are called by naturalists *amphibians*, a word meaning, "with a double life," because they pass part of their lives in water, breathing by means of gills as do the fishes, and spend the other part of their existence on land, breathing through lungs as do true reptiles or any of the other animals of which we have thus far spoken.*

Naturalists who have traveled and studied much, tell us of many rare and peculiar forms of frogs and toads to be found in various parts of the world though not common with us here. There is a somewhat remarkable variety of the former called the *Tree Frog*, common in many parts of the globe. It is a smaller animal than the ordinary frog, and, as its name indicates, lives mostly on trees. To properly fit the animal for such a life, several wise provisions have been made by the Creator. In the first place, each toe of the tree frog is terminated by a small pad, looking and operating much like the leathern

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* In this class belong the different varieties of *Newts* of which some are found hereabouts, and the curious *Salamanders* regarding which so many strange and exaggerated stories are told. It is incorrectly said they can remain in fire without injury; the only fact upon which such a statement rests being that these animals are able to cover themselves with a sort of milky fluid or perspiration, which perhaps protects them in a small degree from moderate heat.

suckers with which boys often amuse themselves. These little cushions are covered with a sort of glue; and by their action the animals cling tight to the trunks or branches of trees. Then again these frogs are of a singular color;—a sort of dull green, very much resembling the hue of the leaves among which they live and move. Such is an odd color for an animal, but to the tree-frog such an oddity is a matter of very great advantage, as by it the little creature can lie among the leaves and branches with very little danger of being discovered. But its sight is just as keen as if it were of some bright and contrasting color. It can see therefore with little danger of being seen, and is consequently able to lie safely in wait for the insects which form its chief food. Tree-frogs are capital trappers and hunters, and a study of their ways is an interesting and deeply instructive lesson. The voice of the tree-frog is mellow and agreeable in comparison with that of other species; it is heard chiefly in the cool of the morning and evening.

Among toads there is a very strange individual called the *Pipa* or *Surinam Toad*, found on this continent only in some parts of Guiana and Brazil. Unlike ordinary toads it has very small eyes, and no tongue. But the distinguishing feature about this queer creature is the manner in which its eggs are hatched. Our common kinds of toads always deposit their eggs in the water and then abandon them; but not so with the Surinam Toad. The female takes the eggs, as soon as laid, upon her back, where they

soon sink beneath the skin, forming each for itself a little socket or hole. The heat of the body soon hatches the eggs, and it is a funny sight to see the young brood in their queer nests.

CHAPTER XVII.

FISHES.

HE animals, about which we talked last, viz., the frogs and toads, and their kindred, were seen to live part of the time in water and part of the time on land. Fishes, however, seem intended, by the Creator, to pass the whole of their lives in water. Let us examine carefully, either of our common stream fishes, such as a trout, a chub, or a herring, and we will discover a great many valuable facts about the curious lives these finny creatures pass in their watery home.

In the first place, we cannot fail to observe the slender form and regular shape of the fish. There are no irregularities about it as are to be seen in other animal bodies; not even a depression, where the neck would seem to be. This spindle form enables the fish to move more readily through the water; any irregularity in shape, on the other hand, would tend to retard the swimmer.

Men have learned this, among many other lessons, from the animal world; they now build their marine torpedoes, which are to be shot with great speed

through the water—in a form very much like that of an ordinary fish.

Now let us look at the sail-like appendages on the back and sides of the body, the fins and the tail. These serve the fish as means of propelling and steering itself through the water; the tail operating chiefly as a sculling-oar and the fins serving to balance and direct the animal in its rapid course. Then there are to be noticed the scales with which most fishes are covered—so different from the hair, fur, wool or feathers, which form the dress of most land animals. These scales are inserted separately in folds of the true skin beneath, and they are made to overlap each other as do the shingles or slates on a roof, the free edges all being directed backward. The whole surface is covered with a slimy, oil-like matter which is also effectual in aiding rapid motion through the water.

Fig. 17.—Skeleton of a Fish. ·

A fair idea of the plan after which the body of the fish is shaped may be obtained from a careful study of the skeleton as represented in figure 17.

From the fact that fishes naturally live in the

water throughout their whole existence, some people think that they do not need air by which to breathe as do other animals. But fishes offer no exception to the rule; they, like other animals, must receive air into their bodies, by which the blood is purified, or they die. We all well know that if a land animal such as a dog or a fowl, be closely confined in a box or a small room, as soon as all the air contained therein has been breathed and rendered impure, the animal is suffocated to death. So with fishes; if they be deprived of a free supply of fresh air, they will suffer and die. Naturally, fishes breathe the air contained in the water in which they live. That water does so contain air—entangled perhaps between the liquid particles—may be readily proved by watching an open vessel of water when placed over the fire. In a very short time after heat is first applied—long before the water has become heated so as to produce steam, bubbles are seen to rise to the surface and there break and escape. These bubbles are portions of the air originally contained in the water; and upon this supply the living inhabitants of the liquid element subsist.

A very conclusive, though cruel experiment is often performed to illustrate and prove this fact. If a vessel of water be boiled so that all the air contained in it is driven away and if then it be cooled to the ordinary temperature, and a small fish introduced into it, the little creature swims around as if in agony for a short time, keeping its mouth close to the surface seeking what little air it can reach, but

soon it becomes exhausted and dies. It has been *drowned* in fact for want of air. It is true that fishes do not need as much air as land animals do; the water in which they live usually contains air sufficient for their use. Instead of lungs, fishes have peculiar organs called *gills*, so constructed as to readily separate the air from the water; and this, the lungs of animals are unable to do. These gills are seen on the sides of the head, looking like small, blood-red feathers, fixed to arches of bone; there are usually four of them on each side, covered by a hard, bony lid, called the *gill-cover*, or *operculum*. By watching a fish quietly at rest in the water, we may easily see how these peculiar organs are used. We notice the little swimmer continually opening and closing its mouth, and just as regularly, the gill-covers are seen to rise and fall—in fact, water is constantly being taken in through the mouth, and driven out between the gills, from under the gill-covers, thoroughly bathing the little feathery fringes with a continuous supply of fresh water charged with the life-giving air.

Through the filaments of the gills blood is constantly flowing in very fine vessels or tubes; there are so many of them that if looked at with a magnifying glass, the gills appear almost like bundles of blood-vessels; it is the large quantity of blood in these vessels that gives to the gills their bright red color. While passing through the gills, the blood is purified by the action of the air, and cleansed from the many foul matters with which it had become

contaminated in its former courses through the body, and is again started on its rounds to invigorate and to strengthen. These fringe-like gills are kept apart from each other by the action of the water passing between them; but when a fish is taken from the water the fringes fall together and become dry, although supplied more plentifully than usual with air. Some fishes can keep their gill-covers forcibly closed for considerable time in the air, so that the feathery gills beneath are kept moist; such fishes live much longer than others out of water.

A fish weighs almost exactly the same as a quantity of water equal in bulk to itself, consequently it has no tendency through its weight alone either to rise or fall in the water, and a very slight change is sufficient to enable it to move easily up or down. There is found inside the fish's body and near the back bone a peculiar membranous sack called the swimming-bladder, filled with air, and capable of being contracted or enlarged at pleasure. When the fish compresses this bladder by a muscular effort the bulk is decreased, though the weight in reality remains the same, and consequently the fish sinks. On the other hand, if the fish removes the pressure from the bladder of air so that it assumes a larger size, the bulk of the fish is increased, whereas its weight remains unchanged, and as a consequence the animal rises toward the surface.

The eyes of fish are generally large and motionless and as they are kept constantly moist by the water in which the animals live, there is no need

of protecting lids or lashes, nor of any apparatus to produce tears, which are of such service in our own eyes, by preventing the delicate coverings from becoming dry. Only a thin transparent skin covers the most delicate parts of the eye.

Most fishes are voracious feeders,* living mostly upon the various kinds of aquatic animals inhabiting the same water; indeed many of them feed on fishes smaller than themselves, and do not always hesitate to include their own young in their bill of fare.

Most fishes have large mouths, containing several rows of teeth; the tongue and palate are also very frequently covered with teeth; while others, devoid of teeth, habitually swallow their food whole.

Fishes are generally *oviparous*, that is to say they are hatched from eggs previously deposited in the water. Most of them are prolific to an astonishing degree, a single salmon being known to lay sometimes twenty thousand eggs; a herring over sixty thousand, and a cod-fish frequently deposits nine millions of eggs. In contrast with this there are some fishes that deposit but very few eggs; and here is another illustration of Divine wisdom; the fishes

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* "At a lecture delivered before the Zoological Society of Dublin, Dr. Houston exhibited as 'a fair sample of a fish's breakfast' a frog-fish two and a half feet long, in the stomach of which was a codfish two feet in length. The cod's stomach contained the bodies of two whittings of ordinary size; and the whittings in their turn held the half-digested remains of many smaller fishes, too much broken up to be identified.

most useful to man are of all the most abundantly prolific, while the dangerous and injurious kinds multiply but slowly.

CHAPTER XVIII.

SOME FISHES.

NO ATTEMPT any sort of a description of the different classes or kinds of fishes, is almost a hopeless undertaking, from their wonderful and surprising number. There are no less than ten thousand kinds of fishes now known and in part described. The ordinary fresh water fishes of our rivers and lakes exhibit the features already pointed out; but for species of almost incredible size and strength, the finny denizens of the ocean must be examined.

Many sea fishes, as for instance shad and salmon, go up the rivers and deposit their eggs in fresh water; the young fry, however, soon seek the briny element. Among salt water fishes, some are of migratory or wandering habits, appearing off certain coasts regularly at particular seasons. It is found to be a fact also, that individual fishes frequently visit the same place year after year. This interesting item has been proved by fishermen taking fishes from the nets, marking them and setting them at liberty again. The same marked fishes have been re-caught year after year.

Among ocean fishes, the *Sharks* are of great interest. Sharks grow sometimes to a length of thirty feet, and all varieties of them are extremely ferocious. They are the tigers of the ocean, the dread and the scourge of all other inhabitants of the deep. Their covering is not scaly, but formed of a hard, tough, leathery skin, and the bones are soft and gristle-like. Such bones are said to be cartilaginous in structure.

The shark's mouth is comparatively large and filled with numerous rows of sharp, lance-like teeth. These readily attack men who may be swimming or diving in the water, and are able to bite off a human leg with ease at a single snap.

Though these savage monsters are doubtlessly intended to be butchers and destroyers, the Creator has wisely checked their facilities for unrestricted slaughter. The shark's mouth is not at the end of the nose as is the case with most fishes, but underneath the head—much as the mouth of a hog is situated. The shark therefore is unable to bite without first turning over on its back; and while doing this, its intended victims sometimes make good their escape. *

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* Many accounts of shark fishing have been given; and the following is taken from one of our popular works on zoology, the author of which quotes it from some unspecified source:—"I was holding the heavy hook and wire rope over the side, when I felt that I had caught a big fish, and pulling it cautiously, a shark came to the surface. I called out, when the passengers ran to my help. He struggled so violently, lashing the water with his tail and trying to bite the hook asunder, that we were obliged to keep dipping his head under the water and then haul him

The *Sword-fish* often reaches a length of from twelve to fifteen feet. It owes its celebrity and its name to a peculiar elongation of its upper jaw into a kind of dagger, called its *sword*, of surprising strength. This it uses in transfixing its prey, and some species have so powerful a sword, that they have been known to drive it for a third of its length through the copper-covered hull of a vessel. There is preserved in the British Museum an interesting specimen, it being a part of a ship's side with a sword of a sword-fish thrust through.

The *Saw-fish* is appropriately named from the notched or toothed prolongation of its jaw. This is a formidable weapon, and the owner is not afraid to attack with it any inhabitant of the sea; even the gigantic whale not being exempt.

The *Flying-fish*, about which so many "fish stories" have been told, is a brilliantly colored crea-

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up two or three feet to let it run down his throat. At last he was nearly drowned, when, sending a running bow-line down the rope by which he was caught, and making it taut under his back fin, we clapped it round the steam winch, and turned the steam on. Some then hauled him up while all available hands dragged at the other line, which held his head. As soon as we got him on board he broke off about three feet of the ship's bulwarks by a single lash of his tremendous tail. This was then cut off by the boatswain with a hatchet, while a dozen of us with bowie-knives finished him. We found in his stomach six large snakes, two empty quart bottles, two dozen lobsters, and a sheep-skin with the horns and shank-bones, which the cook had thrown overboard two days before. The liver filled two large wash-deck tubs, and when tried out gave us ten gallons of oil."

ture with very broad pectoral or breast fins, so large in fact, that when the animal swims with great velocity to the surface of the water, these fins sustain the impetus for a sufficient time to bear the fish a considerable distance through the air. It cannot flap the fins at all, neither change the direction of its so-called "flight" when once in the air; and it falls into the water again at the expiration of a short time.

Then there is the so-called *Fishing Frog*, common about the coasts of Europe and America. Its head is so large that the rest of the body looks much like a mere appendage thereto. The wide mouth is lined with long and sharp teeth. The front, or pectoral fins are so large and spiny, that they support the weight of the body when the creature rests upon them; and this it often does, seeming really to walk, or crawl along the bottom of the sea. All around the head, and on some parts of its body are fringed outgrowths, looking very much like the sea-weeds, among which it usually lies concealed. Along the top of the creature's head, in the median line, are three long filaments, the first terminating in a kind of drooping fringe. This is the fisher's bait; by lying quiet in the weeds and causing its brightly-colored filaments to wave back and forth, it readily attracts the smaller fishes of the neighborhood, who seem to be deceived by the bait, thinking it to be, perhaps, a worm, or an insect; as soon as they are within easy range, by a quick movement, they are engulfed in the capacious gape.

A very large fish family are known under the name of Flat Fish. They usually lie while at rest flat on one side at or near the bottom of the water; but while swimming they take the usual vertical position. The under side is light-colored, and the upper surface dark—a provision of Nature shown also in the case of other fish—by which they are difficult to see from above or below, the dark upper side appearing much of the same color as the bottom; and the light under surface being scarcely visible from below. In the case of the turbot—a common flat fish, the eyes are *both placed on the same side of the head*. When the fish rests upon its side, this is the position of greatest service.

For the description of many interesting fishes, the reader is recommended to any good work on Zoology.

CHAPTER XIX.

INSECTS.

NEXT to the joyous song of birds, there is perhaps no sound more pleasing to the ear than the merry buzz and cheerful hum of insects abroad among the flowers, in the brilliant summer time. They seem so happy in their darting flight; stopping here to sip a tiny drop of nectar from the lucern or clover flower; and yonder to pick honey from the wild blossoms of the roadside: chasing each other through the air with untrammelled

gaiety, and all the unconcern of romping schoolboys—every day seems a holiday with them.

Yet oftentimes when we think that they are sporting in the depths of fun they are in reality accomplishing the work of their lives; but they have acquired the happy faculty of looking upon labor with joy and of taking pleasure in their work. Here is a lesson for us from the butterflies and the bees.

Most of these little winged beauties seem determined to extract all the pleasure and joy that life can lend, as if they realize that their time of existence is very brief.

Some of them live but a day in a fully developed state; but before reaching that perfection they pass through great and complicated changes, occupying weeks and in the case of some insects even years.

A more wonderful series of changes than that which is shown in the course of an insect's life, it is difficult to imagine. There appears, for instance, but little resemblance between the green caterpillar so often seen crawling about the cabbages, amusing itself by making sieves of the leaves, and the white or yellow butterfly noticed a short time after; yet the caterpillar is in truth the baby butterfly. It will be worth the trouble to capture a few of these caterpillars, and keep them under observation during the time of their growth, supplying them with plenty of leaves upon which to feed.

The caterpillar is usually called the *larva* of the insect—this word means literally *a mask* and is applied in this way because the insect seems to be in

a sort of disguise, the future appearance of the fully developed insect not being at all recognizable. Most insects in the larval condition are prodigious feeders; they seem to consider eating as the main object of their existence; and in consequence many of them prove pests and nuisances to man. Their growth is so rapid that at very short intervals they find themselves too big for their skin; whenever this is the case, the skin is cast away, as one might discard an outgrown coat, and another covering soon comes in its place.

After several of such "moult" have occurred, the larva seems to lose its appetite; it seeks some quiet and sheltered place, under a leaf, or in a crevice of a building or the bark of a tree, or perhaps it buries itself in the earth, and there prepares for a long sleep. This preparation consists in very carefully constructing a sleeping apartment; it may be a woven chamber of fine silk called the cocoon in which the larva incloses itself—or perhaps the little creature forms a cell in the earth or on a tree, and lines this with its own fine-spun silk; in other cases it becomes coated with a hard leathery shell, in which the outlines of the future insect, its wings, feet etc. can be readily traced. In this case the little thing does not look unlike a miniature baby trussed up in its swaddling clothes; and from such resemblance the insect in this stage is called a *pupa*, from an ancient word meaning an infant. Many of these pupae are to be found in the spring lying on the newly plowed land as they have been turned up by the plow from their

underground sleeping quarters. But soon another change follows; the pupa case, whether leathery shell or silken cocoon, bursts open, and the winged insect called the *imago* issues therefrom.

In figure nineteen are shown the larva and imago of one of our common moths; and in figure twenty may be seen the larva, pupa, and imago of the mosquito.

Let us capture a butterfly or a moth, or in fact any flying insect, and carefully look at its parts. A large volume could well be written upon the wonderful structure of an insect's body. Its head is seen to bear two appendages looking something like horns; these are smooth in the butterfly, jointed in the beetle, and feathered or plume-like in the moth. These peculiar organs are called antennæ and they seem to serve important purposes in the insect's little life. With them it feels, and perhaps also smells. By their aid insects seem able to converse with one another, and so perfect their understanding appears to be that Huber, a great naturalist, has called this system of communication antennal language. Watch a couple of ants from the same nest when they meet; they approach and seem to tap each other with their antennæ in a very significant way, and apparently with perfect success. It is not hard to imagine that they are making a mutual report as to the results of the morning's hunt for food; or perhaps consulting as to the best way home, or discussing the affairs of their ant-world in general.

Look carefully now at the insect's eye—it is far

different from the visual organs of most other animals. By the assistance of a magnifying glass we shall doubtless discover a most remarkable arrangement. Select for instance the large, prominent eye of the dragon-fly for examination. It seems to be made up of a great many brilliant little plates placed edge to edge like the facets on the surface of a cut diamond. Each of these facets or plates faces in a different direction, so that although the insect's eye is fixed and immovable in its place, yet by its peculiar shape and setting the little creature is able to see in nearly all directions. Such an eye is said to be *compound* in distinction from the *simple* eye of most other animals, which consists of but one ball and face. In the ant's eye there are fifty such facets, in the eye of the common house-fly over four thousand, some butterflies possess upwards of seventeen thousand, and many beetles show over twenty-five thousand. We are not able to tell the range of insect vision; some of the tiniest have to all appearances powers of sight but poorly imitated by man even with his wondrous microscopes.

CHAPTER XX.

BEES AND WASPS.

BEES and wasps, and all their relatives, are provided with thin, nearly transparent wings. *Bees* have a short body, covered with crisp, dark hair; the first joint of the hind legs is, in comparison, very large, with grooves and channels

upon it, for collecting and carrying the pollen of flowers. They are very industrious little creatures, living generally in communities, in which, there appears to be a most perfect system of organization.

A *queen bee*, is recognized in each colony; she is the only perfectly developed female among them all; and by her, all the eggs are produced. Beside the queen, there are *workers* and *drones*, the latter, being the male bees, and, for the most part, consummate idlers; they are stung to death by the workers, without mercy, as soon as the pairing season is over.

The *honey-comb*, which is manufactured by the bees from the pollen of flowers, is built in the form of numerous little rooms, or cells, each six-sided in form, and all placed side by side, so that each dividing partition is in fact a wall for two cells at once. This is the shape by which all the waste room between the cells is avoided, and at the same time the structure is the strongest imaginable, and the amount of wax employed in the construction, is the smallest.

The division of labor within the hive, seems to be most perfect; the workers laboring with such precision, that an ordinary swarm of bees can construct upwards of four thousand comb-cells within twenty-four hours. As soon as the cells are completed, the working bees industriously gather the nectar and sweet juices of flowers, and store the same as honey within the comb. The value of this delicious material, as one of our most wholesome sweets, is known and appreciated by us all. It has always

been held in high esteem;—*Deseret*, the *honey-bee*, was carried by the Nephites of old, from place to place in their wanderings, and gave the sweet fruits of its industry for sustenance and enjoyment.

Humble Bees, or, as they are sometimes named, *Bumble Bees*, are considerably larger than the ordinary honey bees. They are of a wild nature, preferring not to accept any of the provisions that men may make for their residence, such as hives or boxes; they usually build their nests under the surface of the ground, or beneath a large stone or some such object.

Figure 18 shows the humble bee, natural size, and its peculiarly-shaped honey cells.

Fig.18.—Humble Bee and its honey cells.

The bees already spoken of are sometimes called *social bees* from their instinctive association in communities; but beside such, there are a number of bees that lead a more secluded life, each living by itself; all such are termed for distinction *solitary bees*. Of these there

are some that build for themselves little cells, covered with sand grains or small stones fastened together by means of a sticky fluid formed in their mouths; these

are called *Mason Bees*. Then there are the truly ingenious little *Carpenter Bees*, those that bore holes in dry tree trunks and the like, in which they deposit their eggs. In each of the cells so formed, along with the eggs, they lay away a store of pollen gathered from flowers, to serve as food for the larvae, as soon as hatched from the eggs. And still another kind are noted for their wonderful skill in shaping cells from leaves; they cut and fashion these leaves with all the precision of trained workers, and they fully deserve their title of *Upholsterer Bees*.

Many kinds of *Wasps* show a remarkable dexterity in the construction of their homes. They usually build with a stout sort of paper which they produce by first gnawing wood to a fine powder, and then mixing it with the saliva to form a kind of pulp; this dries and becomes very hard and tough in the air. It is only during the last few years that man has learned to follow the example so long set by these humble insects—using of wood in paper-making. From this tough material the “paper wasps” build their cells, six-sided in form like the cells of the honey-bee’s comb. The wasps arrange their cells within the nest in stories or floors of different levels, each floor being suspended from the one above it by stout rods of paper. Wasps build their nests as homes for themselves and their young and not for the storing of food. They do not gather or eat honey as do bees, but feed on insects more defenseless than themselves.

The *Hornet* is a large and fierce kind of wasp,

which lives in a paper house constructed as before described and usually hung from the branch of a tree. Such nests frequently measure from one and a half to two feet in diameter. The inmates are so pugnacious in their dispositions, and so ready to resent any intrusion on their domains, that one has usually cause to regret his temerity in approaching the paper mansion too closely.

The *Mud Wasps* construct with great skill and precision small cylindrical cells of mud, the material for which they temper and mix as carefully as a brickmaker does his clay. These are used only as depositories for the eggs and as nurseries for the young. As soon as a cell is completed, the wasp places an egg or two within, then fills the remaining space with spiders or caterpillars or the like, and seals up the opening. These imprisoned insects are designed to serve as food for the larvae as soon as developed from the eggs; for these infantile wasps seem to inherit and show from their birth the prodigious appetites and ravenous dispositions of their parents.

The female insects of nearly all of the wasp and bee families sting severely if angered. The sting of the working bee is curved, so that when thrust into the flesh of an animal it is held there; it is usually therefore torn from the stinger's body and remains in the wound. Such is not true of the stings belonging to the queen bee and the wasps, which are straight and can be repeatedly used without serious injury to the owner, but always with considerable inconvenience to the unfortunate victim.

The sting is connected with a poison gland, from which an irritating fluid issues and enters the wound whenever the sting is used.

The effects are in all cases painful and in some actually dangerous to health and life. In case of such a sting, great relief may be gained from rubbing a little dilute ammonia (hartshorn as it is frequently named) over the affected part. If this be not obtainable, a little soda dissolved in water may be used. The poison from the sting is of an acid character and any weak alkali will tend to neutralize it and diminish the distressing effects.* Even mud, if applied immediately after the injury, will afford relief, owing to the action of the free alkali always present, though in very small quantity, in the earth.

