B. Land-zonal periods. Zones of climate, continental climate, and unquiet shallow seas. Plants and animals are developed on the increasing land; but in the sea they are changed or destroyed by its saltiness, calcareousness, cooling, and restless surface. The continually increasing land-flora causes permanent rivers, hinders the passage of the clastic products considerably, favours their decomposition, and consequently the increase of salt and lime in the sea. With the development of terrestrial fauna and flora the proportion of carbonic acid in the air is raised, and land-plants increase. 8. Eighth, or dizonal-littoral (two-zoned littoral) period (Mesozoic). Broad mid-zone tropical; polar zones subtropical: $1\frac{1}{4}$ –2 *per cent.* of salt in the sea. Flora and fauna more limited to the shore and neighbourhood of inland waters. 9. Ninth, or dizonal-continental period (Tertiary). Tropical mid-zone and temperate polar zones: up to 3 *per cent.* of salt in the sea. Flora and fauna more continental. The shiftings or derangements in the crust of the earth reach their maximum. The greater cooling causes great variability in plants. The origin of man, at first black only, dates from this 9th period. 10. Tenth, or three-zoned (trizonal) period (Quaternary). Hot, temperate, and cold zones. Development of the existing conditions.

The main principles and very much of the details on which the foregoing classification of the geological periods and orders of nature has been founded by the author are treated of in Chapters IV.–XI. Thus:—the climatic interpolations of the geological periods, the progressive salinity of the ocean, the absence of salt or muriatic acid in the inclusions of the last-formed primary quartz, the passing of fish from fresh to saline water, the sea containing in early times some phosphate of lime and more of lime than soda, the salinity of fresh water, geological time, the Caspian anciently freshwater, the gradual decrease of lime in the sea, carbonic acid in the economy of nature past and present, hypotheses of the developmental condition of early marine beings, the relationship of the oldest recognizable land-plants to sea-weeds, the genealogy of the vegetable kingdom (table, p. 140), the differences between Monocotyledons and Dicotyledons explained by their developmental history, carbonaceous sediments in the sea, proofs of the oceanic life-habits of all coal-making plants, and refutations of erroneous hypotheses of the formation of coal. This last subject is very fully treated in Chap. XI. under more than forty headings. Arguing throughout on premises of his own making, the author satisfactorily arrives at his own conclusions, which are far from being in accordance with the views of geologists and botanists of the present day.

MISCELLANEOUS.

On the Operculum of the Gasteropoda. By M. HOUSSAY.

IN 1825 Blainville wrote, in his ‘*Manuel de Malacologie*,’ as follows:—

“The operculum is evidently the production of the skin which

covers the foot. . . . But how does a flat oval or circular surface produce a material which rolls into a spiral, often in a very regular manner, and sometimes forming a great number of turns? It is a question which it really seems to me very difficult to answer, perhaps especially because it has not been sufficiently studied."

In 1829 Dugès endeavoured to fill up this gap, but, considering only opercula detached from the animals, he arrived at the false conclusion that the operculum is a production of the mantle. The authors who have followed him have scarcely attempted to do more than try to find out with what part of the Acephala the operculum was homologous; but, as they had no basis for their argumentation, they arrived at the most contradictory results, some regarding it as the homologue of the second valve of the Lamellibranchs, others, like Lowén, comparing it with the byssus.

The foot alone is implicated in the formation of the operculum, and I have set myself to determine precisely what parts of this organ excrete the material, and how the growth of the operculum takes place. Contrary to what is generally supposed, I have ascertained that the whole surface of the foot does not take part in the production, but only a very clearly defined small portion.

I shall give the name of the *columellar margin* of the operculum to that which lies on the side of the columella when the animal is withdrawn into its shell, and that of *parietal margin* to the opposite part. The operculum presents an internal and an external surface; it is necessary to distinguish them, as they have not the same mode of formation.

Let us first of all see to the external part. It presents on its surface striæ of variable form according to the genera under examination. On examining carefully a *Littorina*, a *Murex*, or a *Purpura*, we observe, quite close to the columellar margin of the operculum, a small transverse fissure which penetrates about 1 millim. into the thickness of the columellar muscle, and which occupies the whole length of the foot. The walls of this pedal fissure are lined with a peculiar epithelium, folded, or rather goffered, so as somewhat to resemble the polypary of a *Mæandrina*. We see within it a very delicate and very flexible transparent lamella. With a fine needle this lamella may be taken out, when after remaining for some time in the air, it dries and acquires a horny appearance.

By making sections we find that the epithelial cells of the fissure excrete a structureless material, of a yellowish colour, and strongly refractive, which, by agglomeration, constitutes the hyaline lamella. The latter issues from the pedal fissure and adds itself to the old operculum.

The newly formed parts apply themselves to the epithelium situated between the fissure and the parts of the operculum which are already fixed. At this point the epithelial cells are but feebly adherent to each other, and only by their basal part, a remarkable exception among epithelia. From this it results that the still plastic opercular material invests these cells, and even diffuses itself

somewhat among the elements of the subjacent tissues (muscular fibres and connective cells). It is thus that, by successive appositions of new parts issuing from the pedal fissure, the striæ are formed, of which only the most salient are visible to the naked eye or the lens.

On the other surface of the operculum we must distinguish two regions, the surface of insertion of the columellar muscle, and the free internal surface. It is very easy to see that the free inner surface and the outer surface of the operculum have not the same constitution. The inner surface is covered with a homogeneous layer which forms, as it were, a varnish without any striæ perceptible to the eye. This coating may even be so thick that we cannot see through it the striæ of the other surface (*Murex*). In other cases it is delicate enough not to hide them (*Littorina*, *Trochus*). This difference of constitution arises from a difference of origin. In front of the surface of insertion the metapodium forms an anterior expansion or lip, which, during the life of the animal, is constantly applied against the inner unattached part of the operculum. The epithelial cells of this anterior lip produce the varnish.

It still remains to ascertain why the opercular material is rolled into a spiral. To elucidate this point we must study the muscular impression. As the operculum grows, the surface of insertion of the operculum is displaced with a slight movement of rotation, since during the same time the shell grows in a spiral. The muscle attaches itself to the newly formed parts, abandoning the old parts on the side of the parietal margin. These stages of the columellar muscle are marked by striæ independent of those of the superior surface. We observe them when preparing an operculum after removing all traces of muscle. By studying these lines we can even understand why there are opercula of which the form always remains the same, while there are others of which the form varies with the age of the animal. The latter are said to have a *nucleus of formation*. The posterior secreting portion of the foot always retains the same form in the first case, whereas in the second we see it from nearly circular become almost straight.

Thus we see that the operculum is a production of a definite portion of the epithelium of the foot, and appears to be very different from the byssus of the Acephala, which is produced by a highly developed gland occupying a good part of the volume of the foot. It