Most of us have perhaps observed at times a number of small hard swellings on the leaves of such plants as the oak, willow, or rose. These so-called galls are produced through punctures in the leaves made by insects very much like bees and wasps in character, and known as *Gall Flies*. Let us cut through some of these galls with a sharp knife; within we are apt to find either eggs or young gall-flies; or perhaps a little hole through the side of the gall, tells us that the tenant has already taken his breakfast and left home. As soon as hatched the

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*Ordinary prudence will indicate the care to be used in applying any remedy if the injury be near the eye or any such delicate part of the body. In such a case, the application may cause greater trouble than the original injury, unless very feeble solutions are used.

larva feeds vigorously on the soft, pulpy material of the gall, which strange food seems to be of all kinds best adapted to its nature. Nut-galls formed on oak trees in tropical parts are used very extensively in the manufacture of ink and other coloring matters, and also in medicine.

CHAPTER XXI.

ANTS, GRASSHOPPERS AND BUTTERFLIES.

NTS are usually wingless for the greater part of their lives; in fact they voluntarily tear off their wings as soon as a place has been selected for a permanent residence. Most of them live underground, their houses being marked by mounds of sand, or earth, or, even such loose material as bits of sticks and the like. The interior arrangement of the ant-dwelling shows numerous chambers and halls, in which food is stored, and the young are protected and reared. These little creatures seem to live under a remarkable system of organization and government. The wise man of old gave good advice when he said: "Go to the ant, thou sluggard; consider her ways and be wise." Within the ant kingdom, labor is divided, and each inhabitant follows the profession for which it is best fitted; some of them are builders, others hunters, and some do nothing else but fight; these are soldiers by profession, and seemingly take no part in ordinary labor and household duties.

Most ants are extremely fond of sweets; and we may often find a score of red or black ants feasting on a fallen pear or peach, if soft and ripe, provided there is a crack in the rind. But they frequently seek to satisfy their liking for sweet things in a more interesting way. There is a remarkable little insect called the *Aphis* or *plant-louse*, in size about that of a large pin head, and usually of a greenish or black color, often to be seen on the leaves of peach and plum trees and many garden plants. These little creatures have the power of forming within their bodies a sweet fluid called honey-dew, and of this the ants are extremely fond. Toward the plant-lice they show the greatest respect, and the kindest of treatment, often carrying them off bodily to their nests, and there tending them with all the solicitous care of a faithful herder watching his cattle. The plant-lice have been called the ant's milch cows; and these they keep in little pens or stables within their nests, feeding and fattening them, and frequently taking them out to pasture when the day is fine, and returning them to their stalls at proper time. The ants greedily devour the honey-dew as fast as produced; and frequently excite the flow of the juice by stroking the aphides with their antennæ, as a milker presses the teats of the cow.

ABOUT GRASSHOPPERS AND LOCUSTS.

Grasshoppers and *Locusts* have many peculiarities by which they are distinguished from other insects. They do not pass through the complete changes already spoken of, as common to insects generally,

appearing first as *larvæ*, then as *pupæ*, and finally as *imago*s or perfect insects.

As soon as hatched from the eggs, they exhibit a ravenous appetite, and seem to retain it throughout their lives. Ordinarily, we make little or no distinction in speaking of grasshoppers or locusts; but, for the sake of precision, it should be known that the insects we usually call grasshoppers, are, according to the classification of entomologists, in reality, locusts. The pretty little katy-did, with its delicate wings, its pale green color, and its monotonous sound—from which it gets its name—is a species of the true grasshopper. It is thought that the male katy-did, produces the characteristic sound, by rubbing together a couple of stiff membranes, like drum-heads, situated at the base of the wings.

Locusts have larger bodies, shorter antennæ, and much smaller limbs than grasshoppers. As is known to us through the sad and painful experiences of our early settlers in these parts, locusts prove a most distressing scourge when present in great numbers. They swarm at times so thick as to partially obscure the sun's light in their flight. The land was "as the Garden of Eden before them, and behind them as a desolate wilderness." But terrible as their visitation has proved itself in these mountain vales, they have been miraculously removed through {the prayers of the people and the mercy of a kind Protector

BUTTERFLIES AND MOTHS.

These may be called the aristocrats of the insect-world; with their delicate wings painted as if by fairy

fingers in heavenly tints, and their dainty tastes, they offer truly a strange contrast with the worm-like caterpillars from which they sprang. They are usually called *Scale-winged Insects*, from the feathery scales that form the gaily colored covering of their wings. These brilliant scales are easily rubbed off if the insect be at all roughly handled; and a little of this dust looked at through a powerful microscope shows itself to be made up of many little plates, each as distinct and perfect as the coarse, heavy scales on the body of a fish. Each is shaped somewhat like a blunt-tipped leaf, with a little stalk by which it is inserted into the membranous framework of the wing. They are so placed as to overlap and by their symmetrical and truly artistic arrangement to produce the wondrously beautiful effects of color—too gorgeous in fact to admit of an adequate description; but why should such be attempted in words when the living wonder in all its glorious beauty can be observed by every one who has such a desire. Upon the butterfly's wing the brightest hues of nature seem to be assembled; there we behold the flashing light of the diamond together with the brilliancy of the sapphire the depth of the emerald, and the lustre of burnished gold.

Let us glance now for a moment at the peculiar form of the insect's head. The antennæ are long and club-shaped in the case of the butterfly, and generally of a featherly form in the moth. On the under side of the head of a butterfly is seen a long slender trunk, usually coiled up as a rope when not

in use. This is a tube, which can be made to operate as a perfect little suction pump and pipe. By this ingenious mechanism the insect readily pumps up the juicy sweets from the flower cups which it honors by its visits.

Butterflies feed and fly in the day-time and rest at night, but most moths are night-fliers. Many moths are of great use to man, by furnishing a kind of silk in their cocoons. This is especially true of the *silk worm*, which spins a large oval cocoon in which it rests during its sleep as a pupa. The silk is in fact a hardened kind of glue or gum,

Fig. 19.—Tent Caterpillar Moth, showing the eggs, larva, and imago.

which the insect secretes in a cavity near the head; and the cocoon consists of a single continuous thread. In the processes of preparing this silk for

use, the pupæ within the cocoons are killed by heat or suffocation, else they would cut their way through the silken house and thus destroy the continuity of the thread. The silk is then unwound, reeled and spun.

Fig. 19 shows the "Tent Caterpillar Moth," which has several times destroyed the fruit crops in different parts of Utah. The eggs are deposited as a collar around some small twig. The caterpillar is a pretty creature in spite of its destructive nature, ornamented with brilliant tufts of colored bristles. The name tent caterpillar is given to these insects from the silken net which they spin upon the tree, and which serves as a temporary house or tent.

CHAPTER XXII.

FLIES AND BEETLES.

OUSE-FLIES, mosquitoes, and all their kindred are characterized by having but two wings instead of four, the latter being the usual number with insects. In place of the hind wings, they have a pair of thread-like appendages with knobs at the extremities called *balancers*.

The ordinary house-fly is well worth our attentive study. Watch it while it is quietly feeding, you see it thrust out apparently from the head a short club-shaped organ, usually of a brown color, and commonly called the tongue, but more properly

the trunk or proboscis, for the appendage serves many purposes foreign to the ordinary uses of a tongue. It is in fact a very delicate though perfect pump, by means of which liquids may be drawn into the fly's mouth. A piece of dry sugar or any such solid substance must first be moistened by a fluid from the fly's mouth, so as to form a syrup which is then drawn through the trunk into the mouth. Each tiny foot of the fly has a sole consisting of a couple of expanded plates or discs, acting like suckers. By pressing these little discs firmly against any smooth surface, the fly is enabled to hold itself attached, though hanging back downward. The flaps are lifted and the foot loosened by means of a set of little hooks with which each foot is provided.

Mosquitoes are on quite intimate terms of acquaintance with most of us, and need no introduction. In the early part of their existence, they live in the water and are known among the boys as wigglers, or wiggle-tails. They are extremely active in all their movements, offering a strong contrast to the slow-moving caterpillars and maggots, which are the larvæ of some other insects. Swarms of wigglers may be seen frequently, during the warm weather in stagnant pools, each hanging head downward in the water, the posterior part of the body being kept at the surface. A small breathing tube is attached near the extremity of the body.

The appearance of the larval mosquito, also the pupa, the imago just escaping from the pupa-case,

and the perfect insects, male and female are shown enlarged in figure 20.

Fig. 20.—The Mosquito—male, female; imago, pupa and larva.

The activity of the wiggler is not lost even when the mosquito reaches its adult age. The lances with which the little creature bores the skin of its victim are very sharp, and when not in use they are kept carefully protected within a double sheath or covering.

We are very apt to think of mosquitoes as if they were worthless pests, calculated only to cause annoyance and pain to man and beast. Such an extreme judgment is in a degree unjust. Earnest students of

nature have not yet been able to declare any created thing positively worthless: the Creator has a purpose in all his works; and even flies and mosquitoes are of certain benefit to the rest of the animal world, and to man who claims superiority over all. Flies devour vast quantities of decaying matter about our houses and premises, which, if left unconsumed, would prove a most fertile soil for disease germs; and mosquitoes do similar work in the marshes and swamps, which form their homes. They are found in greatest numbers during the heated season, when their services are most needed. They certainly do not seem to have been created as ministers to man's present comfort; but they do him good nevertheless, and that too in spite of his enmity and disgust for them.

Dragon Flies or *Darning Needles*, as some are used to call them, have very large wings of a beautiful gauzy character, looking finer than the finest muslin. They possess very long bodies, and large lustrous eyes, and cannot fail to attract one's notice by their swift and graceful flight. Far from being harmful, as many suppose them, they are incapable of doing hurt to anything larger than a mosquito or a gnat, but upon the hosts of these troublesome little creatures they wage an incessant warfare. They are indeed the hawks of the insect world; and whenever we see them darting about over pools of water or across the meadow lands, we may know that a wholesale destruction is going on among the smaller flies hovering in those places.

Beetles are frequently called *sheath-winged insects* from the fact that the first pair of wings are hard and horny, forming an effectual sheath for the more delicate wings beneath. Only the hind wings are used for flight, and when not in use these are safely packed away beneath the cases. Watch a beetle just alighted from its flight; see how skillfully it folds and lays aside its lace-like wings by the help of its hind legs. The known varieties of beetles are said to exceed thirty thousand and these differ widely in size. There is the delicate little *Half-winged Beetle*, smaller than a millet seed, which flies mostly at night, and occasionally makes its presence uncomfortably felt by getting inside our eye-lids. There is also the gaudily-dressed *Lady-bird Beetle*, so common about our gardens and flower plats, which should be carefully protected for the good it works by destroying such vast numbers of plant lice. Then we meet frequently with the busy little *Tiger Beetle* and a great many forms of *Water Beetles*.

A very remarkable beetle is shown in figure 21. It is called the *Stag Beetle*, or stag-horn beetle, from the stout branched projections upon its head, resembling, somewhat, the antlers of a deer. It flies mostly at night, and is often attracted by the light into our houses, where it usually is an innocent cause of much alarm among the frightened inmates. The stag-beetle, however, is harmless; though, if picked up and handled roughly, it may resent such treatment by a sharp pinch from its powerful jaws.

Figure 21.—Stag-horn Beetle.

The *Grave-diggers* are remarkable little beetles, almost sure to be found near any small animal carcass left upon the ground. They usually travel in pairs, and seem to discover the existence of their prey from very great distances. Several roving couples soon congregate about the body of a mouse or a small bird; and by shoving away the earth around and beneath the same, soon lower it below the surface. The females then deposit their eggs in the flesh—where the maggots or larvæ will be sure of finding abundant food. By performing such offices for the unburied dead, they not alone provide suitable places for the growth of their offspring, but, in addition, benefit us all by safely removing from the surface of

the ground decaying and offensive matters, and also do much in fertilizing the soil. Thus the beetle, by serving itself does good to all.

CHAPTER XXIII.

SPIDERS.

ROM what has already been said we are fairly acquainted with the essential characteristics of true insects. Now, let us catch and examine some common spider. We would better select for our study, a fairly small kind; the bite of nearly all is severe, and of many, poisonous. But we do not need to handle the specimen, so as to be bitten at all. Our spider has eight legs—insects have but six; its body is naturally divisible into two parts, the front being head and chest, and the hind part the abdomen; while, in insects, three divisions are noticeable; the head, chest, and abdomen being each distinct. The spiders are devoid of wings, and do not pass through the changes of life, characteristic of insects. In consequence of such facts, spiders are usually considered apart from the true insects.

Most spiders have, connected with the abdomen, a reservoir of sticky fluid, which hardens in the air; and from this, the web is spun. The microscope shows each delicate thread of the spider's web to be composed of four thousand smaller ones; and each of these comes from a separate opening in the spider's spinneret.

These threads are so fine, that Leowenhœck, calculated that it would require four millions of them to make a thread as large as a human hair. The holes in the spider's body, through which these threads issue, are so small that, according to Reamur, a thousand of them occupy a space no larger than the point of a pin. The four thousand strands, of which each thread of the web consists, are united at some little distance from the spinnerets, so that each is dry before it is joined to the rest. By this arrangement, greater strength is secured; for it is a well-known fact, that a rope or cable, made of many fine cords, is much stronger than one of the same size consisting of a single cord.

Many spiders construct large and beautiful webs, which are spread out in various forms to serve as nets for the capture of insects.

Let us seek a freshly made web, and watch the spider as it captures its prey. As soon as a fly or other insect becomes ensnared in the meshes of the web, the spider rushes from its place of concealment near the centre of its silken net, and pounces upon the body of its victim, holding it firmly by means of its own powerful jaws; or if the captive be of large size, the spider spins additional cords about its body, so as to keep it as secure as possible during its death struggles, and avoid all unnecessary injury to the web. The body of the victim is sucked dry of its juices at leisure, and the dessicated remains are discarded.

Not all spiders spin webs however; some called

Mason Spiders make for themselves nests of clay in the earth, lining the cavity with a stout silky tissue, and fitting to the opening on the surface of the ground, a door which works on a durable hinge. When hiding within, the spider keeps the door closed against intrusion by holding firmly to the under side; and when the ingenious little builder leaves its nest, it is careful to close the opening in as perfect a manner as possible, so that it is almost invisible. These interesting little creatures are not common in these parts: occasionally specimens are met with in the warm south, and in California.

The *Tarantula* is a hairy spider, common in all parts of our Territory, sometimes attaining a spread of feet of over three inches, and capable of inflicting a dangerous bite. Several enormous spiders abound in the tropical regions, characterized by powers of quick movement and surprising strength. They capture and kill the largest insects, and even small lizards and birds.

CHAPTER XXIV.

WORMS AND SNAILS.

WORMS and snails! Not a very elegant title for a chapter, you say! Well, no; but an interesting and instructive subject nevertheless. Let us capture an ordinary *Earth Worm* or *Angle Worm*; we can find them in numbers

thrown up by the spade or plow in rich soil. Its body seems to consist of a number of rings or segments, each of which is provided on the under surface with several little bristles or short hairs, tolerably stout, and all directed backward. By rubbing a worm lightly between the fingers, from head to tail, the body seems perfectly smooth, but on attempting to stroke the animal in an opposite direction the bristles can be distinctly felt. By the aid of these little appendages the worm holds itself steady while boring its way through the soil, and resists any effort made to draw it forcibly from its burrow. Earth worms prove of very great benefit to the farmer by boring and loosening the ground below the reach of the plow. They eat by swallowing large quantities of soil, and after the vegetable matter has been extracted within their bodies, the rest is rejected in the form of worm-casts, which are composed of the richest and most productive mould. In some parts, especially in moist climates, these little creatures are found in very great numbers, and the labor that they accomplish in rejuvenating the soil is surprising. These common worms upon which we are inclined to bestow hardly a single serious thought, will often convert a barren patch into a most productive field.

We may often observe a number of dark colored worms crawling on the bottoms of our ditches and ponds, especially in low marshy places. These are called *Leeches*; but the boys have given them the title of *blood-suckers*, and with very good reason too,

as we shall see. Let us pick one of them from the water and look at it closely. We see on each end of the body a flat disc by means of which it can fasten itself firmly to any solid object, such as an animal's body. In its mouth we observe three sharp teeth; which very readily bore through the skin of its victims. The most active leeches are met with in the running streams of southern Europe, and one common variety is called the *medicinal leech* from having been once so extensively used by the surgeon in drawing blood from the body of his patient, for the purpose of allaying fever or local inflammation. When applied to the affected part, the leech soon perforates the skin with its lance-like teeth and draws the blood with vigor.*

But there are worms much smaller than these. The little *Hair-worm*, or as we erroneously name it the *hair-snake*, is a common inhabitant of our ditches. Ordinarily it grows from four to six inches long, and in thickness about equal to a hair. The notion has gained a foundation in the minds of many that this little creature is a transformed horse-hair. The author has talked with many people who feel absolutely certain that such an unnatural change as the resurrection of a lifeless hair into a living worm

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* This professional use of leeches is now very greatly restricted; but a few years ago they were as common as the lance is at present in medical practice. In 1846 it is said that between twenty and thirty millions were used in France, and in 1863 there were used in London alone over seven millions, and in the hospitals of Paris from five to six millions.

is a matter of every day occurrence. A careless experiment is always likely to suggest erroneous conclusions. If you throw a handful of horse-hair into a pool of standing water, very likely in a few days several hair-worms will be found wriggling among the hairs, but the little wrigglers have probably come there from other portions of the pool. Such is an improper way to make a trial. Now, count several hairs, place them in water in a safe place, then if you are lucky enough to find a hair-worm among them, count again; and all the hairs will be there. No such transformation can be effected; a hair is a hair and a worm is a worm, and nothing short of a Creator's power can form one from the elements [of the other. The hair-worm during its early life is a parasite in the intestines of many insects and small aquatic animals. Lying coiled up within the body of its host it attains a great length; but at maturity it escapes and deposits its eggs in the water.

There are many parasitic worms, that is to say worms that live in the bodies of other animals. One of these called the *Trichina* is found in diseased flesh, especially that of hogs.

Figure 22 shows the appearance of a piece of infected pork, as seen under the microscope, highly magnified; 1 shows the worms migrating in the fibres of the muscles; 2 represents a single worm encysted in the flesh, and 3 is a picture of a worm very much enlarged.

The trichinæ usually lie coiled within a little cell,

in the muscles of the animal. If such meat be eaten, these dreaded parasites live and multiply within the

Fig. 22.—Trichina in flesh of Swine.

body, and terrible disease, or even death frequently follows.*

SNAILS AND THEIR KINDRED.

Now let us catch a common *snail*, and see what it has to tell us. The most striking peculiarity is its colored shell, in which the soft body is enclosed. This snail is a member of a very large family of animals, called *Mollusks*, from a word, meaning "soft." It can withdraw its body completely within the shell when alarmed, and even close the entrance,

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* Only meat from clean and healthy animals should be eaten; swine's flesh, never; and all meat should be thoroughly cooked, so as to kill the parasites if they are present. Living worms are not good for food. Meat need not be burned or scorched, but it should be *cooked* through. Meat "done rare," may be a favorite article of diet with some, but it is always liable to contain living germs of troublesome parasites.

by means of a horny plate or disc. When extended, however, the head and main part of the body are outside the shell; and a couple of little pillars are seen affixed to the head, on the top of which the eyes are placed. Rather strange, isn't it, that the little creature should carry its eyes on a couple of poles, so that it can see farther?

Some mollusks live on land in damp parts, but by far the greater number inhabit the water, either fresh or salt. The beautiful sea shells with such an infinite variety of color and form, and an indescribable lustre are examples of the houses in which these humble creatures dwell. The highly-prized "mother of pearl" is obtained from the shells of such mollusks; and the beautiful pearls so much used in jewelry are derived from a species of oyster.

Returning to our snail once more, we see that its shell consists really of one continuous piece; the snail and all such mollusks are called *univalves* in consequence, while the oyster, clam and the like, the shells of which consist of two parts, are called *bivalves*.

Some mollusks are destitute of any shell, such is the case for instance with the common *garden slug*, a thick fleshy mollusk, usually covered with slime and looking much like a snail that has escaped from its shell. On the head are four little pillars, the longer pair bearing the eyes. The head can be drawn in somewhat as the finger of a glove is inverted.

CHAPTER XXV.

SOME TINY CREATURES.

BESIDE the many forms of animal life at which we have already glanced, there are countless others too small to be perceived by the unaided vision. A drop of stagnant water by the magic power of the microscope is seen to be literally a world of wonders; it is densely inhabited by crea-

Fig. 23.—Chalk from Gravesend.

tures, whose smallness alone would make them remarkable, and yet as wonderfully formed and as

admirably fitted for their prescribed course of life, as is the kingly lion or the eagle in its sphere.

Figure 23 is a picture made from a drawing by the celebrated microscopist, Ehrenberg, of a bit of chalk dust seen under the microscope. Chalk then is seen to be made up of the shells and calcareous skeletons of these minute animals.

Who of us has an imagination sufficiently strong to picture the myriads of separate shells in a mountain of chalk? Much of the beautiful marble and the solid limestone of our hills consisted once of such hard shells and the stony skeletons of similar minute animals.

Fig. 24.—The Amœba.

Many of these smallest forms are so simple in structure that they seem to consist only of a little fleshy sac, filled with fluid.

Two pictures are given in figure 24 of a form frequently found in the water of our ponds and streams, invisible to the unaided eye, and looking, when magnified, like a very small patch of jelly, with no regular shape. It is called the *Amæba*; and though so simple, it lives and moves in its allotted way with perfect order. Some people have argued that from such minute and simple structures as this one, all the higher animals have been developed in course of time through a process of growth or *evolution*. Such an idea is without the least foundation in fact or observation; no man has yet succeeded in producing

from the amœba any other kind of animal than itself. Each animal produces others of its own kind, and its own kind only. This seems to be a law of creation. An animal may grow and develop till it becomes perfect in its own sphere; but one cannot transform itself into others. The Creator has placed upon His earth a vast variety of living forms, small and large, simple and complicated, some to live in the air, others in the water, and still others on the ground, yet each with a special purpose to meet, and a particular place to fill in the great household of Nature; and every one is contented to live and to move within the sphere for which its Maker intended it.

PART II.

The Vegetable or Plant Kingdom.

“Consider the lilies of the field, how they grow; they toil not, neither do they spin, and yet, I say unto you that even Solomon in all his glory was not arrayed like one of these.”—*Matthew vi*, 28, 29.

CHAPTER XXVI.

PLANTS, AND HOW THEY GROW.

IN THIS great kingdom of Nature, we may find a variety and diversity even greater than that already seen to exist among animals. Like animals, plants also live; they need food and drink, which they absorb through their roots, and they breathe through their leaves. Their nourishment is derived from the soil, water and air; and in turn they furnish food for animals. It appears to be a universal law that plants should form the food of animals. Carnivorous or flesh-eating animals feed upon the bodies of other animals, which in their turn lived upon plants; and thus even they are indirectly sustained by the great vegetable kingdom. *The food of all animals is produced by plants.*

As a consequence of this alone the study of plants should be of interest to us. Surely Solomon was wise in his declaration: "The profit of the earth is for all: the king himself is served by the field."

Plants exist under most extreme circumstances in different parts of the globe. Wherever man has gone on the surface of the earth, he has found vegetation of some kind, even far beyond the limits of animal life.

Among natural objects, there are none others that do so much as plants to change and diversify the general aspect of the landscape. Without flowers and trees this would be to most of us a dreary world indeed. But these fixed residents of the soil do more for man than merely ministering to his sense of beauty, they offer him shade and shelter from the heat of summer, and bring him sweet perfumes, and untold treasures for food and useful service. From plants come the almost endless variety of fruits, which furnish us with so many of the necessities and luxuries of diet: sugar and spices, the frankincense and the myrrh; tonic herbs and wholesome medicines, resins and waxes; starch and oil, cotton, linen and paper, gums, rubber, cork and dyes, beside the many varieties of truly beautiful woods, for his buildings, furniture and fuel—woods, hard and soft, coarse and fine—of almost every conceivable shade and condition, and of universal adaptability to the needs of man.

Let us change our attention from the general aspect of vegetation to the more intimate examination of a single plant. We may select a young fruit

tree, for example. We perceive that it consists of three distinct and separate parts. There is the *root*, deeply inserted in the soil, and firmly holding the growing tree in position; next, the *stem* rising above the ground and oftentimes to a great height, and bearing branches from which grow the *leaves*. It is through these organs, root, stem and leaves, that the ordinary processes of vegetation are performed, and hence they are frequently termed the *vegetative organs* of the plant; contrasting with the *reproductive organs*, which comprise the *flower*, *fruit* and *seed*.

THE ROOT.

The roots of all plants show a natural tendency to grow downward. They are usually colorless, though occasionally of a reddish or brown tint, but never green. Suppose we now continue our examination of the young fruit tree already selected, by digging around it and removing the soil from its roots. Without doubt, we will find the main roots divided into many branches, as we follow them in their winding courses through the ground, and these branches again divide, to form still smaller ones, and so on, till the final divisions are so small, that they are to be seen only by means of the microscope. The ordinary branches of the root are called *rootlets*, and the finest divisions are termed *root-hairs*.

Of what use are these hair-like outgrowths? To obtain an answer to this question let us transfer our attention from the young fruit tree already examined to some smaller plant; an ordinary "*weed*" will do. If we pull it from the ground carefully, but little or

no injury will befall the roots; a gentle shake will remove the bulk of soil which clung to the roots as we pulled the plant and the general form and structure of the underground parts will be easy to follow. There is the main root, connecting with the stem at the surface of the ground, and giving rise to numerous rootlets. A careful scrutiny of the rootlets by the help of a pocket glass will show the root-hairs in great numbers; and it is these little structures that entangle and hold the soil so firmly. The roots striking into the soil and branching in so many different directions give the plant a firm support in the earth, insuring it against the danger of being torn from its established home by any ordinary force. And it may be noticed that the plants having the longest main roots and the greatest number of branches are the firmest in position. Try to pull from the ground a thriving lucern or clover plant, and see if you have cause to doubt the statement.

We may illustrate in a very pretty and instructive way the growth of roots, and at the same time observe the germination or sprouting of seeds, by performing the following simple experiment: Take a piece of muslin,—cheese cloth will be best, but a double thickness of mosquito netting will answer; tie it over the top of an ordinary tumbler, and fill the glass with water. Press the muslin or netting lower in the middle, so that it is kept moist, but not flooded; then sprinkle over it a pinch of seed of any small garden vegetable—the common garden cress seed will answer admirably. Set the glass aside for a day

or two, carefully supplying more water to replace that lost by evaporation, so as to keep the seeds constantly damp. In a few days the seeds begin to sprout; each sends a tiny white root between the fibres of the netting into the water below and at the same time small leaves appear above. It would be well to set the glass near a window, so that it may have plenty of light; and if it be put in direct sunlight for a short time each day, it will be all the better, provided that the roots be kept below the water. The roots will spread within the glass till they appear to fill it, and a luxuriant crop of cress flourishes above. The writer frequently keeps several vessels of cress growing in this manner during the winter, and raises enough of this pungent salad for table use. And farther, a glass holding a growing crop of cress is no less ornamental than useful, and it is certainly as instructive as could be wished.

CHAPTER XXVII.

PLANT ROOTS.

ITH a powerful magnifying glass the tiny root hairs, already spoken of, appear to be perfect tubes, through which the moisture of the soil is absorbed and conveyed to the main parts of the plant. In this interesting way the plant derives its food and drink—by absorbing the same through the tubular hairs covering the rootlets, thence passing it to the larger branches, and finally

through the main root, and the vessels of the stem to the most distant twigs.

We are usually not aware of the great force exhibited by the plant in absorbing water from the ground and distributing the same throughout its structure. Follow this simple experiment, first performed by Dr. Hales over a hundred and fifty years ago, and since that time repeated by many others. The stem of a young grape vine in vigorous growth was cut off a few inches above the surface of the ground and a small pressure guage, similar to the kind used on steam-boilers and the like, was attached. The moisture absorbed by the roots and passed upward through the stem, escaped where the stem was cut, and exerted its force on the liquid within the pressure guage; the pressure thus produced was sufficient to force water to a height of over thirty-six feet in the long arm of the guage tube.

Since all the material upon which plants feed has to be absorbed in this way, it follows of necessity that all such food must be in a state of solution, or the plant cannot absorb and use it. The soil may be rich in all the solid matters needed by the plant; but such cannot be absorbed unless water be supplied. The rain falling upon the soil, as well as the irrigating stream flowing over the surface, soaks into the ground, and in so doing dissolves all that is soluble; and when this water passes through the root hairs into the plant, it carries with it the materials in solution. During the growing season, when plants require the largest amounts of food material, the

roots are most active absorbents; but as soon as the leaves fall and the plant prepares for its winter sleep, the roots rest from their labors, most of the tiny root-hairs shrivel and die, the soft parts become hard, and the whole activity of the plant is suspended till awakened once more to growth by the return of spring warmth and moisture. During this period of rest, the plant may be removed from the soil and reset, with less danger of injury, as there are fewer active rootlets to be broken and checked in their work.

The quantity of roots attached to an ordinary plant is far greater than is ordinarily supposed. By digging away the soil some distance from plants selected for examination, and then washing the rest till the roots are laid bare and clean, the roots of beans, peas and rye have been found to form a tangled mat beneath the ground to a depth of about four feet from the surface. Roots of winter wheat have been found seven feet in the soil in less than seven weeks from the time of sowing.

Complete measurements of the roots of several plants with all their branches have been made for the purpose of determining the total extent of root material. A barley plant was found in this way to possess one hundred and twenty-eight feet of roots. Remembering that the small rootlets are thickly covered with root hairs as before described, the absorbing surface of the plant is seen at once to be very great. And this explains also why the plants that send their roots deepest into the soil are able to endure the vicissitudes of dry weather with fewest ill

consequences,—the deep branches of their roots reach the moist subsoil below, though the ground near the surface may be parched and dry.

Through the uncounted multitudes of root hairs with their eager thirst for moisture, the plant is fed. These are its mouths, and their capacity is great. In this perfect manner has the Creator provided for the welfare of the herb and tree; they too are subjects of His care. He made them, and in their welfare He takes delight.

Another great use served by the roots of plants, is that of preserving and storing for future use the materials taken from the soil. This is especially true of plants that require two seasons of growth in which to fully develop and produce their flowers and seed; such as the carrot, turnip, beet and parsnip. The roots of these plants are extremely large as compared with the other parts and very fleshy at the end of the first year's growth. If, however, we carefully watch such a root during the second season, while the plant is blossoming and maturing its seeds, we will doubtless see that the root withers and shrinks as if being gradually exhausted of its store.

By removing these roots from the soil at the close of the first season, the farmer secures the rich supplies of food material for the support of himself and his animals; but if left to follow its natural course of life uninterruptedly, the plant employs that food to nourish its flowers and fruit. All plants that require two growing seasons in which to perfect their growth are called *biennial plants*; such are the

carrot, beet, parsnip and turnip already named, and to this list the cabbage may be added. Distinguished from all such are the *annual plants*, which ripen their seed during the first year, and then die roots and all, re-appearing only through the growth of the seed. Such is the nature of wheat and barley, and in fact all our grains, beans and peas and all crops that need to be re-sown each year. Other plants are said to be *perennial* in nature; they live several years before they bear flowers and seed, and after that continue to bear for a great many seasons in succession or at intervals. This we know to be the nature of ordinary trees and shrubs, such as the apple, peach, oak and the rest. In all of this class the leaves, flowers and root-hairs die with the summer; but the roots and stem retain their vitality, and annually renew the beauties of flower and richness of fruit with the return of the sun in its power.

These fleshy roots, forming, as we have seen, rich stores of plant food appear in a number of shapes. They may be conical as is the case with the carrot and parsnip, or more globular like the turnip, or spindle-shaped—that is long and tapering, and thickest near the middle as are beets and long radishes.

We are apt to speak of some underground growths as *roots* whereas in reality they are not roots at all. A potato for instance, though growing beneath the surface, is a thickened part of the stem. True roots never produce buds; whereas a single potato tuber often shows many buds; these are the “eyes” seen upon its surface from which branches will rise and

true roots will sprout if it be planted. The onion is another example of a plant stem being called a root, because of it happening to grow under ground. The large onion bulb is in reality but a swollen part of the stem, the true roots, being seen at the lower extremity in the form of a tuft. Underground stems of the rose-bush, raspberry and other shrubs greatly resemble roots in outward appearance; but their true nature may be unmistakably recognized by the buds upon their surfaces. From these buds, branches are sent upward, each of which may grow into a perfect stem, bearing branches smaller than itself and these support leaves, flowers and fruit. After having reached a fair size these underground branches may be safely cut off from the parent stem; the severed parts strike root for themselves and become independent plants. Gardners frequently increase their stock of such plants in this way; the process is called "*multiplying by the root*,"—really an incorrect term, because, as we have already seen, the growth is from stems below ground and not from roots at all.

CHAPTER XXVIII.

PLANT STEMS.

AKE a sharp knife and cut straight across, a small branch or stem of a currant shrub, or other small, woody plant; and now, look carefully at the cut surface. Several distinct parts are clearly seen; there is a rather dark-colored *bark* or

skin on the outside; a light and hard part inside the bark, which we call the *wood*, and a very soft, central core, or *pith*. If such a stem be more closely looked at, by the assistance of a microscope, a truly beautiful arrangement of parts, of complicated structure, is at once apparent. The woody part of the stem, for instance, looks like a bundle of vessels or tubes, which, during the growing season, are filled with the sap of the plant, as it flows from the roots to the farthest branches and twigs. Not all of these tubes, however, are of exactly the same shape and size; some appear plain and others beautifully marked and ornamented with rings and spiral lines, and orderly-arranged dots; all such markings seeming to be really thickenings on the walls of the tubes, imparting thereto strength and stability.

Thus, even in the structure of these smallest of small things, a principle of order and system, has been followed. Not an ornamental dot is found, without a purpose and a use.

The outside covering of the stem, if hard and coarse, we are apt to call *bark*, but if softer and finer in structure, we speak of it as the *rind*. To this bark or rind also there are an outer and an inner portion; the outer being in most cases hard, and in some scaly and apparently lifeless, while the inner part is of a fine fibrous nature. The bark of the birch tree is so fine and smooth that it is useful for wrapping and even for writing purposes in place of paper. People who visit the great birch forests of the Northern and Eastern States, frequently strip off

the smooth bark by the aid of their pocket knives, and use the same in writing letters to their distant friends. In former days, before paper was known, it was customary to write all kinds of books and records on the smooth inner bark of trees. In fact the Latin name for book, *liber*, is the name given by botanists to the inside layer of the bark of trees. The bark fibres of some plants are of great use to us in the manufacture of ropes and cordage. The well known linden tree derives its peculiar name from the fact of its bark being so valuable in making lines or ropes.

Let us now examine, attentively, the end of a large tree or log that has been sawn squarely off. Here we notice that the hard part of the stem or wood proper, is marked by a series of rings, all of different sizes, arranged *concentrically*, that is around the same centre, the smallest, of course, being inside. These concentric rings indicate the different periods of growth through which the tree has passed. Some people believe that each ring indicates one year of the plant's development, and that the number of the rings expresses the age of the plant in years. This is not strictly true. In tropical lands, where there is no clear division of the seasons, no summer during which plants grow, and, no winter during which they rest, rings in the stems of plants, are still to be seen; and in our own parts, several rings are frequently produced during a single year.

The soft, new wood found just below the bark is called *sap wood*; this is comparatively useless as timber, and the lumber cutters strip it off from the

trunks of their trees and discard it. The hard, solid wood within—that which we usually call *wood*, is much harder and more solid; it is called *heart wood*. This is the part of the tree so useful to the carpenter and the builder, and occurs in a great many different forms. In some plants it is white and soft, as in the pine, grayish in the locust, dark brown and very dense in the walnut tree, hard and dark-colored in mahogany, black and almost of stony hardness in the tropical ebony.

In all of these woody plants, the stem increases in thickness through forming layers of new wood between the bark and the old wood, the sap wood being the newest and youngest part of the stem. Such a method of growth must appear to us to be the most natural; it is almost impossible to imagine very extensive growth and increase in size occurring in the solid heart wood. Plants that grow in this

way are called *Exogenous Plants* or outside growers. The arrangement of parts in such plants is shown in figure 25; the layers of inner and outer

Fig. 25.—Structure of an Exogenous Stem.

bark, of wood and of pith are clearly illustrated.

For comparison, let us now look at a stem of maize or sorghum cane, or one of the many kinds of rushes to be found so abundantly in marshy places. Here we find no such arrangement of parts as we discovered

while examining the woody stem. Take a sharp knife and cut off the stem of one of these plants; it will be seen to consist mostly of a porous, spongy material inside a hard rind. There is no distinction of parts into sap-wood and heart-wood; such plants seem to increase in size uniformly throughout the whole stem, and hence are called *Endogenous Plants*

or inside growers. Figure 26 represents such a stem; the outer rind and the porous contents are clearly shown; the dark dots seen in the cross section and appearing as dark-colored streaks are the hard or woody parts of the stem.

Nearly all the endogenous plants of these regions are small when compared with the larger trees of the exogenous class, but in warmer climates many of the largest trees belong to the endogenous kind. Such for instance are the palmetto trees of the Southern States and the larger palms of the torrid zone. The trunk or stem of these trees is of nearly the same thickness from the ground upward. Then again, the palm throws off no branches along the trunk, but bears at the top a wide-spreading bunch of stout thick leaves. In these stems, though large, there is no distinction into bark, wood and pith, and no con-

Fig. 26.—Structure of an Endogenous Stem.

centric rings of growth are to be found. There are to be seen scattered throughout the whole thickness of the stem, hard black spots or streaks of woody tissue.

The difference between these two great orders of plants, does not lie wholly in their stems; the leaves and the seeds of these two divisions differ materially from one another as we shall subsequently see.

Let us now examine a stem of some smaller plant, for instance a straw of wheat or barley, or the vine from a pea or a bean. Cut this across in the same way, and note the difference between it and the others already examined. All of these smaller stems are hollow and therefore extremely light and yielding. Every mechanic knows that an iron tube is much stronger than a solid iron bar of the *same weight*; and the Master Workman who fashioned the grass stalk and the wheaten straw, employed that principle by which to give pliant strength to these lowly objects of His care. In consequence, the stalk of grain supports an ear of many times its own weight, and bends and bows before every breeze, but does not often break.

Most branches resemble the stems from which they grow, in form and structure; they seem, in fact, to be divisions of the stem; but in the case of many plants, rather odd branches are produced. Look, for instance, at a growing grape vine, a Virginia creeper, a squash, or a cucumber vine; growing from the stem of each of these, are several small, slender branches, devoid of leaves and buds, and apparently not intended for the offices that branches ordinarily

fill. These are called *Tendrils*, and are admirably devised to assist the plant in climbing or spreading over the ground as it grows. Observe, carefully, such a tendril, at intervals, for several days in succession. It grows comparatively straight, until it reaches some support near by, such as a post, or an adjacent stem; the point of the tendril then hooks around, and the slender branch twists itself into a spiral coil, like a cork-screw, thus drawing the growing plant closer and closer to the support. When such plants grow near a wall, or other flat object, around which, the tendril cannot twine, the end of each tendril flattens itself, forming a kind of sucker-like disc, which adheres closely and firmly to the neighboring surface, and thus supports the plant. Such a remarkable adaptation to circumstances as this, is not mere chance; it is a mark of infinite wisdom; the creeping plant and the twining vine speak forth in their very growth, the wisdom and care of their Maker.

CHAPTER XXIX.

LEAVES.

EAUTY and usefulness are frequently associated in Nature. The arrangement of the vegetable kingdom offers an illustration and a proof of this remark. The most attractive and strikingly beautiful parts of plants are as a rule, the most indispensable organs. Look for a moment upon the tree in the fulness of its summer foliage; if each

of the unnumbered host of leaves does but a trifle toward the general good of the plant, the result must be indeed stupendous.

To learn something regarding the structure and use of leaves, let us pluck some from the tree and look at them with thoughtful care. A leaf from a fig tree is pictured in figure 27. There is to be noticed a stalk (*p*) by which the leaf was attached to the branch; this is called the *petiole* and the two small appendages (*st*) seen at the base are the *stipules*. The expanded portion of the leaf is called the *blade* (*b*). Running through this blade we see a number

Fig. 27.—Leaf.

or veins branch again and again till they form a perfect network of fibres over which the true fabric or membrane of the leaf is stretched. In the case of leaves belonging to the endogenous plants, already described, the veins are nearly parallel with one another from base to tip, and in consequence, such leaves are said to be *parallel-veined*, while the leaves from exogenous plants are *net-veined*.

Figure 27 is a good picture of a leaf from an

exogenous plant. The frame or skeleton upon which the green tissue is stretched can be readily observed.

If the thin membrane or skin from the under side of a leaf be carefully stripped off by means of a small pair of forceps or pliers, and then examined with the microscope, it would be found to be full of little holes which we call the *stomata* or breathing pores of the plant. The number of these present in common leaves is indeed surprising; five thousand of them are found in a single square inch of the rhubarb leaf; twelve thousand per square inch in the garden iris or blue-flag, thirty-six thousand per square inch in the leaf of the pink, and one hundred and sixty thousand per square inch in the hydrangea. Through these thousands of little pores the plant breathes, as perfectly as animals do by means of mouth, lungs and skin. We can very readily prove that plants do breathe by proceeding as follows. Secure a clean dry glass bottle having a large mouth—a common fruit-bottle will answer admirably; invert the bottle over any small growing plant, say a house plant in its flower pot; now watch the bottle carefully, and within a very short time the inside will be seen to be clouded from the deposition of vapor; and after a longer interval, so much moisture will be condensed that it gathers in drops and trickles down the sides of the bottle. A sunflower, standing three feet and a half high, was found by experiment to exhale between twenty and thirty ounces of water every twelve hours. When tested in a similar way, a cabbage breathed out between fifteen and twenty

ounces of water in the same length of time. This would be equal to the amount of moisture exhaled in the breaths of half a dozen men.

But even more surprising than this is the almost perfect manner by which the exhalation of moisture is controlled and varied. Around each of these tiny pores, is a thickened band which has the power of automatically opening and closing the little mouth, according to the amount of moisture present in the atmosphere. Thus, when the air is drier than usual, and there is danger that the plant would lose too much moisture, these little pores close by contraction of the rim or band around each, and so any undue evaporation is checked; but whenever the air is moist, the breathing pores are opened wide, and free transpiration is encouraged.

The green color of leaves is an important feature. Most leaves are of this characteristic tint when in a state of vigorous growth, and they lose it wholly or in part when they become affected in any way to interfere with the proper discharge of their functions. Loss of green color in a leaf is indicative of a check of growth, usually resulting in the death of the leaf.

In general shape, we find almost an endless diversity of leaves; some smooth and others rough on their surface, some toothed like a saw, others gently waved or deeply cut on their margins. Compare for instance a leaf from an apple or a pear tree with that of the common dandelion. Indeed, the name *dandelion* is but a changed form of a French expression meaning "lion-toothed," having reference to the

tooth-like, jagged edges of the leaves. Look now at a leaf from a peach tree; it consists of but a single blade growing from the stalk; then compare with it a locust leaf;—that is said to be compound—it consists of a number of separate blades all joined, however, to a single stalk. We are liable to mistake such compound leaves, and think of each as really a small branch bearing several leaves; now let us examine more closely and discover, if we can, how to guard against such an error. We find at the bottom or base of each leaf stalk a tiny bud from which the leaf seems in reality to grow; but one such bud is found in a compound leaf, and that is situated at the junction of the main stalk with the branch. As another method of proving the true nature of compound leaves, notice that in the autumn, the whole leaf, or what appears to be the branch of leaves, falls from the tree entire; and such would not be the case if the so-called leaf were really a branch with leaves upon it, for branches do not fall as winter approaches.

CHAPTER XXX.

SOME CURIOUS LEAVES.

HE general shapes and uses of leaves have been already pointed out; but Nature presents us with a great many variations from the common condition, or, as we may say, adaptations to special purposes. In the case of peas and wild

vetches, for instance, the upper part of each leaf is prolonged so as to serve as a *tendril*, very similar in form and use to the tendrils already noticed on the grape vine and other plants, which, it will be remembered are, in reality, modified branches. By the aid of these tendrils, these plants climb in a very perfect and well-adapted way.

But, perhaps, of all curious developments of leaves, the strangest and most remarkable are shown in the various forms of *Pitcher-plants*, which are so named, from the peculiar jug-like shape of the leaf. In the *Nepenthes*—an East India variety of pitcher-plant, the blade of the leaf contracts into a tendril; but the end of the tendril expands again to form a very beautiful hollow pitcher, wonderfully regular and symmetrical in form, and usually from five to six inches in length. At the top of the pitcher is a lid, which exactly fits the opening, and works automatically upon an admirably-fitted hinge. Usually, the pitchers contain a considerable quantity of water—a half-pint in each, being a very ordinary amount. Following are the words of a traveler, Mr. Alfred R. Wallace, in reference to our subject. He is describing an ascent of Mount Ophir, and says: “The height was about two thousand eight hundred feet. We had been told that we should find water, * * * but we looked about for it in vain, as we were exceedingly thirsty. At last we turned to the pitcher-plants, but the pitchers were full of insects, and otherwise uninviting. On tasting it, however, we found it very palatable, though

rather warm, and we all quenched our thirst from these natural jugs."

Another variety of this interesting class is called by various names, such as side-saddle flower, huntsman's horn, Sarracenia, etc. Its leaf is curved and the edges joined so as to form a slender cup, bulging near the middle and bearing at the top a hood-like expansion of the blade.

The California pitcher-plant or *Darlingtonia* is found growing under favorable circumstances in various parts of the Western and South-western States, but principally in California. The pitcher here seems to have been produced by an expansion or flattening of the leaf stalk, the thin part of the leaf or the blade as we call it, appearing as an appendage or a hood. This is remarkable for the fact that the opening to the pitcher is beneath the curved or vaulted hood, and consequently the liquid contained therein cannot be attributed to rain or dew, but must have been secreted by the plant itself. Inside the pitcher at different heights are fringes of hairs, *all directed downward*. Many insects enter the hood and explore the recesses of the pitcher, though but very few of them escape to tell their fellows what they saw. It is easy for an insect to pass down the pitcher toward the bottom, but any attempt to return is frustrated by the hairs within, as they cannot be pushed upward, and so the insect is held a prisoner. Its death is a matter of short time only, and as its body decays within the cup, it furnishes without doubt a rich nourishment for the

plant. All pitcher plants partake somewhat of the nature of insect traps; their victims being most likely allured into the treacherous cups by the sparkling liquid contained therein and a sweet exudation to be found on most of the leaves.

But even more remarkable and strange in this respect is the so called *Venus Fly Trap*, a small though common plant in the bogs and marshes of the south, as far north as South Carolina. Each leaf of this truly wonderful growth is divided at its end, forming a pair of thick, somewhat fleshy lobes, so placed as to resemble in form a book with rounded corners held partly open. The surfaces of the lobes are covered with a set of stiff hairs or bristles, which are as sensitive as the whiskers of a cat. Whenever a small insect alights on one of the lobes, and brushes against the bristles, the two portions of the leaf fly together with the rapidity of a spring trap, usually enclosing the intruder as a prisoner. The lobes press closer and closer together till the little victim is crushed and smothered to death. The bodies of the captured insects undergo a kind of rapid decay or rather digestion, to accomplish which a fluid oozes out from the surfaces of the lobes, and rapidly accomplishes the process, after which the softened parts are absorbed or soaked up by the leaf.

The more common *Sundew* family of plants are also professional insect catchers. Each member is small; the leaves growing directly from the roots flat upon the ground so as to form a kind of rosette. The leaf is shaped somewhat like a tennis racquet or

an old-fashioned wooden spoon with a comparatively large round bowl. On the upper surface of the expanded or bowl-shaped part of the leaf a great number of fine long filaments are to be found, each of them terminated by a little ball or knob. These filaments and glands are usually of some bright color, and at first sight the leaf looks very like a small flower. It may be that insects visit the leaves under such a mistaken notion. To render these pretty leaves more attractive and illusive, a viscid fluid is secreted and poured out on the surface, each tiny drop glistening like a diamond in the sunlight. This sticky fluid disables any insect that may alight upon the leaf; in its annoyance and efforts to escape, the unfortunate little creature struggles violently, and in so doing touches the sensitive little knobs or glands already referred to; immediately the filaments bend over toward the excited spot and hold the struggling prisoner in a secure grasp. An acid fluid soon appears on the surface of the leaf, and the body of the insect is soon dissolved and absorbed. The extreme sensitiveness of these glands and filaments is worthy of our notice and admiration. An experimenter found that a short piece of hair, weighing only one seventy-eight thousandth part of a grain was sufficient to cause a bending of the filaments with which it was in contact. Any small object, whether living or dead, —a fragment of dust for instance, if brought in contact with the leaf surface will cause the filament to bend and hold it secure, but the plant soon seems to discover its error if an indigestible morsel be

caught, for it soon releases its hold and resets its trap. But whenever a nourishing substance is secured, the plant loses its extreme sensitiveness for some little time—its hunger appears to have been satisfied and it is less eager and ravenous in its efforts to capture additional prey.

Truly, the Creator has inscribed a record of His power, even on the leaves of plants. Each bears marks of the wisest adaptation. What man can suggest, even, in his own mind, an improvement on the purpose and effect of the leafy fabric, or, in fact, any other item of Jehovah's hand-work? Each in its sphere, every one after its kind, is the great law in Nature.

CHAPTER XXXI.

FLOWER-CUPS.

E ARE now to talk for a short time about the flower, the most conspicuous and attractive part of the plant. To aid us in this pleasant undertaking let us procure any well-developed, bright, tolerably large blossoms, say as the fuchsia, or "ladies' ear-drops," or of the geranium, both so deservedly prized as ornamental plants.

Here, on the outside of the colored part of our blossom, borne upon the flower stalk, is a sort of cup, formed of small, green leaves partly connected

together; this is called the *calyx*, a word meaning really “a cup,” and separate leaflets of which it consists called the *sepals*. Within this outer cup grows the brightly colored portion of the blossom, and this is called the *corolla*, or the “crown,” and is seen to consist of several leaf-like parts which are called *petals*. Still other parts are visible within this colored cluster; there we may readily discern a number of small thread-like organs, each bearing at its top a sort of little box; these have been called the *stamens*. Another and stouter kind of a thread is found in the centre—perhaps more than one, however; it is usually curved or expanded at the top and considerably thickened in its lower part near the part at which it is attached to the flower stalk; this is called the *pistil*.

An illustration of these parts in their relative positions, though dissected each from the others is shown in figure 28.

Fig. 28.—Parts of a Typical Flower.

The number of each of these organs or parts present is usually constant for any one kind of flower

though great diversity exists amongst the vast variety of flowers. By cultivation also, what appears to be the normal or regular arrangement may be changed, and any one of these organs may disappear wholly or partly and be replaced by an extra number of another kind. For example let us pluck a blossom from the modest little wild rose, or the scented sweet brier; by carefully examining it we notice five distinct sepals, and within are five petals, enclosing a multitude of stamens and pistils. By a proper cultivation and a careful arrangement of all the conditions of growth, the many queenly roses of the green-house and garden have been produced from this simple flower; yet see the difference existing between the wild blossom, and the cultivated offspring! Look at the richly tinted fragrant moss-rose; the flower seems little else than an orderly cluster of large petals, the stamens and pistils are not to be found at all, or at least but very few of them; while the beautiful petals may be counted by the score.

The pistil of nearly all flowers, toward its lower extremity, is considerably enlarged, forming a swollen case, which has been named the *ovary*, or seed box, and within which the *ovules* or seeds are to be found.

Flowers consisting of all of these separate parts, calyx, corolla, stamens and pistils are said to be *complete*; but sometimes one or more of these parts are missing, in which case the blossom is termed *incomplete*. But only the stamens and pistils are in

reality essential for the growth and perfecting of the seed. If either of these be missing, however, the plant is unable to perpetuate its kind by producing seed.

In many blossoms the sepals and petals are connected together so that their separate parts can scarcely be seen. Look for an example of this at the open cup

Fig. 29.—Morning Glory Flower. Monopetalous Corolla.

here seems to consist of but one part, the separate petals being joined together into a trumpet-shaped blossom, the fine edge however is waving or undulate in outline showing five notches or indentations. Such a corolla is said to be “monopetalous,” i. e. consisting apparently of but one petal. In the figure, the calyx or outer cup is seen below.

The arrangement of the blossoms is as varied as are their forms and colors. In many plants, each flower-cup stands separate and alone upon its stalk, while others are seen each to be composed of many distinct blossoms. Here, for example, in the pretty daisy, each of the little blade-like white or pinkish organs, shows itself, when magnified, to be in reality a perfect flower, consisting of five little petals formed in a tube—on the same plan as the morning-glory, already examined—within which are five tiny stamens

and a pistil, with a little seed in its ovary. This is also the case with the more conspicuous sunflower, and the familiar dandelion, the marigold, and many of the commonest of our floral friends.* There is an infinite variety in the flowers and leaves, but each form proves itself to be the best for the conditions under which the plant has been designed to grow.

CHAPTER XXXII.

HOW FLOWERS ARE FERTILIZED.

NOW let us select some large, conspicuous blossom—a stately tiger lily is a superb illustration, and look carefully at the little sack or box borne at the tip of each stamen. When thoroughly ripened, this is covered with a kind of powder of a yellowish, reddish or brownish tint. This powdery substance has been called the *pollen*,

Fig. 30.

Pollengrain from rose in a l l o w (very highly magnified).

and each grain when magnified proves to be a little hollow ball or box filled with fluid. A single pollen grain taken from the modest little rose mallow flower is shown in Figure 30, very highly magnified. Even among pollen grains there is a variety wide enough to occupy our attention for a long time; so many different shapes, and each so beautiful. Some look like golden balls, chased and ornamented on the

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* From this peculiarity of their structure, the whole family of such flowers—and it is a large one—is called the *Composite Family*.

surface in the most elaborate way, others are more angular in outline, and many are elongated or flattened; but all are exceedingly compact in form and light in weight.

According to the wise plan of Nature, it is necessary that the fluid contained in the pollen grains of any flower shall mingle with the material in the ovary from which the ovules or seeds are subsequently to be produced; and unless such a mixture takes place, the plant does not produce fertile seeds. The pollen then must in some way be carried from flower to flower, in order that the seeds may be fertile; for the pollen from any flower is not able to well and thoroughly fertilize its own seeds; it is best for the development of the plant and the production of strong and healthy seeds, that the pollen come from some other flower of the same kind. And the methods that Nature adopts to bring about this transfer of the life-giving pollen are as wonderful as they are efficient. As plants are rooted to their places of growth, they cannot individually visit their neighbors and relatives, to mutually exchange their pollen grains, so they employ trusty and long-tried mail and express messengers to do the work for them. Some plants yield their pollen to the insects that visit their cups and entrust them with the mission of bearing it to others of their kin; while others commit it to the wind and hopefully rely that the tiny grains will reach the stigmæ of other plants. These two agents, insects and the wind, are indeed the chief of Queen Flora's messengers, and well they do their

work; but other means are sometimes employed. Thus, aquatic plants discharge their pollen into the water, each granule securely wrapped in a water-proof covering, and so the transfer is made.

Look for a moment at a bee just emerging from some sweet-scented flower cup, at which he has been making a flying visit to enquire if he could obtain a little honey or nectar for himself and family—see he is covered with powder like a dusty miller just fresh from the sacks, and this powder is the pollen about which we have been talking. Then, flying to another blossom, and rubbing against the stigma or pistil tip, as he needs must do while making his way to the honey cup, he leaves some of the pollen dust adhering thereto. At the proper season too, the stigma becomes moist and sticky from a kind of mucilage produced upon the surface; by which simple but admirable device a grain of pollen once falling upon the stigma is securely held.

It is a well known fact, that in seeking nectar or honey, insects show decided preferences for flowers of one kind at one time, rather than for several kinds in rapid succession. Thus even the tastes of bees and butterflies are to the advantage of the flowers. A grain of pollen from a violet cannot fertilize a lily, and would be but wasted if left upon its stigma; but an insect that starts out to collect nectar from the lily would not be likely to visit violets upon that trip. In many of our common plants the devices to secure the safe transfer and interchange of pollen through the visits of hungry insects are of the most

surprising and striking kind. Examine the small and humble blossom of the lucern or the clover. The flower is somewhat irregular in form it is true, but this very irregularity is of the greatest importance in the fertilizing of its flowers. Take a stiff bristle or horse hair, or a fine grass stalk, or something of the kind and thrust it carefully into the opening of the corolla as a bee would insert its trunk in quest of honey. Look carefully into the flower cup as you do this, and you will be rewarded by a strange sight. Before the insertion has been carried far, the curiously shaped stamen, which before this time has been hidden, is liberated forcibly as by a spring, and immediately it flies forward, striking the hair or bristle and leaving pollen upon it. Now thrust this hair into another blossom of the same kind, and you will doubtlessly see that the pollen is rubbed off and left upon the stigma of the second flower. Such an occurrence is common when an insect inserts its long hair-like trunk into the cup, and in this way the exchange, so indispensable for the production of good seed is accomplished.

A more beautifully perfect arrangement and adaptation than is shown in the plan for the fertilization of different flowers, can scarcely be seen or conceived. Many flowers are of so peculiar a shape, that not all classes of insects are able to pollenate them. Such, for instance, is the case with the clover blossom, which is best fertilized through the visits of bees. In this connection, it is recorded, that shortly after the English people began to colonize Australia,

they carried to that land, the seed of their much-prized clover; and though the crops were heavy, and the quality the best, yet no fertile seed was produced. All the seed had to be imported, though appearances indicated that the plants grew perfectly, stalk, leaf, and flower, all vigorous and strong. An observing student of nature, pointed out the cause of the difficulty—there were no bees in Australia, and consequently no transfer of pollen could be effected between the plants. Instead of bringing fresh supplies of seed, the colonists began to import a great number of bees; these thrive so well on the clover flowers, that their stock of honey was an ample return for the labor and expense of importation; but of far greater value was the fertilization of the clover which these insects brought about. As they flew from flower to flower, they bore the pollen with them, and, in consequence, large crops of healthy seed were produced. Thus the insects assist the flowers, and the flowers support the insects; neither can thrive without the other.

Between the two great classes of flowers, those fertilized through the agency of insects and those whose pollen is carried from one to the other by the wind, many great differences exist. In the case of any and all flowers fertilized by insects, the blossoms are more or less conspicuously colored, apparently with the design of attracting insects to them; and then again, all such flowers secrete some kind of sweet juice or nectar, to secure which the insects eagerly enter the corollas.

Many flowers unfold their petals only at night, as for instance the large evening primrose family; such plants are fertilized through the visits of various nocturnal moths, and their flowers are always white or at least light-colored, apparently so as to be seen the more readily by these insects. It would be a decided disadvantage to such flowers to be open during the day; their fragile blossoms would be exposed to injury, and the nectar would perhaps be stolen away by insects not of the proper size and shape to effect the fertilization, or perchance the sweet juices would be dried up by the heat of the sun, so that by night they would have no alluring nectar to tempt the nocturnal moths to visit them. In consequence, the flower cups are tightly closed during the day; but as soon as the twilight comes, they wake from their sleep, and spread out their brightly colored petals like banners of light, offering a tempting resting place to the passing moth, and asking in return for such courtesy only the small favor of bringing a tiny packet from another plant and carrying a similar parcel to the next. By another wise provision, those flowers that depend upon bees, butterflies, and all kinds of diurnal fliers for their fertilization, close their petals with the sun, and sleep in peace and quiet till the return of day, with its warmth and light and merry insect hum.

On the other hand, wind-fertilized flowers are in general small, and inconspicuously colored, and they secrete no honey. Such plants as a rule grow in large groups or bunches, as is the case with the

grains and grasses, so that a greater quantity of pollen is borne by the wind over the region in which they grow. But this beautiful adaptation is carried even farther. It is a well known fact that insects are usually attracted by brilliant colors. Remembering this, let us examine any bright variegated blossom, a light-tinted pansy or "heart's ease" for instance: notice the arrangement of the streaks of most striking colors upon the outspread petals, all directed like the veins of a fairy's fan toward a centre; this centre is the entrance to the nectary where also the pollen-covered anther lies concealed. Watch now an insect as it alights on the expanded lip of the flower; it follows the direction of the brightly-colored lines, and thrusts its proboscis into the nectary, gaining the honey for its pains, and receiving also with very little chance of failure, the pollen from the well-stocked stamens. In many variegated flowers bright-colored hairs are seen pointing toward the cup of sweets so much desired by the flying visitors.

Observe also that many flowers hang with their corollas opening downward, by which means the nectar is protected in its cavity from rain; and see also how nearly all honey-producing plants with erect blossoms close their cups and bow their heads at the approach of rain or storm.

Such, then, seems to have been the great Creator's purpose, that not even the color of a flower or the tinted streaks on the corolla tube, or the particles of dust on the stamens, or the honey drop within the blossom cup, is made without a purpose both great and wise.

CHAPTER XXXIII.

FRUITS.

IS SOON as the fertilization of the flower has been affected by any of the methods of Nature, some of which have been briefly referred to already, the object for which the corolla of the plant seems to have been created, is accomplished; and thereupon the most brilliant part of the flower begins to wither and very soon disappears. If the corolla continued in its beauty after the pollen had been given and received, as far as the plant itself is concerned, it would be purely an object of display; and to insects flying past it would be but a delusive snare to visit the blossom when the nectary was empty and the anthers devoid of pollen. Such a visit would not be simply useless to the visiting insect, but positively injurious to the flower; for no insect can possibly enter a flower without causing danger to the delicate parts: such dangers are certainly best avoided in the critical time at which the seed is forming within the ovary. Beside, should a large insect alight upon a blossom and find no nectar within the cup to slake his thirst, nor honey to bear away, after having been attracted thither through the bright tints of the flower, he may show his disappointment by undue haste to retire, with injurious consequences to the flower.

As fast as the corolla withers away, the ovary containing now the fertilized seeds, increases in size,

forming the so-called *fruit* of the plant. There are many varieties of fruit, differing in form and size; though some of the soft and luscious parts of plants which we esteem under the name of fruits, are in fact no fruits at all.

A fruit, strictly speaking, is the ripened ovary of a plant with its contents. The *pod fruit* is a common kind, familiar to us all through the typical form of peas and beans. And of this one kind there are many minor varieties differing in proportionate size and shape; all of them, however, readily splitting open at maturity so as to scatter the ripened ovules. Examples of small pods are furnished by the fruit of the mustard plant and the common pepper grass, and also the sack-shaped vessel of the modest little shepherd's purse. Then there is the *gourd fruit*, such as the melon, squash, cucumber and pumpkin, with its hard rind on the outside, and the soft, pulpy interior with its multitude of seeds. These monstrous fruits are simply the swollen ovaries of the spring blossoms, and it is instructive to watch the development of the fruit from the flower through the various stages. When the gourd is ripe, the dried and withered corolla may be seen still attached at the end.

Now let us glance at another form of fruit, the *berry*, in which the seed vessel has grown soft and fleshy throughout, the seeds being contained in the pulp. Examples of berries are furnished by the currant, gooseberry and tomato. Then there is the *drupe* or stone-fruit, in which one part of the ovary has hardened into a shell like that of a nut, enclosing

the kernel or seed proper, while the outer portion is soft and juicy. For this provision we have reason to be thankful, since such fruits are so delicious as food.

The *pome fruit*, such as the apple, pear or quince, is a peculiar kind. The core is in reality the true seed vessel; the "pips" contained within are the seeds, while the soft parts, forming so large a proportion of the whole is produced by an abnormal growth and thickening of the calyx or outer tube of the original blossom.

To produce flowers that finally ripen into fruit with perfect seeds, is apparently the great achievement for which all plants strive; and as soon as this labor is accomplished the plant withers and dies, either wholly as with all annual plants, or partially as in the case of biennials and perennials.

THE SEED AND HOW IT SPROUTS.

A vegetable seed has always seemed to me to be an object of great interest. It holds within its little shell such wondrous possibilities. Who would even dream, if he had never seen the actual occurrence, that the tiny apple pip, concealed beneath its tough little jacket the germ of so vigorous an existence, a spark of vitality that may develop into a wide-spreading tree, blazing in the spring-time with beauteous blossoms and verdant leaves, and, in the autumn months, laden with fruit, producing yearly thousands of other seeds like itself. It would be interesting to watch it as it grows, and instructive to learn the lesson of its little life. But as the apple seed is too small to be closely examined by our un-

aided vision, let us select a more convenient, and an easier form, showing, however, the same principle. Take, for instance, a few plump beans, of almost any kind—common white or black beans will answer well. Soak them for a few hours in water, by which treatment they will lose their hard and brittle character and become soft and yielding. Now, let us tear off, carefully, the outside skin—look at it attentively before throwing it aside; note its tough, leathery nature—well adapted, indeed, to protect the still more wonderful structures within. We see that our bean consists of two parts, readily separated from each other; let us open them—laying them back as one would the covers of a book—and there, snugly packed between the lobes, is the baby bean plant—a pair of little leaves, folded as Nature is wont to fold her treasures when she lays them away, and a tiny root.

The process of germination then is really one of development only; the young plant is present in the seed, formed there through the agency of the parent plant, and only awaiting the influences of warmth and nourishment to hasten its growth. But what are these two large thick lobes already spoken of between which the young bean was so snugly laid away? Man values them as food for himself and animals, but they were originally intended to serve as food to the young plant when it would begin to grow, and before it would have developed sufficiently to absorb its own nutriment from the soil.

By the aid of the microscope we would soon dis-

cover that this bean is composed mostly of starch—the form in which the food of plants is commonly stored up for future use. Starch is to plants what fat is in the animal body. Now we have already pointed out that no food is available to the plant unless in a state of solution, and starch cannot be dissolved in water. How then can the rich stock of starch present in the bean be made use of? As soon as the bean begins to sprout, a peculiar change is effected in the material of which it is composed, the starch being transformed into a kind of sugar, which as all of us know full well, is readily soluble in water. The sugar thus formed in the germinating seed has not been created from any external source, but is formed from the elements of the starch already present. As fast as the sugar develops the starch disappears. The moisture present within the plant dissolves the sugar to a kind of syrup, which is absorbed and assimilated within the tissues of the infant plant. Some may ask, why it would not have been better for the plant if its food had been formed of sugar in the first place; no such complicated transformation would in such case be required, and the food would have been in a more available state. The answer to this furnishes another proof of the supreme wisdom exercised by the Creator over the many objects of His care. If the bean and other seeds contained sugar instead of starch, the first rain storm would wash it away and leave the tiny plant for whose benefit the food was designed, entirely destitute of nourishment. It is better then that the

food remain in an insoluble and unavailable form until the time of sprouting. Again, many of these rich and starch filled seeds are of great practical use to man; and he could not feed himself and animals on sugar. Starch is very valuable as food to animals and is constantly being eaten by man and beast in great quantities, but sugar can only be eaten sparingly.

By taking advantage of this strange change of the starchy matter into sugar as the seed germinates, the brewer obtains his malt. A quantity of grain is taken (barley is found to be the best adapted to the purpose) and kept for some time in a damp and warm place—just the conditions which naturally prevail in the spring time, and are so effectual in awakening the sleeping germ. Under these artificial conditions the barley forthwith sprouts, at the same time, a quantity of sugar is developed from the starchy material of each grain. This we may satisfactorily prove by chewing a few of the sprouting grains, or a kernel of the prepared malt—the sweet taste is conclusive evidence of the presence of sugar. The malster then increases the heat sufficiently to kill the tiny plants and thus he prevents them absorbing and using the food now ready; then by soaking and fermenting the malt, the sugar is transformed into the intoxicating alcohol which is present in all liquors produced.

What has been said of the bean is true of all plants of the kind. There are some seeds however, like that of Indian corn, which consist of but one

lobe in place of two; and when such seeds sprout they produce but one leaf at first, instead of a pair. These are characteristic features of all *endogenous* or "inside growing plants" while the *exogenous* or "outside growers" possess double seeds and a pair of first leaves like the bean. This is a distinctive feature between the two classes of plants and has been already referred to. We may readily watch the seed through all the wonderful and interesting stages of germination and growth at least until the distinct parts of the plant, root and stem and leaves, have been formed, by taking seeds of various kind, peas, beans, Indian corn and the like—and sowing them on moist cotton wool. By keeping this damp and warm for a few days germination is induced, and can be easily watched and studied. If it be desirable to carry this method of culture farther, the plants should be taken one by one, and each loosely inserted into a vertical slit cut in a cork, which has been previously fitted to a bottle containing water. By a careful arrangement the roots can be kept immersed, while the seed itself and the stem are out of the liquid. Let us observe how the thick bulky seed shrivels and shrinks as it gets rid of its load of food matter. The root of the growing plant soon spreads within the bottle and fills the greater part of the space while the stem and leaves develop with equal vigor above the cork. In this experiment ordinary hard water should be used, the solid matters contained in the water are needed within the body of the plant, and pure water could not sustain the

growth. Unless the soluble matter which naturally forms the food of the plant when growing in the soil be added to the solution, the growth will be checked long before maturity is reached. The process can be assisted by adding water in which wood ashes have been stirred and allowed to stand for some time; the clear fluid being then poured off; but to secure the best possible result with large and mature plants, a chemically prepared solution is requisite.*

By this method of "water culture" we may easily study the growth of seeds with all their wonders. By these means plants can be developed to maturity; maize plants have been grown from five to six feet high; and buckwheat plants nearly seven feet high.

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* For the information of those who would desire to carry this truly interesting subject further, the following directions are given for preparing a culture fluid. Great care must be exercised in the mixing: Take 75 grains of fine powder of well-burned bones (bone-ash can be procured at drug establishments); place in a large bowl or vessel not of metal; pour on it a little boiling water, and add cautiously while still hot a small quantity of nitric acid. (This acid is sometimes called *aqua fortis*; it is extremely corrosive and poisonous and must be used with great care.) Enough acid should be added to nearly dissolve the bone ash; do not use too much, however, not enough to give the solution a permanently sour taste. Then add 45 grains of nitre, 28 grains of Epsom salts, and 15 grains of potassium chloride—all of which can be obtained at the druggists for a very few cents. When all are dissolved, add enough water to make the solution up to two gallons. This can be used to advantage in cultivating any ordinary plant by the method before explained.

CHAPTER XXXIV.

WANDERING SEEDS.

THE number of seeds produced by a single plant, is frequently surprising; and if this multitude of seeds were deposited when ripe, in the neighborhood of the parent plant, the space of ground would soon be impoverished, and prove unable to furnish necessary nourishment to the increasing numbers. As with mankind, when a family increases so that the habitation is really too small for their accommodation, the grown-up sons and daughters, leave the parental roof and seek homes for themselves. So with plants; Nature has provided many devices, by which the seeds are borne away from the locality in which they grew, and are scattered under circumstances best calculated for their future development and well-being.

Some such wandering seeds travel to very great distances. Look with care at the white plumes of the dandelion—the flower of civilization. The button or head of the ripe flower is seen to be studded with small, hard bodies, each covered with little barbs directed upward, and surmounted by a pretty little tuft of shining hairs, called the *pappus*. These are the seeds, each equipped for travel in the neatest and most compact way; all its belongings packed in the smallest possible space—packed as only Dame Nature can pack—no unwieldy trunks, nor bulky carpet-bags, and yet, containing within the little parcel,

the possibilities of future flowers, with honey and hum of bee associated, of meadows carpeted with golden blossoms, and fields ablaze with a fire that speaks of Omnipotence. With the least stir of wind the wide-spread pappus is borne away, the seed suspended below. Watch it riding upon the air, poised more beautifully than cumbrous parachute or swollen balloon. When it rests it is perhaps many miles away from the place of its birth. As it floats, the barbed seed being the heaviest part is always below, and as it comes to the ground, the seed touches the earth first. Then, by the waving to and fro, of the downy pappus, the seed is worked deeper and deeper into the soil; the little barbs or hooks upon its surface effectually preventing its withdrawal. In this wise and perfect way the seed is safely sown. Such an admirable adaptation to travel, explains the wide distribution of this humble flower, originally native to Europe, but now scattered over the world. Neither mountains nor plains, winds nor oceans have been of sufficient power to intercept it in its wanderings.

All that has been said as to the arrangement of the dandelion seed may be repeated with truth regarding the seed of the sowthistle, with its silken tuft of hairs; and the lettuce seed, and the sneezeweed, and the sun-flower with its short pappus composed of but a single scale. For another striking example let us seek the seed of our ordinary milk-weed or silk grass. We may find the ovaries bursting open in autumn and revealing the bundles of seeds

within each bearing a tuft of silvery hairs of almost indescribable beauty. The seed itself is flattened, and the surface roughened by numerous projecting points. The seed is borne away by the breath of the wind, though it be but the gentlest zephyr, and when deposited, it falls and is sown after the manner of the dandelion already described. The seeds of some plants are so minute that their very smallness insures their transportation; of such a kind are the spores of mosses, lichens and ferns; they seem to find their way everywhere from the mountain top to the deepest caverns of the earth.*

The seeds of maple, elm, box-elder, ash and pine are provided with wing-like expansions to aid in transportation, while others are wrapped in a cottony† or woolly covering, as is the case with the willow and poplar families of plants, and by these means they are borne from place to place.

In the case of plants whose seeds are not adapted for long journeys, arrangements no less remarkable and perfect are made to secure a proper distribution and scattering of the seed over less extended areas. The jewel-weed, sometimes also called snap-weed, and by others very appropriately named touch-me-not, is a common little plant in many parts of Europe;

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* Mr. Swartz, a reliable traveler and observer, states that he found in Jamaica many species of mosses and ferns identical with those common to the northern part of Europe, though all other plants were new and peculiar.

† The raw cotton of commerce, which is reckoned among the most valuable productions of the vegetable kingdom, is the downy covering of the seeds of the cotton plant.

and, though less common here, it is of so remarkable and interesting a nature as to merit at least a mention. Its seeds, five in number, are attached to a carpel or seed case; at maturity the attachment becomes very highly elastic, ready to break loose at the slightest touch. When shaken or in any way disturbed they coil themselves with a sudden jerk and scatter the seeds to a considerable distance. The seeds of the so-called lady's slipper and of the sweet-pea are scattered when ripe in an analagous way by the elasticity of their capsules.

The squirting cucumber is even more peculiar than these in its method of scattering its seeds. As it ripens, the fruit becomes filled and finally distended with a watery juice; soon the pressure becomes so great that the cucumber breaks loose from the stalk at the point of attachment, the mingled water and seeds being projected through the orifice with sufficient force to carry them a great distance.

Nearly all wandering seeds manifest decided preferences for fine, dry weather, the parent plants seem willing to release their winged progeny only at such times. There is consequently, less liability of moisture being condensed upon the wings or the downy attachments of the seed and thus impeding its progress. A notable exception ought to be recorded to this rule, so marked, in fact, that it testifies, as strongly as the general tendency from which it differs, to an Omniscient design. The desert ice plant, found on dry and sandy plains, opens its seed capsules during the wet seasons, for only at such

times, in places naturally parched, would there be sufficient moisture to promote germination.

But aerial travel is not the only mode of transportation employed by vegetable seeds in their wanderings; they go also by water and by land. Most seeds are snugly wrapped in impermeable coverings, within which they can safely remain submerged for a long time. Seeds of semi-tropical plants are frequently cast ashore on the northern coasts, and would doubtless grow there but for the severity of the climatic conditions. The seeds of many aquatic plants are known to be carried on the feathers of water fowl to distant lakes and rivers.

Now let us look at the seed of a burdock plant—the burdock button, as we call it, though it is doubtful if buttons made after such a pattern would be at all desirable. These prickly seeds are literally covered with sharp hooks and barbs, by which they become attached, and firmly too, to the hair or wool of animals that may come in contact with the plant. See the condition of horses and cattle as they come in from their winter range, their manes and tails matted with burs—not a very pleasing spectacle, it is true—they are at such times unwilling agents in the employ of eager plants, seemingly anxious to give their offspring a start in life. When the wool or hair is shed, perhaps far from the mother plant, the seed reaches the ground where it subsequently germinates and establishes a new home. Or as it frequently happens, the animal may be killed, and its hide sent to distant parts, even across the

ocean, where by cleaning, the seeds are set free to grow afresh.

Many birds feed largely on seeds and small fruits; which in some cases are so thoroughly protected by hard and tough outer coats or shells, that they resist for a long time the action of the digestive fluids within the body of the bird, and may be deposited and grown in distant parts. Amateur gardeners in southern Europe are in the habit of shooting migratory birds that are just returning in the early spring from more southern climes, for the sake of obtaining the foreign seeds within their stomachs.

Dr. Sumner states that the Hollanders, being unable to retain their possession of the Spice Islands determined to abandon them, but before doing so, they jealously rooted out the nutmeg plants, which formed in fact the most valuable production of the islands. The birds, however, administered a striking rebuke to such cupidity, by soon disseminating the nutmeg seeds over the land. Such a case shows but the selfish ignorance of man; the Creator displays His wise power through the humblest instrument, but accomplishes His purposes in all their righteous fulness. The currents of the sea, the breezes of the land, the birds and the beasts and even men are unconsciously acting in the service of an all-directing power, and do much to diversify and beautify the earth by carrying the ovules of flowers and fruits from place to place.

CHAPTER XXXV.

PARASITIC PLANTS.

PARASITE, whether among men, animals or plants, is an individual who contrives to live at the expense of another. And many such are to be met with in the vegetable kingdom. As we have already seen, the root is the organ by which the plant obtains its food from the soil; but there are some plants, which, instead of developing roots of their own and striking into the earth, manage to become attached to larger plants and rob them of their juices.

Such for instance is the case with the majestic *mistletoe*, with which we are most familiar from the interesting rites attending it at Christmastide. This plant is a true parasite on the oak tree, striking a kind of root into the branches or stem of its host, and abstracting the juices and sap therefrom.

The common *dodder*—of tantalizing frequency in many gardens and fields, is another of the kind. In the early part of its existence it appears to be a perfectly natural and well-behaved plant, rising from a seed within the soil as other respectable vegetables do; but it is by nature a climbing plant, and to assist itself in its ascent, it twines itself about the body of any other plant that may be near at hand. It tightens its hold upon the supporting plant from the first, and finally becomes entirely parasitic, taking the juices of its living prop, and ceasing to absorb

food for itself from the soil. At such time it may be severed near the ground from its root without detriment, as it no longer supports itself.

A much smaller, and in fact a more unwelcome form is the *potato-blight*, which frequently occurs in such profusion as to destroy the entire potato crop through very large districts. The spores (corresponding to the seeds of larger plants) from which this growth is developed, are extremely small, and may be borne by the wind or through the medium of water to the potato plant, upon which they immediately begin to grow. They attach themselves to the leaves of the potato plants, by sending off little threads corresponding to roots, which penetrate the tissue of the leaves and stems by passing between the fibres and the cells; and succeed in stealing away the juices and the sap, resulting before long in the ruin of the plant. The potato-blight has many relatives, all extremely small, and all growing with rank luxuriance under favorable conditions. Some infest one particular kind of plant and others are found on many. We are familiar with those that grow on wheat, rye, barley, Indian corn and the like, of which we speak as *rust*, *smut*, *mildew*, *ergot*, etc. The black or brown dust to be seen in grain smuts is composed of innumerable spores of these parasites, each of which under proper conditions may develop and thrive to infest future grain crops, though some seasons seem much more favorable than others to such growths.

There is an unknown number of microscopic plants,

all interesting and instructive in their structure and growth. A very common form is the *mildew* or *mould*, so common on damp leather, old shoes, bread and vegetables that have attained a venerable age, fruits and preserves and the like. There also are plants, growing in much the same way as the potato-blight by absorbing nourishment from the substances to which they are attached. If we examine such, even with an ordinary pocket lens, the patch of mildew becomes transformed into a beautiful forest, like those we read of as existing in fairy-land, wherever that may be. There are the stems, looking like trunks of trees, and bearing the spore cases, not unlike the ripened seed capsules of the garden poppy, each filled with spores.

Moulds seem to grow almost everywhere, often springing up without apparent cause, so that some people have imagined that they originate spontaneously from the materials upon which they are found growing. Such an idea is erroneous. Though but simple in structure and with very few parts when compared with the apple tree and the oak, that little patch of mildew is still a colony of perfect living organisms, and such can only originate from germs or seeds of their own kind. But whence came the spores of these musty moulds on our walls and books and everywhere. The microscope again comes to our aid and shows us that the air in nearly all places is heavily laden with the tiny spores of these fungi; which indeed are so fine that they are borne about through the air without our knowledge, but as soon as they

fall in any still damp place, affording proper nourishment, at once they begin to grow.

Man is as utterly unable by his own knowledge and instrumentality to *originate* a tiny patch of green mould, as he is to raise an oak tree from the soil without first planting the acorn. Every plant and every animal increases *after its kind*, and only so.

PART III.

The Mineral or Stone Kingdom.

“My heart is awed within me, when I think
Of the great miracle which still goes on
In silence round me—the perpetual work
Of Thy creation, finished, yet renewed
Forever.”

CHAPTER XXXVI.

ROCKS AND STONES.

HUS far in the course of this little book we have directed our attention to the study and observation of animals and plants, the two great and natural divisions of living things. It will be remembered that these were spoken of as two of the three great kingdoms of Nature, the *Mineral Kingdom* being the third, and about this thus far we have said nothing. The mineral kingdom includes all those natural objects that are without life, such as stones, metals and their ores. These do not grow and increase as do things that live; they do not feed or feel; in short, they are dead. Common and unattractive things these stones seem to us

at most times, devoid of the beauteous form of leaf and flower, and showing none of the winning traits of our animal friends. Yet we may find the stones capable of teaching most valuable lessons to those who are willing to learn.

Stone or *Rock* is the material of which the earth's crust is composed; in small masses this is called stone, in larger ones, rock.*

Thus even layers of soil and loose bodies of sand and clay would be termed rock in referring to the structure of the earth's crust.

There seem to be so many different kinds of stone, that one feels to despair of the hope of finding out much about each; but we have already met a similar difficulty in speaking of animals and vegetables—their name was “legion” too; and yet we have been able to classify them in companies, each comprising such as resembled one another in most respects; and by these means we have extended our understanding over these subjects in a way which would have been impossible under other conditions. And so also will it prove with stones and rocks. Look for instance at the cobble stones, such as lie scattered about the

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* A very common application of the word “rock” to stones of any size is peculiar to certain regions of the United States. In other parts of the English speaking world such a lack of all distinction would be regarded with disfavor; and to speak of boys throwing “rocks” at each other, one writer says, would be regarded as “a supremely ridiculous expression.” To be precise therefore we should speak of “stone” when meaning a small mass of rock, and of “rock” when we refer to very large stones.

streets; they are of many colors, and of a still greater diversity of shape, so that any kind of a classification based upon color or form would appear to be nearly if not quite impossible, so we must try some other means of distinction and separation.

Take your pocket-knife—a stout, blunt blade will be the best—and try to scratch with it several of these stones. In some cases you will succeed in scoring or furrowing the surface of the stone; in others, nothing but a glistening streak appears—no furrow, no indentation, because the stone was too hard; the shining line is caused by particles of the steel having been rubbed off, through the superior hardness of the stone. Now chip off a small piece from one of the softer kind, and a piece also from one of the hard sort. Provide, then, a small vessel, such as a nappy or a wine-glass, half-full of strong vinegar. Put the fragment of hard stone into the vinegar; most likely, nothing sufficiently striking to attract our attention will occur, unless the stone be porous, in which case, several bubbles of air will rise through the liquid as they escape from the pores, but this will very soon cease.

Now place the bit of soft stone into the vinegar and watch again. In all probability there will appear to be a very great disturbance within the glass; bubbles of gas escaping from the stone throw the vinegar into violent agitation, so that it appears at first sight to be actually boiling; this, however, is a delusion, the contents of the glass are far from being

warm enough to boil. This gas which is escaping from the bit of stone is called "carbon dioxide"; it used to be known under the name of "carbonic acid gas"; and it formed in reality part of the stone. It has been imprisoned within the hard material of the rocky mass perhaps for centuries, but is set free at once through the action of the vinegar. If the stone had been ground to powder before being added to the vinegar, the action would have been much more violent, perhaps sufficiently so to throw the liquid out of the vessel. The bubbling and agitation within the vessel would be all the more striking if a stronger acid were used instead of the vinegar. *Muriatic acid* or *sulphuric acid* may be employed—the former is better; a small quantity of either may be obtained at any druggist's establishment at a low price. Very great care must be exercised in the use of these acids. They are both exceedingly poisonous and corrosive, but this is especially the case with sulphuric acid or "oil of vitriol" as it is sometimes named. A single drop falling on the dress may produce a hole in the cloth; if it comes in contact with the flesh it will result in painful sores unless washed off immediately; and if accidentally taken into the mouth it would prove a rapid and fearful poison. Strong vinegar, though less powerful in its action, is safer for our present purpose, and would better be used in testing rocks, except by those who are somewhat used to handling chemicals.

Here, then, is a ready distinction between several varieties of common stones. We have seen that

some are so hard that a knife does not scratch them, and upon these, acids have no effect; these are termed *siliceous stones*. Then we have spoken of others, which, although quite hard, can yet be easily scratched with a knife blade, and upon which acids act vigorously; these are called *calcareous stones*. All kinds of marble and limestone belong to this second class; and from such lime is made by burning (or more properly, by heating, since it is the fuel that burns and not the rock itself). Heat will set free and drive off the carbon dioxide gas contained in the stone as the acid did in our little experiment already described; and after this gas has gone from this kind of stone, lime remains. The Romans called lime *calx*; and from this word we have learned to speak of all rocks that yield lime when heated, as *calcareous rocks*.

We may find many stones, however, which are soft enough to be readily scratched by a knife, and yet are not affected by acids to any degree. Such for instance would be the case with stones produced from clay, such as *slates* and the like. These we may call *clay stones* for the present. In some parts of Utah and in many other regions we may find stones so soft that they can easily be scratched by the finger nail, and are not acted upon by acids at all. This soft material is called *gypsum* or *plaster stone*. The latter name is given from the fact that if such stones be placed in a kiln and heated, steam would escape instead of carbon dioxide gas; and in place of lime the so-called *plaster of Paris* is formed

within the kiln. This substance is called "plaster of Paris" because it was first produced a great many years ago from a rock found near Paris, in France. It is very highly prized for producing the fine and smooth hard finish, so much admired on the inner walls of houses; also for taking impressions and casts of various objects. When mixed with water so as to form a kind of paste or cream, it can be moulded or poured, and soon afterward it "sets" or becomes hard, preserving all the details of form of the object by which it was shaped.

Gypsum exists in great quantities and in a wide variety of forms in many parts of our mountain regions. Beautiful specimens of transparent gypsum (called from their lustre "selenite," meaning like the moon) may be found in many parts of Sanpete County, in the hills around Manti and Gunnison, also in Salina Cañon, Sevier County; and immense deposits of uncrystallized gypsum or plaster stone are found near Nephi, Juab County, in Kane County, and in many other parts.

We have learned, then, to recognize these four classes of stones: *siliceous*, *calcareous*, *clay* and *plaster* stones, whenever we meet with them; and these are the commonest we will be likely to find on the surface of the ground. These are simple stones, so named from the fact that each one of them consists of but one kind of material, but there are many others more complicated in structure, each consisting of several kinds. Examine a piece of *granite*, for instance, it is a common kind of stone, and

will be recognized by most of our readers without difficulty. It is of this beautiful and enduring material our great temple in Salt Lake City is built. Even a hasty glance shows this to consist of several distinct constituents; there are some white pieces scattered through the rock which prove to be very hard; a knife does not scratch them, and acid cannot affect them; these are pieces of siliceous stone usually called *quartz*; then there is another kind of material to be seen, usually flesh-colored or white, and showing brilliant faces if held toward the light, so as to reflect as a mirror would; this is called *feldspar*; and then there are some darker specks, in reality little scales, and are called *mica*. Granite, then, consists of three simple rocks, mingled and solidified together—quartz, feldspar and mica. We shall, perhaps, find other stony mixtures of this kind, if we look about us. With the aid of our little pocket magnifying glasses we will be able to distinguish the ingredients of most of the common ones.

CHAPTER XXXVII.

PEBBLES AND WHAT THEY HAVE TO TELL.

NLY a pebble from the brook! Look at it with care—rounded and worn, it looks old, and indeed it is. Without doubt it has existed in that state for a very great time—longer than any of us have lived on earth. If it had a tongue

and could 'talk' to us, that rough-looking stone would have strange stories to tell of its past history. I would like very much to ask it how it came here, what gave it that smooth surface and rounded form, and how it is that there are so many different sizes and shapes of pebbles, and so on.

It has certainly gone through a polishing process, and the mill in which this was carried on, was in fact the river itself. Look at the stones in the bed of a running stream; as the water moves they are constantly jostled against one another and rolled over and over and knocked together, in consequence of which they become smooth and round. Fast flowing water is able to move much greater weights than slow streams, and therefore only small pebbles reach the lower parts of the stream, where the water has become spread out and runs but slowly, while as we follow the stream toward its head the stones in its bed become larger and larger, until we reach the cañons in which the river has its source, and there we find large boulders in the course of the stream. These are constantly being torn loose by the stream from the rocky sides, and sometimes they fall from the overhanging cliffs and thus reach the river bed, when they are carried along grinding and being ground as they go. Here then is the source of our pebbles; these boulders are the rocks from which the smaller stones are made. This is an answer to the first of the questions which we asked of the pebbles—as to how they came to the place at which we found them.

Not all stones wear away with the same rapidity as they descend the stream; the harder kinds will resist the grinding process much longer than their softer companions. For instance; if two boulders, say of equal size, but one of hard, siliceous rock, and the other of the softer calcareous kind, should chance to fall into the stream, together; after a short time, the softer rock would most probably be so worn and reduced in size, that we could scarcely recognize the outlines of the original; whereas, the harder, siliceous mass, would scarcely have changed its form at all.

And thus we obtain the answers to two of our questions in one—as to why pebbles are of so many sizes and shapes, and what gave them their polished faces.

The author was very much interested and instructed on an occasion a few years ago by a short visit to a large establishment in the East, in which boys' marbles are made. The manner in which the operation is carried on is illustrative of pebble-making and polishing, under the best conditions. These "marbles" are made of many different kinds of stone, the best being of marble and agate and the common ones of limestone and slate. But one kind of material is used at any one time, however. The stone is first broken into little blocks, all of about equal size; these are then placed in a large cylinder or drum, which is made to revolve by steam power, and through which a stream of water is kept flowing. As the revolution continues, the bits of stone within the cylinder are thrown against one another in much

the same way as pebbles are on the bed of a running river. There is, however, one great difference between the two processes. The drum turns completely round, and in consequence the blocks of stone are jostled and rubbed on all sides equally, and thus they become shaped into almost perfect spheres; whereas in the corresponding operation on the bed of the stream the grinding is far less uniform, the stones being moved by the force of the stream alone. And furthermore, as the river stones are of widely varying size, and of different degrees of hardness, there is little likelihood that perfect spheres will be produced. If the stones be longer in one direction than another, and especially if somewhat flattened, the running stream will rather slide than roll them, and thus the irregularity would be increased.

Pebbles are also formed in great numbers on the sea-shore. Those readers who have visited the ocean edge have, without doubt, noticed the long, sweeping waves rolling up the beach and receding, only to return and again retreat. The stones upon the beach are rolled and rubbed by this wave action with truly wonderful force. It has been found, from careful observation, that the beach moves to the depth of over two feet, and the grinding sound produced can be heard at a considerable distance from the shore. An interesting calculation has been made by Prof. Shaler, on the distance traveled in this to and fro style by an ordinary sea-side stone during the day. He says "it travels in time of calm a little distance every time the wave

strikes, and as this is, say, six times a minute, the stone moves a few feet (we may average the distance at ten feet) in all weathers, they would thus travel between twelve and fifteen miles a day."

But, it may be asked, where are the large rocks from which these sea-side pebbles are made? These are really detached portions of the coast, broken off by the action of the waves from the cliffs against which they strike; and being driven by the force of the water back and forth upon the beach, the grinding process goes on with great rapidity, the debris worn off in the process forming sand and mud. Under certain conditions, large deposits of pebbles and gravel are made with sand or mud, and the stones are bound together so as to form a solid mass of rock. Such a formation is called *conglomerate*, though, if the pebbles be rounded and smooth, the somewhat expressive name of "*pudding-stone*" is bestowed upon it. The cement that binds the pebbles or gravel together becomes as hard and durable as the stones themselves. Many of our local cañons show extensive formations of *conglomerate*.

Such is a little of that which the pebbles can tell us. Job, the great prophet of patience and of faith, once said, "stones shall speak;" and indeed they have done so, and are still ready to talk to those who are willing to hear and to learn. But they do not use our language any more than does the dog whining at his master's feet, or the bird singing upon its perch. We must learn to understand the tongue of the rocks and stones if we would know their wondrous

secrets; we must question them through the medium of steady and prayerful examination; they will answer more by looks than sounds it is true, and the mind must act as interpreter between their language and ours.

CHAPTER XXXVIII.

SAND AND SAND-STONES.

WE HAVE already discovered how sand is formed; it is by the breaking up and wearing away of certain kinds of rocks through the means of river currents and ocean waves. Let us gather a few grains of sand, and see if they differ in any other respect than that of size from the larger pebbles about which we have already spoken. Yes, there are many differences; these bits of sand have sharp edges in spite of all the wearing and bruising to which they have been subjected during the long period of their preparation; in hardness they compare favorably with the hardest of common pebbles. These tiny grains are altogether too small to allow scratching with a knife to ascertain their relative hardness; but we may reach the same result in another way. By rubbing a pinch of sand on a piece of glass, the glass will be easily cut and scratched, proving the hardness of the sand. Now, place some sand in a little strong vinegar or other acid, as we tested the bits of stone in a former

experiment; there will be no bubbles of escaping gas to be seen. The liquid seems to have little or no effect upon the sand. We are justified in concluding that sand grains are really broken and angular fragments of *siliceous stone*. Being so very hard these little grains do a great deal toward grinding larger stones when driven along by water or wind. This operation has been imitated by man to his own advantage in grinding and polishing various objects for ornament and use. The beautiful figures so much admired on ornamental glassware, are usually produced by the cutting action of sand, which is driven through a small pipe by a blast of air or steam with very great force against the surface to be etched, producing the roughened, frosted appearance, which contrasts so strikingly with the smooth and unworn parts.*

A similar operation on a stupendous scale may be observed in the case of desert sand-storms; and the remarkable effects of such action are visible in many parts of our territory. A simple current of air, though moving with the velocity of a hurricane, could have but very little effect upon the face of a rocky cliff against which it may strike; but if the wind bears sand

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* Prof. Dana tells us that the glass in the windows of houses at Cape Cod on the Atlantic coast is *worn through* by the beating of the wind-driven sand. Not only is glass ground and etched as described above, but also precious stones and even granite. "In this way," says the authority above quoted, "the deep carvings of a granite frieze have been made in six hours, that would have required two months of work by hand."

upon its wings, each little grain strikes like a miniature bullet against the obstruction and thereon leaves its mark. All the softer parts of the rock will soon be worn away and the cliff presents before long a rough and weather-beaten appearance. In time the hardest rock will yield to the incessant battering of this wind-driven sand. Those of us who have ever traveled through the truly beautiful Clear Creek Cañon, leading from Joseph City, Sevier Co., to Beaver, Utah, cannot fail to have beheld and admired the fantastic cliffs, which form the cañon walls, and which owe their curious forms mostly to the action of sand-laden winds. This is but one instance among many of local interest; the cliffs about Richfield, Sevier Co. and indeed the hills throughout Iron, Kane, and Washington Counties of this Territory, all bear unmistakable evidence of their battle with the sand.

In some places the sand is so fine that it is borne to very great distances, and there perhaps deposited in large bodies, called sand banks, or *dunes*. These are common in the neighborhood of sandy ocean beaches and in deserts. On the sea shore such dunes frequently attain a height of a hundred feet and an unbroken length of miles. On the coast of Norfolk, England, the sand drifts have advanced inland so as to completely bury farms and houses. The church spire of the little town of Eccles is about all that is left exposed to mark the spot of the buried burg.

Many beautiful sand dunes may be seen in the desert regions of northern Arizona. In traveling

from the little town of Orderville, Utah, to Pipe Springs Fort—the one oasis in the arid wilderness beyond which lie the Buckskin Mountains—the ever shifting sand dunes form an impressive spectacle. The golden sand is piled up in a way no less beautiful than wonderful. Whenever the wind blows, more sand is brought to add to the enormous store, or some is taken from the banks to increase the deposit in other parts.

Where great quantities of sand have been deposited by water, year after year, the pressure upon the lower layers becomes so great, as to solidify the loose material into a compact mass of rock. This is the *sandstone* so common in most parts of the earth, and so useful to man for building and other purposes. Sandstones are of varying degrees of compactness, depending upon the intensity of pressure to which the sedimentary masses have been subjected, and to the presence or absence of heat during the process. Some are so friable as to be readily reduced to powder between the fingers, and others are so hard that they can be shaped only by saw and chisel. If the grains are not alone pressed together, but also cemented more or less perfectly through the aid of heat, so that the separate bits from which it was originally formed cannot be detected, even by the aid of the magnifying glass, we call such rock *quartzite*, and many siliceous stones of our streams and mountains are of this kind.

CHAPTER XXXIX.

MUD AND MUD-STONES.

NOW let us turn our attention for a short time to the state of ordinary mud, so common everywhere. According to the definition already given of the term "rock" in its widest sense, mud is a variety of rock, and forming as large a proportion of the surface foundation as it does, it is certainly of sufficient importance, to claim a few minutes of our study, during a life-time. Mud is oftentimes in so fine a condition, that it scarcely feels gritty, when rubbed between the fingers. It is, in fact, the smallest subdivision of rock, and is formed through the battering and wearing operation to which stones are subjected in the water-mill already described, and also by a rotting or decaying process of the rocks, which is constantly going on, upon and beneath the soil. Plants are continually dying in the soil, and the remains of their bodies, in undergoing decay, produce certain kinds of vegetable acids of a corrosive nature, which are easily dissolved by the water percolating through the soil. This acid liquid comes then in contact with rocks within the ground, and hastens the process of disintegration.

By digging into the crust of the earth at any place, a floor of solid rock will be found underlying the more finely divided soil. The upper part of this rock foundation is generally somewhat soft and

friable; it is in fact, partly decomposed, and in this condition, has been named "rotten rock." Below this, the hard, solid mass is encountered. In many places the soil is found to be composed of the same material as the rock upon which it rests, though in a divided and an altered form; and we are safe in concluding that such soil was once a continuous part of the rock below. There is present in the atmosphere, under ordinary conditions, a definite amount each of watery vapor, and of carbon-dioxide gas, which together, exert a most powerful effect in disintegrating the rocky crust of the earth.

It is no less instructive than interesting to contemplate the stupendous labor that is often accomplished by what might seem to us the weakest of Nature's forces. The action of frost for example, is a powerful means of breaking up the rocks. We have without doubt taken notice of the fact that in the act of freezing, water swells considerably, so that a piece of ice occupies more space than the water from which it was formed. This principle is at times rather unpleasantly demonstrated to us by the bursting of pitchers and bottles that had been left with water in them to freeze. As water percolates through the soil it enters the pores and crevices of the stones and rocks, and there by freezing expands with surprising force, and accomplishes the bursting asunder of the rocky masses on a mammoth scale.

Vegetation on the surface of the soil does much to increase and assist this general disintegration. The first roots that are sent off by the growing plant are

as thin as the finest hairs; they can therefore easily make their way into the small cracks and crevices of the rocks; they are, however, constantly growing larger, and soon completely fill the spaces in the rocks, finally bursting apart the rocky walls. Growing roots have been known to separate in this way immense masses of stone; they act like stout wedges driven by giant hands. In cities, immense paving stones have been lifted and the foundations of colossal buildings have been disturbed through the growth of the roots of some large tree, which perhaps at first were no larger than hairs. By these means the rocks are broken to pieces, and prepared for the processes of finer division already described. And in such simple though effectual ways the stony covering of the earth is reduced to the finest state, and thus forms the soil, upon which depends all the higher operations of life.

Ordinary mud, though fine throughout when compared with sand or gravel, yet consists of particles of many different sizes. Put a bit of mud in a glass of water, then stir and set aside; the heavier and coarser particles are seen immediately settling to the bottom; but the finer bits remain suspended in the liquid for hours or even for days. In a manner similar to this the pebbles, sand, and mud gathered by rivers in their flow are carried and distributed; the heavier bits of stone being deposited first, while the fine mud is borne in all probability low down toward the mouth of the stream. Now let us take a wee bit of this mud, spread it out carefully upon a

piece of glass, a saucer, a small dish or anything of the sort, and look at it through a pocket lens; we will then be able to discover clearly the bits of stone of which the mud consists. It is a complicated mixture however; there would be found almost all the kinds of stone thus far spoken of. Such mud forms a very large proportion of common soil, the rest consisting mostly of sand and the decayed parts of plants. A fertile soil is usually composed to the extent of one half of the entire mass of clay and mud grains. But much of the mud produced by the wear and decay of the rocks is carried by the rain water and by other means into the rivulets and rivers, in whose capacious bosoms it is borne onward perhaps for many miles, and is finally deposited as large mud flats in the neighborhood of the river mouths, or on the bed of the ocean into which the larger rivers flow. As such sediment increases in depth year after year, the pressure upon the lower strata from the weight of the overlying layers, becomes so great that their particles are forced together into a close and compact mass. Beside these effects, that of heat, which is so universally present in the deeper parts of the earth, must be considered. By this means the lowest layers of sediment may be partly softened and thus be brought into a more compact and solid state than ever. In this way are the mud-rocks formed; and of these many varieties exist, some of great practical value to man, such as the beautiful slates and cleavable shales from which our roofing plates and writing tablets are made.

The rain falling upon the land, then running off in tiny rills into the flowing streams, and carrying the finer parts of the soil along; and the rivers moving ceaselessly onward, laden with sediment, toward their destination in lake or sea, thus lay the foundation of future quarries, from which will come the material for architectural wonders in beautiful residences, stately churches and holy temples.

CHAPTER XL.

ABOUT LIMESTONES.

LIMESTONE is a general name given to all those rocks of the earth that contain lime; the lime is prepared by heating such rocks in a kiln by a process already described. They all belong to the calcareous family of rocks, and yield large quantities of carbon-dioxide gas when acted upon by acids or subjected to great heat. It is estimated that not less than one-sixth part of the surface rocks of the earth consists of limestone. This material exists in almost all shades of color, the purest kinds being nearly or quite white; but the largest deposits of limestone, such as form in many places the bulk of the mountain masses, are of a deep blue color; and are called "blue limestone."

To the unaided vision, a piece of limestone appears to be composed of fine particles pressed together in the manner of the mud-rocks and sandstones

spoken of before; though sometimes the outlines of mollusk shells and other animal remains may be discerned. When highly magnified, however, a bit of limestone is seen to have a wonderfully complicated and interesting structure. There we see the outlines of beautiful shells, some oval, others circular, and of many other symmetrical forms, with curious markings like ornamental lines upon their surfaces, others looking like radiating stars; in fact there appears a never ending variety of shape, yet all symmetrical and beautiful. Limestone really consists of the consolidated remains of these minute organisms, which existed in unnumbered variety in bygone times. These wonderful little rock-builders are still in active work in many parts of the world, especially in the warm seas.

In the clear and salt waters of the tropical oceans, *corals* are found in almost endless profusion. The hard and solid substance which we ordinarily call "coral," consists really of the shells in which the coral animals lived. These tiny creatures have the power of separating from the sea-water in which they live, the hard materials contained therein, and of using the same in the formation of their calcareous homes. Perhaps this process is in great part analogous to that taking place within the human body, by which certain parts of the food are digested to form hard bones and teeth. Coral animals belong to the class of *polyps*—a word meaning "many-footed," and given as a name to these little beings because when in active life, each expands around the

entrance to its tiny home, a number of radiating arms or tentacles, usually called feet.

These polyps live together in very great numbers, each building its little house or shell in contact with others, and so in time vast masses of solid coralline matter are formed. As the animals die, year after year, others build upon the remains, and thus the process continues uninterruptedly.

These little beings demonstrate by the results of their ceaseless growth what may be accomplished through concerted action of many, though each individual performs but an inconsiderable part.

The greater part of the Florida peninsula consists of the remains of coral polyps. A very careful examination of that region has convinced scientific men that at one time Florida was not more than half its present length from north to south; and that it has grown through the agency of corals, by which in fact, it has extended over two hundred miles toward the south; and the area of land thus added to the continent is more than twenty thousand square miles. Beside corals, there are many other animals that form for themselves such calcareous shells.

Chalk (see figure 23), if examined with the microscope, is found to consist almost entirely of the skeletons of foraminifers—a word of Latin origin meaning really porous, and given to these tiny inhabitants of the water from the fact that the shells of most of them are perforated by a great number of passages or holes.

Many larger animals also employ this power of extracting the calcareous matter from the water to form-their coverings. To such a class belong the oyster, clam and the snail, and all the beautiful shells so much admired, belonging to the order of mollusks. By the action of moving water these calcareous formations are frequently broken to pieces and ground to powder, by which the larger shells of course lose their original form, though their mutilated remains may frequently be recognized in the rocks formed from such material; but the smallest of shells above described are protected from destruction by their very fineness.

In the dust that may be scraped from a glazed card, and in the chalk mark left upon the blackboard may be seen such tiny monuments of past life. Some limestones are much more solid and compact than others, having been subjected to greater degrees of pressure and of heat in the process of formation. These conditions may so affect the rock that it becomes of a crystalline nature, which form is known and prized by us as *marble*. Of this beautiful material there are again many, very many varieties; of almost every known shade of color from the purest white to the deepest tint of jet. The whitest marble comes from Carrara and the island of Paros, from the latter source it has been named Parian marble, and it is highly prized for statuary purposes. Small quantities of foreign matters mingled with the rock give to it a mottled or clouded appearance. Man has great reason to prize so beautiful and valuable a stone,

fitted as it is for so many purposes in architecture and art.*

Many of the mountain ranges of the globe, the Appenines and the Corderillas, part of the Rocky Mountain system, and the historical Cliffs of Dover, are built of the calcareous remains of animal life. Years, perhaps centuries ago, these tiny architects reared their small, though beautiful dwellings; and proud man is glad to erect his stately edifices from the remains of their worn-out homes.

The massive limestone, marbles and chalk already named, are the most widely distributed of all the calcareous rock; but beside these there are many others. A semi-transparent and crystallized variety is called *calcite*, and the purest kind, which is transparent and exists in regular crystals, has received

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* Ruskin has written in the following expressive way:

“What are marbles made for? Over the greatest part of the surface of the earth we find that the rock has been providentially distributed in a manner particularly pointing it out as intended for the service of man. It is exactly of the consistence which is best adapted for sculpture and architecture. It is neither hard nor brittle, nor flaky, nor splintery, but uniform and delicately, yet not ignobly soft—exactly soft enough to allow the sculptor to work it without force, and trace on it the finest lines of finished form; yet it is so hard as never to betray the touch or moulder away beneath the steel; and so admirably crystallized and of such permanent elements, that no rains dissolve it, no time changes it, no atmosphere decomposes it; once shaped, it is shaped for ever, unless subjected to actual violence or attrition. This rock, then, is prepared by Nature for the sculptor and architect, as paper is by the manufacturer for the artist; nay, with greater care and more perfect adaptation.”

the name of *Iceland spar*. Then there is another variety called *oolite*, the name meaning "eggstone," and given to this member of the great limestone family, because composed of numerous rounded grains, like the eggs or roe of a fish. Good specimens of oolite are obtainable in several places in Utah; among the best being those found at the temple quarry, Manti. *Marl* is another calcareous rock, containing a considerable proportion of clay, and usually, also, whole or broken shells. Being in a loose and friable condition, it very readily yields to the disintegrating action of frost and rain, and so becomes rapidly incorporated with the soil, and is used extensively as a fertilizer.

CHAPTER XLI.

LIMESTONE MADE OVER.

T will readily be believed from what has already been said regarding the formation of rock, that the materials of the earth's crust are undergoing continual change. The solid cañon walls, and the stony banks of streams are broken and loosened by the torrent in its fury, and the fragments are hurled onward and downward, being broken and powdered as they go till reduced to the state of sand and mud, which then are borne by the waters to quiet places, and there deposited to form new beds of rock.

Much of the water that falls upon the earth as rain and snow, runs directly off the surface into the streams; but a portion of this water sinks into the soil, and there accomplishes a great labor before it comes to the light of day again. We all know that water dissolves many substances with great readiness. A little fine sugar or salt for instance if placed in a vessel of water very soon disappears from sight, and seems in fact to have been absolutely lost. This is not possible, however, and the characteristic taste of the water after the solid matter has disappeared shows that the sugar or salt is still there, though the solid particles are suspended or dispersed between those of the liquid. If we evaporate the water by heat or other means, the same amount of solid material as was originally added will be recovered. In such a way does the water falling naturally upon the rocks and soil or flowing over the same dissolve away the soluble matters and carry such along with it in its descent into the earth. All natural waters contain in solution more or less of solid material, derived from the soil and the rocks as here described. Look for an example on the inner surface of a much used fire-kettle or steam boiler; a hard material, looking not unlike stone is found there; this was without doubt present in the water before boiling, and has been left behind as the liquid evaporated.

Pure water is able to dissolve limestone to a very small extent only, but water containing carbon-dioxide gas, is a ready solvent of all kinds of calcareous material. This carbon-dioxide is known to be

present at all times in the atmosphere, and it is set free within the earth wherever calcareous rocks undergo decomposition, and by other means, so that natural water contains a considerable proportion of this gas. Such water, then, dissolves the limestone with which it comes in contact; and as it comes to the surface after its long subterranean journey in the form of springs, it is frequently so heavily charged with calcareous matter, that as the carbon dioxide gas escapes into the air it can no longer retain the solid material in solution, and consequently deposits it around the mouth of the spring, forming oftentimes a curb about itself or even a large mound. This is a very common phenomenon about the carbonated springs so deservedly famous in this region; truly beautiful examples are found at Soda Springs, Idaho, and in the wonderful water-pots at Midway, Utah. The solid matter in such waters as these will be deposited on any object placed in the spring. A bunch of grapes kept immersed for some time will be completely covered with a layer of stony matter; before long, however, the grapes themselves decay, leaving the original plump and beautiful form represented in the stony casing. Flowers, pine cones, baskets, expanded fans, and objects of such a kind are frequently subjected to the incrusting process, by visitors to such springs, and carried away as instructive mementoes of this action of water.*

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* The process above described is not an example of petrification, in which the particles of any body are replaced as fast as they decay by solid matter dissolved in the water;

It frequently happens that water in seeking a course through the rocks and soil, washes out for itself wide passages and enormous caverns, oftentimes at very great distances below the surface. Such caves are common in limestone formations and prove most interesting and instructive occurrences. Imagine a cavern of this kind existing in the earth, and water trickling in through the sides, having in solution much solid matter which it has dissolved in its course. If this be of a calcareous nature, it will be deposited on the inside of the cavern, forming a lining and ceiling to the underground room, often of the purest white. A drop of water oozing through the ceiling would leave a part of its solid matter there, then falling to the floor would evaporate and so deposit the rest; and thus in time pendant rods of calcareous matter called *stalactites*, are formed on the ceiling and upright pillars known as *stalagmites* on the floor. The water dripping from the point of a hanging stalactite above, would fall of course in a straight line to the spot directly below, and there make its calcareous contribution to the growing stalagmite so that the stalactites and stalagmites form in pairs, point to point. Finally they touch, then of course a column exists from ceiling to floor, down which the water runs instead of dripping and splashing as before; it evaporating as it flows, and leaves its dissolved solids year by year

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it is merely an incrusting or covering of the object which is immersed with a solid layer; the particles of the body itself remaining unchanged in other respects.

to increase the size of the pillar. But few spectacles can be imagined that surpass in impressive brilliancy the hangings and the decorations of such a subterranean apartment; what architect can compete with water in its quiet but effective style of building! Within these rocky recesses of the earth, water has erected its stately pillars, reaching from paved floors to frescoed ceiling, of wondrous beauty; oftentimes these have formed a long succession of chambers, with majestic archways leading from one to the other, passages below stupendous architraves, and corridors, the entrances to which lie through colossal gateways of dazzling purity. The walls and roofs and floors all glisten in the light of the torch-fires as if studded with diamonds and sapphires--such formations are Nature's palaces.

Several of these interesting caverns exist in Utah and surrounding regions; there are the Formation Caves at Soda Springs, Idaho, the Crystal Grotto near the Mammoth Mine in the Tintic Mining District and the caverns connected with the Cave Mine and Pace Mine in southern Utah, all of great beauty, though at present considerably marred and defaced, through the spirit of vandalism displayed by visitors to these beautiful places.

Very large and wonderful caves exist in Tennessee, of which the Nicojack Cave is the best known; in Virginia are the celebrated Luray Caverns; but by far the most extensive region of caves yet discovered in the United States, exists in Kentucky; in which State there is a district of country nearly eight

thousand square miles in area, the surface of which is the ceiling to an almost continuous series of subterranean caves. Of these, the deservedly famous Mammoth Cave is the most important. It is so extensive that several days would be required to explore its intricate passages and capacious chambers. The entrance to the wonderful formation is through a natural archway, having a span of seventy feet. The main cavern within varies from forty to three hundred feet in width, and from thirty-five to a hundred and twenty-five feet in height, and is divided by crystal walls into several large rooms, to most of which expressive names have been given, as "Rotunda," "Star Chamber," and the like. At a place within the cave, situated about a mile underground, thirteen little cottages have been built, in which visiting tourists and invalids used to pass their leisure time; but these houses have now fallen into disuse to a very great extent. The combined length of all the accessible avenues is about one hundred and fifty miles. The walls in many of the rooms and passages are ornamented with stalactitic tapestry, of the most imposing kind, displaying an almost endless variety of color, and a radiant beauty beyond description.

In the depths of these dark recesses large streams of water flow with great velocity and force toward their hidden destinations, and along their course they frequently leap from one level to another, forming grand cascades of several hundred feet fall. Within these caverns there have been found several

distinct forms of animal life; twenty-eight species have been already described as truly subterranean, beside several others which are regarded as visitors from the outside. A peculiarity of all animals native to those dark regions is that they are without eyes,—not even a rudimentary apparatus for vision exists. In this strange circumstance we are brought again face to face with another forcible declaration of Nature's purposes—that the Creator never brings into existence a useless organ nor a superfluous form of any kind. Eyes would have been of no practical use in places such as these, where the light of day can never penetrate; and in consequence, visual organs have been withheld, and by the same Omniscent power other senses of these animals, especially that of touch, have been wonderfully strengthened. There is a blind fish native to those dark streams, possessing a most sensitive power of touch in the parts of the head and face; there is too a wingless grasshopper, with its antennæ so excessively long and of such delicate power, that we may with good reason think this high development of the sense of touch was intended by the Creative mind to be in a degree a recompense for the absence of vision.

In some parts of Europe very large caves have been found containing vast quantities of bones, many of which belonged to animals not now living on the earth. Such caverns were doubtlessly used by the savage beasts of that day as dens and retreats, into which they dragged the animals upon which they fed, and when they themselves died their own

bones were added to those of their victims, thus preserving these relics of extinct animals, without which science to-day would embrace but scanty knowledge of those curious creatures. Many of such caves have been used in the past by the partly civilized races of men as burial places for their dead. Within these vaults, explorers often find human skeletons with various ornaments, weapons, and utensils which were buried with the bodies, apparently according to a custom similar to that now practiced by certain tribes of Indians and others.

CHAPTER XLII.

ROCKS FORMED BY HEAT.

LL the rock formations thus far studied have been in some way associated with the action of water; pudding-stones, sandstones, clay-stones, slates, and calcareous deposits are all indeed sedimentary in their origin. Few of us have traveled far in this Territory without noticing a number of rocks differing much in general appearance from any thus far described. Some rocks are found containing numerous small holes or bubbles, looking very much as if produced by the escape of gas or steam from within, and in all their characteristics they appear as we think rocks would that had cooled from an originally heated and molten state. They are usually called *igneous rocks*,

for this reason. The name signifies literally that they have been produced by fire. To this class belongs the *lava* which is found within the craters of volcanoes in action, and poured out from their heated tops in molten streams. A volcano may be defined as an opening in the crust of the earth, through which rock matters of various kinds are ejected, always heated and usually in a liquid condition, associated also with various gases and vapors. The intense igneous action taking place within the earth often causes a swelling of the surface, forming a sort of earth-bubble, which permits the escape of the contained vapor and molten matter. This results, of course, in the formation of a conical mound, the elevation of which is usually increased by deposits of solid materials ejected from within. Some volcanoes are in fact among the loftiest mountains of our globe.

The cause of the great heat existing within the earth, and especially marked in volcanic districts, has given rise to much speculation and great diversity of opinion. But putting all theory and supposition as to the cause aside, we may accept as a fact the statement, that the interior of the earth is in a condition of great heat, sufficiently intense in some places to completely fuse the rocks and to eject the fluid material as lava upon the surface. At the time of an eruption, large quantities of rock dust, sometimes called ashes, are thrown out. The lava runs from the crater as a stream, until by cooling it becomes viscid and finally too thick to flow. The

outer parts of a lava stream will often become perfectly cool and hard, while the inner portions remain heated and in a liquid state perhaps for months. A hardened lava stream may sometimes be traced continuously for many miles; and of this Utah furnishes many examples, though the volcanoes from which such streams sprang are now no longer active, and are therefore said to be extinct. Several extensive lava "flows" have to be crossed in traveling through Beaver and Millard Counties, and wonderfully distinct streams exist about St. George in the south. Dameron Valley, or Diamond Valley as the place is sometimes called, lying between the little town of Pine Valley and St. George, contains a number of such streams, and also several interesting volcanic cones, from which the lava courses lead. It is a rather laborious undertaking, but one well worth the effort, to climb the rugged side of such a blackened mountain. On reaching the top we discover a cup-shaped hollow, into which we can with care descend. This is the crater, from which issued the vast quantities of lava now to be seen extending in all directions. The floor of the crater is formed by the hardened lava which remained after the last eruption.

Such volcanic forces, though mighty and even terrible in their operation and effects, are necessary to the preservation of the proper condition on the earth. Through these natural vents the pent-up gases and expansive vapors from within the earth, together with the molten matters resulting from the

intense heat, find their outlets. Without volcanic discharges we have all reason to believe greater and more destructive effects would be produced from violent earthquakes and other intense convulsions of a kindred order. Again, volcanoes belch forth large quantities of carbon-dioxide gas, which, though fatal to human beings and animals in the immediate neighborhood, is still essential to the support of plant life upon the earth. Even the fiercest of volcanic fires, and the maddest fury of igneous forces, serve a purpose tending toward the general good.

ROCKY VEINS.

Most of us, perhaps, have noticed pebbles and other stones having streaks of a light color running through them. These light-colored seams are called "veins," and have been formed in a most interesting way, which we are capable of discovering and, to a degree at least, understanding, by remembering the admirable and effective way in which the water excavates large caverns and passages within the ground. We have seen that the sand, mud and calcareous powder produced by the grinding of stones in the river channel, are deposited by the water in the form of stratified sediment, which eventually hardens into rock. As it dries and hardens, it shrinks, and oftentimes cracks, leaving many gaping fissures in the rock. Look at any mud flat from which the water has receded, and upon which the drying effect of the sun's heat has been felt—the cracks there to be seen will illustrate all that has been said.

By volcanic disturbances, earthquakes, and similar violent forces, the earth's crust is sometimes moved over great areas, producing many a rent and fissure in the rocks. Such cracks and fissures, whether large or small, when re-filled, are called veins. If the rock, in which such rents are formed, is soluble in water, or if soluble rocks exist in the neighborhood, the water in percolating through will dissolve much solid matter, and deposit the same in the vein-fissure; just as it deposits its load of dissolved material on the walls of subterranean caverns. Such a tiny vein as we see in an ordinary pebble, may, in fact, be regarded as a miniature cave, into which the percolating water has brought so much solid matter as to entirely fill the space. This is one of Nature's means of healing the wounds and rents that may be produced through violence in the rocky tissues of the earth; just as a cut in the flesh is naturally healed by a liquid serum oozing from the sides of the wound, finally filling the cavity and uniting the parts. Under certain circumstances this dissolved material is deposited in the stony fissure in the form of beautiful crystals extending from one wall toward the other, till perhaps they meet, and so accomplish the joining. In such cases they look remarkably like rocky stitches put in to sew up the rent and hold the parts in proper place.

Vein fissures are also formed in other ways. Molten material from below may be forced by volcanic disturbances into the rocks above, completely filling all such cracks and fissures, and opening many others by

the violence of its injection which it fills at the same time. Whether any particular vein was filled by matter in solution or by molten material may be determined by examining the nature of the filling and the condition of the rock bordering the vein. Calcareous crystals for instance could not be formed from a molten mass; because calcite undergoes ready decomposition by heat. If the rock on either side close to the vein is in no way different from that at a considerable distance from the vein, we may conclude that the fissure has been filled by infiltration and not by the injection of igneous matter, as in such case the vein walls would doubtlessly have suffered change—chalk or limestone would in all probability have changed to marble; and clay would have become slate under the influence of the heat.

The vein matter in large fissures is frequently impregnated with metallic substances or their compounds, brought there in all probability by heated water in most cases rising from below. Such a mixture is called “ore;” and whenever a vein of this kind reveals itself by any surface indication, it is eagerly explored and worked for the sake of the rich treasures that it contains, so do we obtain our lead, and tin, copper, iron, silver and gold, without which the present state of civilization would be materially changed. Among such veins, only those that afford some indications of their presence at the surface are available, and these may be indeed very few compared with the unknown and hidden treasures of the ground. Un-

told wealth lies concealed within the stony bosoms of our hills, as to the locations of which, however, nothing yet has been learned. At present, man labors blindly in his search for mineral riches; he may yet be taught the secret combination of the rock-bound safe within whose deep recesses these treasures lie secure.

CHAPTER XLIII.

A TALK ABOUT COAL.

MANY of our readers have heard or read or perhaps they have thought for themselves about the fact that coal is formed from plants. Yet it appears truly remarkable that any vegetable production should be dug from the earth as rocks and ores are, or that such should be called, in any sense, a mineral. Proof of the vegetable origin of coal are simple but strong. Remains of plant life, such as the leaves, twigs, and trunks of trees, flowers, fruits and seeds are all found imbedded in the clay and rocky layers lying above and below the coal deposits, and sometimes within the coal itself. This is especially true of the anthracite coal seams in which the original structure has not been so completely obliterated. The author has had the pleasure on several occasions of visiting some of the celebrated Pennsylvania coal mines. He was fortunate enough to find while

there, several pieces of slate and coal matter, containing most perfect impressions of ferns and other plants, pieces of gigantic rushes, fragments of bark showing intricate and complicated markings upon the surface, a number of cone-like fruits produced without doubt by plants closely allied to the pines, and many other evidences of vegetable origin.

Fig. 31.—Fossil Fern in Coal Slate.

A picture of a fern leaf from such a source is given in figure 31; every fibre and veinlet is clear and distinct; so perfectly are the details preserved that the nature of the plant is as readily distinguishable as are the living ferns of this day. A close examination of the coal itself results in farther proof of the same fact. It was said in speaking of the structure of plant stems that the micro-

scope revealed a number of ducts and vessels which bore marks upon their surface of a peculiar and characteristic kind. Similar vessels marked after the pattern of the vegetable fabric, are found in all coal, even the hardest stone-coal. The ash remaining after the coal has been burned, shows to the skillful microscopist the same characteristic structure.

Another argument, urging strongly an unqualified belief in the vegetable nature of coal, is that men have succeeded in manufacturing an artificial coal from saw dust and other finely divided vegetable matter, by placing the same under great pressure and subjecting it at the same time to heat. If we take the trouble to dig and examine the soil to a depth of several yards in any marsh or swampy place, we will find an interesting gradation as we descend. Near the surface the roots of growing grasses, rushes and other plants form a kind of mat, which entangles the soil, but each root fibre can be clearly and distinctly traced. Deeper in the ground we find roots and stems of plants not now living, and to all appearances buried by the sediment that has been carried by the streams into the marsh; they have all turned to a dark color and are brittle and friable. The soil entangled between the fibres of this deeper root-mat is of a black color too, being saturated with soluble organic matter derived from the half-decomposed plants. This mixture of soil and vegetable remains is called *peat*, and in many parts of the earth it is cut into blocks and dried, and so used as a fuel, plentiful, cheap and effective.

The conditions favorable for the formation of peat, are a tolerably low temperature—without which the vegetable matter would entirely decay before it had been converted into peat—and a moist or humid state of the atmosphere. Where such conditions exist, peat is formed in immense bodies called peat-bogs. Large areas in France, Scotland and England are covered with peat; and one-tenth of Ireland is a bog. Prof. Dana has estimated the quantity of peat now existing in Massachusetts, at fifteen billions of cubic feet. If, after such a bog were formed, it were covered with water, either from the sinking of the land or the rising of the sea, heavy deposits of sediment would be made above the peat, exerting a great pressure on the buried matter; and, as the sedimentary layers increased above, the internal heat of the earth would invade the lower strata, and thus still further contribute to the process of change.

Such buried vegetable accumulations have been found in many places beneath layers of sedimentary rocks, converted into a kind of brown coal called *lignite*, in which may be traced all the proofs of vegetable structure. Other bogs have been discovered buried much deeper in the earth, and consequently under the effect of far greater pressure, and of higher heat; such influences would more completely change the plant tissue, resulting in the formation of ordinary *bituminous* coal, so extensively used as a fuel. The dull and lustreless *cannel* coal is a variety of this kind, so rich in volatile matter that it burns like a torch, when lighted, producing a

large luminous flame; in fact it was used at one time to give light, and hence called "cannel," which is a corruption of the word "candle." Where the heat and pressure have been still more intense, the vegetable matter is changed to *anthracite* or stone-coal. This is a very hard kind of coal, with a metallic lustre, and will burn only if a good draft be supplied; then it evolves great heat, but no smoke or flame.

To this interesting series of coal, another substance, apparently not coal at all, should be added. This is the *graphite*, sometimes called plumbago or "black lead." It seems to be formed under the most intense effects of pressure and heat, and though it shows plain proof of its vegetable origin, has undergone such thorough change as to be entirely incombustible. It is used, in fact, as the material of crucibles, which are vessels for melting metals and other refractory substances. Graphite is also used in vast quantities in the manufacture of pencils.

Such is a very short chapter from the family history of a lump of coal. We see in that black mass the preserved matter of trees and herbs which flourished many centuries ago, and which has been safely buried and locked within the rocky cases of the earth's treasure-house, where, protected from disintegration through air and water, it has been effectually hidden till the day of man's greatest need. In its burning, the coal liberates for our benefit and comfort, the light and heat that fell upon it in the distant day of its growth. Through

the mystic processes of plant life, combustible matter has been separated from the air and soil and so preserved for use when most in need.

CHAPTER XLIV.

PICTURES IN THE ROCKS.

HE crust of the earth is to the thoughtful mind as a mighty book, bearing upon its stony leaves the history of the past. But the text of the volume is not entirely abstract nor wholly difficult to read. Upon its rocky pages are numerous pictures and illustrations, engraved with such perfection of form and detail that they are as useful to the earnest student as the originals would be.

In many parts of Utah, such picture-bearing rocks are common. There are lying before me as I write a number of those stony tablets, each telling of a life long since ended. Here is a piece of sandstone which I broke from a mountain cliff near Orderville in Kane county; there are upon it the pictures of two leaves—every line and fibre clearly shown. Surely the methods by which such delicate impressions could be preserved on so hard and enduring a surface, must be almost perfect. Here is another slab of stone; this is from the hills of Castle Valley; upon its surface are the impressions of hundreds of little mollusks, most of them varieties of snails, the graceful curves and the delicate tracery of their shells

more accurately shown than could be done by any feat of human sculpture or painting.

Fig. 32.—Ammonites.

Illustrations of a peculiar kind of mollusk called the *ammonite* are given in Figure 32. These fossils may be found in some parts of southern Utah. Ammonites varied from the size of a dime to that of a small wagon wheel. The shell of these animals was chambered; the last being the largest division and the one in which the animal lived. By forcing liquid into or out of the empty chambers, the ammonite could change its specific weight and thus rise or sink in the water at pleasure.

Yonder are some pieces of stone from the temple quarry at Manti; curious markings appear upon them; these are imbedded scales from a strange race of fishes, which once tenanted the briny waters that rolled over these valleys. Here, too, is a block of stone from Wyoming; it appears to have had painted upon it, the pictures of three fishes lying in different positions. Let us look again; it is no painting; it is an imprint taken from the objects themselves, when the rock was in a soft and plastic state, and every depression and elevation of body is plainly delineated.

A very peculiar animal called the *crinoid* has left its record in the shape of figure 33. In form it

Fig. 33.—Crinoid or “Stone Lily.”

appeared more like a flower than an animal, but it is possessed of a true animal body, and a calcareous shell, though borne upon a long, jointed stalk. A detached section of this stalk is shown below the main body in the figure. The name “stone lily” has been given to some species of these peculiar creatures. The jointed stalks or stems before referred to are hollow, and are found in some parts in very great numbers. They are popularly called “St. Cuthbert’s beads,” and are sometimes strung and used as ornaments. Large rock masses are often formed almost entirely of the consolidated remains of these crinoids.

Figure 34 represents such a piece; and specimens quite as beautiful as the one there shown may frequently be found upon our own hills. When polished, such a stone has a beautiful appearance, and is highly prized as an ornamental material, under the name of encrinital limestone or marble.

Evidences of former life, found in the rocks of the earth, are called by the general name of *fossils*, from a word, meaning really “dug up;” and the way

Fig. 34.—Encrinital Marble.

in which these fossils are produced is not difficult to discover. Look at the muddy river hastening toward its resting place in the lake or sea; beside the particles of clay and sand, it bears in its course, leaves and fruit that have fallen from overhanging trees; insects, by some mishap transferred from the aerial element to the watery; bodies of birds and small animals; all of these and many other objects are carried along, to be deposited, together with the sediments in the still water below. The bodies of aquatic animals, birds and fishes, fall also to the bottom, and are in time buried beneath the accumulating deposits. As we have before discovered, these strata of sand and mud soon harden into rock; but in the meantime the perishable structures buried there have undergone decay, if not destruction, though the impressions still exist in all

their original detailed beauty, and the harder the rock becomes, the more enduring will be the record of the beings that once found a grave within its substance. Truly, Agassiz, the great naturalist, was wise when he wrote, "The crust of our earth is a great cemetery, where the rocks are tombstones, on which the buried dead have written their own epitaphs!"

Let us stroll along the sandy shore of a fresh-water lake; we cannot fail to observe the shells that lie scattered in such numbers all about. Very likely some of them will be found filled with sand. Now we will dig to some little depth in the sandy shore; other shells will be found also filled with sand, but the filling is much more firmly and solidly pressed than was the case with the surface specimens. At a still greater depth we discover other shells, with the sand-filling forced into every curve and crevice of the inside, and as firm and solid as rock. What will become of them after the beach strata have hardened into sandstone? Though the shell-matter itself may disappear wholly or in part, the stony filling shows exactly how the shell was constructed within—we may rely upon the cast, for the shell itself was the mould, and the impression left by the imbedded shell is a representation of its outer shape.

There lies before me what seems, when viewed from a distance, to be one of the vertebræ or spine-bones of some animal. Such it is, or rather was, for by a closer examination we find from its weight and other characteristics that the specimen is really stone

and not bone; it would be usually described as a *petrified* bone. The word "petrified" means really "turned to stone;" but such a process as is implied in that expression is impossible. Bony matter does not consist of the same elements as stone, and one cannot be changed into the other. The explanation is this. The bone itself was buried beneath sedimentary material which underwent a change into solid rock. As the bone decayed, a cavity would be left within the rock; the percolating water, holding solid matter in solution, would find its way into the cavity and there deposit its solid contents, till the space was filled. But the decay of the bone took place slowly, particle after particle wore away and just so fast did the water leave rock matter to fill up the room; so that a petrification really is a body the particles of which have been *replaced by stone* as fast as they were separated by decay. Here is an interesting illustration of a partial petrification; it is a fossil tooth of a shark. It was found in the rocky ledges of South Carolina, and belonged doubtlessly to one of those savage rovers of the sea that inhabited the waters of that locality.

The rocks afford us other proofs of life than the actual impression of the decaying bodies. Waterfowl, stalking along the muddy banks of their native streams and lakes, leave thereon their footprints to be perpetuated in the future rock. Animals frequently come from great distances to drink at the rivers, and often leave their footmarks on the soft and yielding shores to testify, perhaps centuries afterward of their

existence. The water-beetle and the worm make tracings on the mud as signatures to attest their being.

Here is a piece of stone marked upon its surface by a number of indentations as if it had been battered by flying missiles of some sort. Figure 35 is a good picture of it.

Figure 35.—Rain drop marks in mud and in stone.

To understand its story we must again try to interpret the past by the present. Let us pay a visit to a half dried mud flat, during or immediately after a sharp shower, the mud has a battered appearance, which we know is due to the falling rain drops, and such must have been the cause of the indentations in that piece of stone. Yes, there is an unmistakable account of a prehistoric storm, the depth of the impressions tells us of its force, and

their shape indicates the direction from which the rain drops were driven, in that far distant time.

In walking along the shore of a lake, we observe the little waves rolling and rippling upon the beach, and leaving marks upon the soft mud or sand. After the sediments have become transformed into solid rock, the ripple marks still remain plain and uninjured; a slab of stone bearing such undulating marks is shown in figure 36.

Fig. 36.—Ripple Marks.

Who of us can in any way doubt the reliability of such stony records? Upon our own mud banks and lake beaches similar impressions are being *printed before our eyes*. Surely these stones speak, and that too in a language plain and unmistakable;—the way-faring man can read their words. The rocks declare the history of the past to all who are willing to learn.

Referring to such impressions in the rocks, Prof. Winchell has spoken as follows: "It is a solemn

and impressive thought that the foot prints of these dumb and senseless creatures have been preserved in all their perfection for thousands of ages, while so many of the works of man which date but a century back have been obliterated from the records of time. Kings and conquerors have marched at the head of armies across continents, and piled up aggregates of human suffering and experience to the heavens, and all the physical traces of their march have totally disappeared; but the solitary biped which stalked along the margin of a New England inlet before the human race was born, pressed footprints in the soft and shifting sand which the rising and sinking of the continent could not wipe out."

CHAPTER XLV.

CRYSTALS.

MAKE a strong brine, by stirring fine salt in a vessel of water as long as any can be dissolved. If this solution be carefully set aside so that it will not be shaken, or in any way agitated, after a time, some of the salt reappears in the solid state, but not as powder. Beautiful little blocks of salt form on the bottom and sides of the vessel, each of a regular cubical form. At first they are very small, but if left undisturbed, each increases in size, by the addition of layers of salt

deposited on the tiny cube. Nearly all mineral substances, under certain conditions, tend to assume regular and symmetrical shapes, producing solids, bounded by straight lines, perfect angles, and plane, smooth surfaces; and such are called *crystals*.

If a solution of alum in water had been used instead of brine, each crystal would have been in shape like a pair of pyramids, placed base to base, having eight sides all equal in size, and exactly alike in shape, if the crystallization had been uninterrupted. Every mineral has its own characteristic shape in crystallizing.

Man is unable to tell for what purpose, or by what laws substances are caused to assume such regular and symmetrical shapes; but this he does know, that from the earliest times these characteristic forms have been unchanged. Salt crystallizes in cubes; alum, as we have seen, in octahedra or eight side solids; quartz, which very frequently is found in crystal form, always as six-sided prisms, terminated by six-sided pyramids.

Figure 37 is a picture of a beautiful cluster of quartz crystals found in the rocks about Lake Superior. Such crystals are transparent and pass under the common name of *rock crystal*. They are used as gems, and are also of value in cutting glass. Quartz crystals are sometimes found of a very delicate violet tint, and such are known as amethysts. Many brilliant crystals are regarded as the most valuable treasures which the earth affords; such are the sapphires, rubies, topazes and diamonds. The

elements of which these precious stones really consist, are simple and common, but in a crystalline form they are both beautiful and rare.

Fig. 37.—Cluster of Quartz Crystals.

In order that any substance may assume the crystalline shape, its particles must be free to move in any direction, according to the laws of attraction operating between them.

For this reason, crystals form readily from a state of solution or of fusion. If a solid be dissolved, the particles are so separated and suspended within the solvent that they are free to obey any attractive force operating upon them; and so also if the solid be brought into a molten condition. But in a rigid solid, the particles are fixed and in consequence unable to move at all as they may be attracted.

We have seen that crystals form within the caverns of the earth, and also in the vein-cracks or fissures through the rocks; these were probably produced from a state of solution,—water, finding its way into the cavity with solid matter in solution, deposits the same in a symmetrical and regular shape. A pot of molten sulphur, cooled slowly, forms itself into a multitude of regular and beautiful crystals.

Within the mountain-caverns and the subterranean caves, the laws of Nature have operated to produce this crystalline arrangement of matter. This condition seems to be one toward which all mineral solids tend, and short of which they are not in a state of rest or contentment. Any disturbance of the particles in a solid mineral body is attended by an approach toward crystallization. The constant shaking to which the large axles of railway carriages are subjected, in time produces a crystalline arrangement within the metal; the particles being disturbed by the constant jarring, settle at last into the condition of greatest equilibrium, which is the crystalline state. It is a universal tendency of matter to gather particles of like kind together and place them in symmetrical order. In sandstone strata for instance, any particles of clay that may be present seem to be attracted toward one another till they form nodules or concretions of clay-stone in the midst of a sandstone formation.

Thus even among the ultimate particles of matter in their almost inconceivable minuteness, the laws of

orderly arrangement are supreme and obedience thereto is the rule. 'The earth's crust tends toward a crystalline state; and in inanimate matter the crystal is the type of order and system—in a crystal every particle seems to be in its proper place, each holding by its unseen bonds of affinity the particles about it, and being in turn held and bound by them. The prism of quartz, the cube of salt and the foliated mica crystal, all declare by their very existence, the mathematical accuracy, according to which the forces of the universe operate and co-operate. In shaping the crystal of stone, no less than in determining the orbit of the world, the Creator teaches us by example "the principles of a perfect geometry."

PART IV.

The Heavens.

“The heavens declare the glory of God, and the firmament sheweth His handiwork.”

“He telleth the number of the stars; He calleth them all by their names.”—*Psalms*.

“Behold, all these are kingdoms, and any man who has seen any or the least of these, has seen God moving in His majesty and power.”—*Doctrine and Covenants*.

CHAPTER XLVI.

A GLANCE AT THE SKY.

OUR interesting survey of Nature in her beauty need not end with the decline of day. By night also the manifold labors of our Omnipotent Father declare to the listening ear His majesty and might. Do but lift the eye toward heaven upon any clear night, and let it dwell upon that wondrous dome of crystal, whose bounds are only set by the powers of our own vision. Man cannot gaze upon such a spectacle without feeling within his soul those stirring emotions that are always prompted by the presence of the supremely grand.

Wonderful, indeed, are the charms of mountain

and plain, river and lake, with their living miracles of trees and flowers, butterflies, birds and beasts; yet beyond all these, in the far-away depths of space we can discern the lustrous twinkling of other worlds, many of them larger and apparently more awe inspiring than our own.

The thoughts aroused by the contemplation of such a scene of heavenly grandeur cannot be otherwise than elevating in their nature.

“Oh! who can lift above one careless look

While such bright scenes as these his thoughts engage;
And doubt, while reading from so fair a book,

That God’s own finger traced the glowing page;
Or deem the radiance of yon blue expanse,

With all its starry hosts—
The careless works of chance?”

Our wonder and admiration, however, are somewhat checked because of the frequency of the sight; for in our weakened natures, that which has not the air of novelty about it is apt to be considered common-place and worthy of but little notice. Emerson has expressed a deep thought by his words:—“One might think the atmosphere was made transparent with this design, to give man in the heavenly bodies the perpetual presence of the sublime. Seen in the streets of cities how great they are! If the stars should appear one night in a thousand years, how would men believe and adore; and preserve for many generations the remembrance of the city of God which had been shown. But every night come out these preachers of beauty and light the universe with their admonishing smile.”

In all ages, mankind has shown a greater tendency to contemplate the wonders of the sky, than to learn from the nearer and the simpler creations of earth. The heavenly bodies have even possessed for him a deep fascination; they seem to be present, and yet are inaccessible; he yearns to know the nature and purpose of their being, and reaches out toward the realization of that desire, as the babe stretches its tiny hands to grasp the glittering moon. There is a mystery about these ornaments of the sky, and this feature is alone sufficient to inspire within us an attempt to fathom it.

In the oldest times, men delighted to gaze upward upon the diamond vault, and strove to read the meaning of that emblazoned canopy. The occupations of the people in those times were mostly farming, stock raising, hunting, and other open air pursuits; and such would favor contemplative study of the stars. It seems perfectly natural that the shepherds of Chaldea, watching their flocks by night, should be among the first to recognize any unusual appearance or new arrival among the great family of visible worlds. And beside, the people had fewer books than have we to-day; they devoted less time to reading and more to thinking. The changes in the positions of the heavenly orbs marked the natural divisions of time; and for traveling, the sun and stars served as guides. There was a time when the lights of the sky were the only compasses, almanacs and clocks that man possessed; and so deep were his feelings of admiration and wonder toward

these heavenly bodies, that many early nations rendered to them an idolatrous homage.

The science that deals with the sun, moon and stars—the heavenly bodies as these distant creations are called—is *Astronomy*. This word is in reality made up of two Greek terms and means the “science of the stars.” This is indeed the oldest of all branches of science, so old in fact that history tells us but little of its origin, almost all famous nations of antiquity claiming to have been the founders of the science. The Chaldeans, who inhabited the city of Babylon, and the region round about along the banks of the Euphrates in Asia, also the Egyptians, the Chinese, the Hindoos and the Greeks, all pursued attentively the study of the stars in very early times. At the time of the surrender of Babylon to Alexander the Great, about three hundred years before the time of Christ, the inhabitants had among them records of astronomical observations extending back nearly to the supposed date of the tower of Babel.

The earth seems to be situated in the centre of an azure dome, across which the sun appears to move in slow, majestic state, rising at morn in the east, reaching his highest point at noon, and sinking at night below the horizon in the west. During the hours of darkness, however, the position of the sun with reference to any part of the earth, is so changed, that at the proper time, that luminary appears again in its usual place, in the eastern horizon; rising and beginning the march of another day. By night,

however, the heavenly vault presents a much more diversified appearance. At regular periods the moon is seen following a course nearly the same as that of the sun, in her apparent journey from east to west; and on all cloudless nights, the multitudes of stars shine out in dazzling beauty as they move in triumphal procession across the gleaming arch.

A little careful thought and consideration will convince us that this seeming motion of the heavenly bodies day after day is in fact a delusion, depending upon the actual motion of the earth. It is doubtless true that each of the heavenly bodies has a motion of its own; in some cases this can be readily perceived, in others less so on account of the exceedingly great distances by which some stars are separated from the earth; but they do not really make a daily march about this little world of ours. We have perhaps noticed while riding in a swiftly moving railway carriage that we unconsciously transfer our own motion to the fixed objects along the line of travel. The trees and fences seem to dart hurriedly past while we imagine ourselves as remaining still. We know at once that this appearance is a false one; the posts and the trees are firmly planted in the ground while we are swiftly moving. So with the heavenly bodies about the earth; they appear in motion while the earth seems at rest.

The earth is known to revolve once upon its axis in the space of a day; as a large ball or a bead may be twirled on a string. Imagine such a revolving ball, and upon its surface a fly; the insect would in

all probability see the fixed objects about the ball as if they were in rapid motion. We conclude, therefore, that the uniform and regular daily motion of the sun, moon and stars about the earth, is but an apparent one produced by the rotation of the earth upon its axis.

While speaking of the natural objects to be seen upon the earth—the animals, plants and rocks—we referred very frequently to the microscope, a wonderful instrument, by the aid of which, small objects are made to appear many times larger than they really are. The astronomer employs another instrument no less useful in its application, nor less wonderful in its results. This is called the *telescope*, and through its assistance distant objects appear much nearer and larger than ordinarily. By means of this instrument, the heavenly bodies have been carefully examined, and their appearances and position described. The telescope proves to us also that many of the faintest and seemingly smallest stars in the sky are in reality large and bright; though they are so far away from us that their light appears but dim to our unaided vision. By this magic glass countless numbers of stars, otherwise invisible, are brought within the range of vision; and beyond these again, unnumbered others are seen faint and dim even through the most powerful instruments.

Where ends the mighty hosts of worlds? This is not for man to know as yet; it is beyond the powers of his understanding; he can simply acknowledge

with reverence and with praise the endless results of his great Father's labors. There are the *Kokaubeam* without number, yet all in orderly array, each with its path among the other bodies, allotted and decreed; there is *Olea* in all her silvery splendor; and *Shinehak*, in his glorious majesty shedding beams of light and warmth upon many worlds. (See Pearl of Great Price, Book of Abraham.)

CHAPTER XLVII.

THE SUN.

HE sun is to us the most brilliant of all the lights of the heavens; so intense is its lustre that with the unprotected eye we cannot look upon it. If, however, we hold between the sun and our eye a piece of dark-colored or smoked glass, that body appears of a circular form, and to most people seems of about the same size as the disc of the full moon. Astronomers have measured the dimensions of the sun as accurately as their instruments and their skill would enable them to do; and as a result they tell us that 1,245,000 earths like ours would be required to form a body equal in size to the sun. By careful measurement our earth is found to be about 8,000 miles in diameter; the sun is said to have a diameter of over 860,000 miles. It is only the enormous distance between the sun and the

earth that gives to the former its apparently small size. The accepted distance of the sun from the earth according to present measurements is 92,880,000 miles—a number far beyond the comprehension of any of us. Let us seek some more definite idea of these figures by comparison.

If it were possible to make the trip between earth and sun by road, traveling at the rate of thirty miles per day, we would need eight thousand four hundred and eighty-two years in which to accomplish the journey; an express train traveling at the rate of thirty miles per hour without stops could traverse the distance in three hundred and fifty-three years, and the fare for the round trip (without return tickets), at the rate of four cents per mile, would be \$4,715,200. The electric current, which carries a telegraphic message between any connected points upon the earth without appreciable time in transit, would require five minutes to accomplish the journey between us and the sun; and a cannon ball fired toward the sun, if it retained its initial velocity, and moved in a straight line, would be nearly ten years on the way.

It should be remembered that these figures are based upon the most accurate measurements thus far made; but we have no conclusive proof, that the results are in every way correct and reliable. Of this, however, we may feel sure, that in speaking of distance, with reference to the sun, or any other of the heavenly bodies, measurement by miles, almost loses significance; those orbs are far, far away; the

dimensions of space are boundless; to the universe of God there is no end.

The rotation of the earth upon its axis turns each side alternately toward and away from the sun, giving rise thereby to the regular succession of day and night.

That part which is directed toward the sun receives its light, and in consequence experiences day; while the opposite half of the earth being deprived of sun-light passes through its night.

As seen from the earth, the sun appears to change its position in the heavens with the passing of the year; during our winter it is far toward the south, while during the summer months, it appears to traverse its daily course in a line almost over our heads. This appearance is also due to the changes of the earth as it moves in its orbit; and a consequence of such motion is the change of seasons.

In Figure 38 the sun is represented near the centre of an elliptical orbit, around which the earth is shown in several different positions. It must be remembered in thus picturing the earth in its yearly journey that the directions of the earth's axis is not changed to any appreciable extent; the north pole being apparently directly under the Polar Star. On the 22nd of March and the 22nd of September of each year, the earth is in such position that the rays of the sun fall directly upon its equator. This is an imaginary line passing around the earth in an easterly and westerly direction, and situated at equal distance from the poles. The effect of this position is, that

at such times all parts of the earth experience the same duration of light and darkness; the days and nights are then equal over the earth; and such

Fig. 38.—Diagram of the Earth's orbit.

occurrences are called the *equinoxes* or times of equal nights. On December 21, the earth reaches a position, shown in the figure, so that the sun shines

more directly upon the southern hemisphere, giving to that half of the earth therefore its summer, while winter reigns upon the northern section. Six months later, on June 21, the earth has passed to such a position that the northern hemisphere receives the direct rays of the sun, and in consequence, experiences its summer; this time the southern half of the earth is passing of course through its winter season.

In reality the sun does not occupy the exact centre of the elliptical orbit along which the earth moves, and therefore the earth is nearer the sun at one time than at others. The earth reaches its point of greatest distance from the sun July 1, and this position is called its *aphelion*. On December 31, of each year, the earth is at its *perihelion* or least distance from the sun. The hieroglyphic figures accompanying the names of the months upon the diagram, are symbols of particular groups of stars, which appear close to the sun at those times. From the fact that the earth is in its perihelion at the time of the northern winter, and in aphelion during the northern summer, these seasons are much more moderate in our hemisphere than in the southern.

To the inhabitants of the earth the sun is of more general interest than any other of the vast orbs of heaven. From the sun seem to come the light, and heat and chemical power without which life would soon cease to exist upon our globe. That great luminary has been placed in the firmament "to rule the day" and to make of this globe a fit habitation for plant and animal and man.

As a result of careful measurement it is said that the amount of heat received by the earth from the sun during a year is sufficient "to boil an ocean of ice water covering the whole earth to a depth of eighty feet;" and the total heat radiated by the sun in that space of time is 2,300,000,000 times as great as that received by the earth. Prof. Proctor said "In each second the sun sends out as much heat as would be given out by the burning of 11,600,000,000,000,000 tons of coal." The noted astronomer, Sir John Herschel, calculated that a solid cylinder of ice forty-five miles in diameter and 200,000 miles long, if plunged into the sun, would be melted by the intense heat of that body, in one second of time.

The light of the sun is no less surprising in its degree. It is many times as intense as the brightest electric light and every other artificial light appears absolutely black when held before the sun. The sun radiates 600,000 times as much light as the full moon.

Soon after the invention of the telescope, in the early part of the seventeenth century, dark spots were observed upon the sun. This discovery produced a consternation among the superstitious people of that time; they had always learned to regard the sun as an emblem of purity and unsullied brilliancy. and the thought of blemishes upon its fair face was most repugnant to their prejudiced minds. It is now known that spots are usually present on the sun's surface, and sometimes of such a size as to be seen by the naked eye. These spots are often of

enormous size: Shroeter measured one over 29,000 miles in diameter; Sir John Herschel names one of 50,000 miles diameter. The black appearance of the spots is due to the effect of contrast. As has been said, the brightest artificial light appears dark when projected upon the face of the sun, owing to the superior brilliancy of the latter; and so also do we suppose the spots to lack brightness; but in truth the blackest of them would be of insufferable brilliancy when compared with earthly lights. Many opinions have been advanced by scientific men as to the nature of the spots: some consider them merely clouds floating in the solar atmosphere and others regard them as rents in the enveloping layers of the sun, through which the darker nucleus below is revealed. Of their true nature, as indeed of the constitution of the sun, and the structure of the heavenly bodies in general we know but little.

CHAPTER XLVIII.

THE MOON.

SECOND in brilliancy among the great lights of the firmament is the Moon. Though appearing almost as large as the sun, it is in fact the smallest of the heavenly bodies ordinarily visible. Its comparatively short distance from us adds to its apparent size. By measurement, the moon is found to be only one-fiftieth as large as the earth.

When near the horizon, the moon appears much larger than when high in the heavens toward the zenith, though in the latter position the moon is nearer the observer than when at the horizon by the semi-diameter of the earth. We may explain this illusion of distance as follows: When we perceive the moon apparently close to the surface of the earth, as when on the eastern or western horizon, we are more fully aware of its distance, and unconsciously correct our mental impressions as to its size, and conceive it to be much larger than it really is.

The moon, too, is nearest to the earth of all the bodies in space; she is really the companion of the earth. In round numbers the moon's average distance from us is placed at two hundred and forty thousand miles, which, though an enormous distance in comparison with any terrestrial measurement, is but very small when considered in connection with the figures denoting the distance of the sun or any other of the heavenly bodies. The moon moves around the earth in a manner somewhat similar to the earth's revolution about the sun; and in consequence, our satellite appears in widely varying positions at different times.

Figure 39 represents the earth as situated near the centre of the path of the moon, and the latter appears in several different positions along its course. The upper part of the figure is illuminated, to indicate the direction of the sun, from which light falls both upon the earth and the moon, 'these being

dark, opaque bodies, capable of giving light only by reflecting the rays of the sun. The moon being approximately globular in shape, only one-half of its surface can be illuminated by the sun at any one

Fig. 39.—Diagram of Moon's Orbit.

time, and the portion that is turned away from the sun will be in darkness and night. In the figure, therefore, the upper half of the moon in each of its positions is shown as brightly illuminated. By the

side of each representation of the moon along its orbit, is an illustration of its shape at such position as viewed from the earth. Thus, when the moon is between the earth and the sun, its illuminated part is turned away from us; this is called *new moon*; and at such time the disc is invisible to us; we speak of the moon as new after it has moved slightly forward in its orbit, so that a small portion of its illuminated half is visible in the form of a crescent. At the time of *full moon* our satellite is seen in the part of the heavens opposite to the sun; its whole illumined part is then turned toward the earth and a full disc is seen. When half way along its course from new to full moon, one-half of its lighted part, that is one-fourth of the whole surface is seen from the earth; this position is called *first quarter*. So also when the moon is half-way along its path from full to new moon, it is said to be in *last quarter*. As the figure indicates, while passing from new moon to full moon, the illuminated part visible from the earth grows larger; this is called the "waxing moon;" along the opposite half of its orbit the visible part grows smaller, producing the phenomenon of "waning moon."

The moon accomplishes a revolution around the earth, moving from west to east, in about twenty-seven days; and therefore appears each day farther east than at the same time on the preceding day. This causes the moon to appear on the eastern horizon somewhat later each day; the daily retardation amounting to about fifty minutes. The moon

turns upon its own axis in about the same time that it takes to revolve about the earth, and so shows but one side to the earth. The moon requires nearly a month in which to turn once upon its axis; this is therefore the length of the lunar day. The sun shines without intermission upon one part of the moon for nearly two weeks, and then sets, to remain absent for the same length of time. The extremes of heat and cold upon the lunar surface must be therefore very great.

The peculiar markings so readily seen upon the face of the full moon have always excited the interest of even superficial observers. We remember perhaps our nursery stories about the "man in the moon;" though a strong imagination is required to picture any human form upon the moon's bright face. The telescope shows these markings to be due to numerous elevations and depressions upon the surface; there are mountains and valleys upon the moon as upon the earth; and the sides of many such inequalities are steep and precipitous. No one has yet succeeded, even by the assistance of the best telescopes, in discovering the presence of water upon the moon, and if water be entirely absent there can be no rain or snow, no clouds and no atmosphere of appreciable density.

If there be observers on the moon, the earth must present to them a spectacle of indescribable grandeur. When its illumined sides were visible, the earth would look like an enormous moon, having four times the diameter, and thirteen times the

extent of surface which the full moon has to us. The earth would seem to assume all the phases which the moon presents to us. There would be "full earth," and "new earth," and all intermediate shapes; but in an opposite order to that of the moon. Thus, when the moon is to us new, the earth would appear full, as seen from the moon, and so on. The effect of "earth-shine" upon the moon is easily seen, just after the time of new moon; the brilliant crescent then seems to embrace within its curve the feebly illuminated part then turned from the sun. This appearance is pleasantly spoken of as "the old moon in the new moon's arms;" and it is produced apparently by the earth-shine lighting up the lunar surface. The dark part of the moon is passing through its time of night, and the gloom is lightened by the light reflected from the surface of the earth.

The earth would not seem to rise and set, however, as seen from the moon; the same part of the moon being always turned toward the earth, the latter would appear always in the same quarter of the lunar sky. To an observer, near the middle of our side of the moon, the earth would seem always to be overhead; to one near the edge, the earth would seem to be on the horizon, from the farther side of the moon the earth would be of course entirely invisible.

ECLIPSES.

The movements of the earth and moon as already described explain fully the common phenomenon of

eclipses. Eclipses of the sun are caused by the moon passing in its orbit between the earth and the sun, so as to shut off the light of the latter, and cause darkness upon the earth, wherever the shadow of the moon falls. If the moon appears to cover the entire surface of the sun, a *total eclipse* results; if only a portion of the sun's disc be obscured, the effect is to produce a *partial eclipse*. A solar eclipse, as is seen from this explanation, can only occur when the moon and the sun are in the same quarter of the heavens; that is to say at new moon. Some disbelievers in the Bible have tried to explain the darkness that fell upon the earth at the time of the crucifixion of Christ as the result of an eclipse of the sun. This, however, could not possibly be the cause, for the Jewish Feast of the Passover, at which time the crucifixion took place, was always held during full moon; and at such time no solar eclipse was possible.

An eclipse of the moon takes place whenever that body passes into the shadow of the earth; and this of course is only possible at the time of full moon when the moon is on the dark side of the earth.*

By a careful study of the motions of the earth and moon, astronomers are able to predict eclipses with

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* "Eclipses, especially total eclipses of the sun were greatly dreaded by the ancients; and are still dreaded by uncivilized peoples. The Hindoos believe that in a solar eclipse, some monster is trying to swallow the sun. At these times they all turn out with gongs, and every possible noise-producing instrument, and keep up the loudest, and most hideous noises, until the frightened monster disgorges his fiery mouthful."—*Sharpless & Philips*.

great accuracy long before their time of occurrence. It is related by several reliable authorities that Columbus once profited by his foreknowledge of an eclipse of the moon in a rather remarkable way. In 1504 he was wrecked off the coast of Jamaica, and all attempts by persuasion and by threat to procure food and assistance from the natives were utterly unsuccessful. He told the savages that in consequence of their unkind treatment of him, their Great Spirit was angry with them, and would that night darken the moon as a sign of His displeasure. When the eclipse began, the superstitious Indians were greatly frightened, and hastened to do all in their power for the comfort of Columbus and his crew, beseeching him to ask forgiveness of the Deity in their behalf.

CHAPTER XLIX.

THE STARS.

LET us lift our eyes toward the great sky-dome upon some clear night when the moon is absent. Surely none but an infinite power can count these glimmering lights; these "lamps of the universe" as they have so appropriately been called. Think of those unnumbered worlds, and learn that there is one mind supremely great; one who telleth the number of the stars, and calleth them all by their names. But not alone to counting does His power extend. He is at once architect and builder of this imposing structure of creation.

If we note carefully the position of several prominent stars for a number of nights in succession, we will most likely discover that some of them change their position relative to the rest from night to night, just as the moon is seen to apparently move among the stars; while others,—and these the greater number—seem to retain a fixed position, never appearing nearer to or farther from their neighbors. The wandering stars first referred to above will be found very near the daily path of the sun in the heavens, none of them are seen far to the north or the south; and these have been called *planets*,—the name meaning really “rovers.” The second class of stars are called *fixed stars*.

All the great family of planets move round the sun in regular order and at a fixed speed, each accomplishing its long journey always in the same interval of time; though this is different for each planet. All of these wandering stars derive their heat and light from the same great luminary.

There is *Mercury*, which of all known stars is the nearest to the sun. It moves along its path at the surprising speed of thirty miles a second; and completes its orbital journey in the space of about eighty-eight days. This, then, is the duration of the Mercurial year, there being but twenty-two days in each season. In size, this body is about one-sixteenth that of the earth.

The next planet in order of distance from the sun is *Venus*, the brightest star in the heavens, though in reality not nearly so large as the earth. She

moves about the sun, however, along an orbit within that of the earth, and consequently receives more solar light and heat. When in a position west of the sun, she rises earlier than the orb of day, and is known as the "morning star," but when moving east of the sun, she is seen in the western heavens after sunset, and is honored by the title of "evening star." Before the motions of Venus had been carefully studied, these two appearances were supposed to be distinct stars, and were named accordingly, Phosphorous or Lucifer, the Star of the Morn, and Vesper, or the Star of Eve.

Being entirely within the orbit of the earth in all her movements, Venus presents in different positions all the phases or changes of the moon. Next to the orbit of Venus comes that of our *Earth*; for though appearing to us so different from the brilliant stars of the sky, the world we inhabit is really one of them, and moves in obedience to the same laws that hold Venus in her orbit, and that urge Mercury along its fiery path. And beyond our earth *Mars*, the ruddy star, rolls on its way. This planet also is smaller than the earth—being about one fourth the volume of our globe, and requiring about two years in which to complete a revolution around the sun. Still farther off in space is *Jupiter*, the giant planet, moving in majestic state along its prescribed path, and requiring about twelve years in which to complete a revolution. This enormous world is fourteen hundred times as large as ours; its volume is about one tenth that of the sun. Four moons attend it

along its path and reflect the rays of the sun upon its surface.

On the outside of this orbit is that of *Saturn*, which planet is surrounded by a beautiful ring, and is accompanied by eight moons. It rolls once around the sun in thirty years. Still beyond, are *Uranus* and *Neptune*; the former making a revolution about the sun once in eighty-four years, and the latter in one hundred and sixty-five.

The sun, with its family of planets, and their satellites or moons, constitutes the so-called solar system. Wonderful as are these circling bodies, and great as are their separating distances, this system appears to be but one among many in the boundless fields of space.

From what can be learned of the fixed stars, they are all self-luminous bodies like our sun; and each of them may be the central orb of a vast system of planetary bodies, equal to, and perhaps surpassing our own in grandeur. Even without assistance to our vision we may detect many patches of hazy starlight—almost like clouds. The telescope, turned upon such a foggy field, shows it to be but a cluster of numerous stars, differing widely from each other in size and brilliancy, and separated by distances not to be counted in miles.

Figure 40 represents such a misty patch in the constellation Toucan, one of the constellations visible in the southern heavens. To the naked eye this seems nothing more than a very faint cloud; but with telescopic aid it appears to be composed of

innumerable points of light, each telling the location of a bright and blazing sun.

Fig. 40.—Star Cluster in the Constellation Toucan.

The Milky-way or Galaxy may be seen on any moonless night stretching across the heavens as part of a great circle. It looks ordinarily like a ring of misty light, but the telescope shows it to be composed of unnumbered millions of stars of varying degrees of brightness.

Beside such, there are in the heavens numerous hazy patches which even the most powerful instruments fail to resolve into any appearance but that of fog or mist. These are called *Nebulae*, and poetically termed “star dust,” though their true nature man is unable to learn.

Figure 41 is designed to represent an annular or ring-like nebula in the constellation of Lyra. The smaller representation gives its appearance as viewed

Fig. 41.—Annular Nebula in the Constellation Lyra.

through a telescope of moderate power, and the larger picture is as the nebula appeared in the enormous Rosse reflector. The outer part seems to consist of separate and distinct stars, while the middle portions seem of a gauzy or filmy nature as if consisting of tiny particles. "Tiny," we say, but only by comparison, for to be seen at all at that enormous distance, the tiniest speck in that great "ring universe" must far surpass in size and brilliancy our effulgent sun.

The distance between the earth and the nearest fixed star is estimated at 20,000,000,000,000 miles; but what does such a number signify to our finite minds? Light travels through space at the inconceivable velocity of 186,000 miles per second, a speed sufficient to encircle the globe seven times while a watch ticks once. Light passes from the sun to the earth in eight minutes; but not less than three and

a half years must elapse while light travels from the nearest fixed star to the earth; over forty-five years are required for us to receive light from the Polar Star; and the luminous rays that come to us from many of the farthest stars, must have set out on their journey centuries ago.

If such be the wonders of matter, how passing wonder must be He who made all such! The Creator of all we see, according to whose word the heavenly spheres are formed and the forces of the universe are governed—He is our Father; and it is He whom we profess to worship.

CHAPTER L.

CONCLUSION.

THE pages of our little volume are nearly complete. In their course we have bestowed some attention upon a few of the unnumbered objects of our Father's creations. We have spoken of the animals, plants, and minerals of earth, and also of the brilliant orbs of the sky. In the contemplation of all these, we have seen unmistakable proof of a wise and powerful direction; the hand-marks of a Creator are left upon the fabric of Nature in every part; all things, the small and the great, declare with one accord the wisdom of the Almighty Mind that called them into being.

At every step in his attempts to fathom the

“thoughts of God,” as expressed in the visible forms of creation, the student finds himself on the verge of the unknown; he feels ever as if traversing the frontier of an unexplored realm of truth; and without the aid of a Divine director he is apt to wander into dangerous paths. But to the thoughtful and prayerful pupil, the Master is ever ready to impart knowledge and power. Knowledge has no permanent value only so far as it insures to its possessor a firmer reliance and a more implicit trust in the wisdom and might of his heavenly Parent.

To the thoughtful observer, there is more than melody in the throbbing ecstasy of the singing bird; there is much beyond grace of movement, and brilliancy of hue in the flitting butterfly; the flower is more in his eye than a bunch of pretty leaves upon a stalk, such as a skillful artist might in some degree imitate with wax and paint; to him, the sun by day, and the moon and stars by night are not mere lamps to light the world—in all of these he sees and recognizes the existence of a perfect design, that could have originated only in the mind of Omniscience.

Well has it been said, that order is Heaven’s first law; and the second is like unto it, that everything in nature has a purpose; these constitute the sum of all science. ‘This is Nature’s hymn of praise to the Creator, chanted by the lowly objects of earth no less than by the majestic worlds of the universe. “In Him we live and move and have our being.”

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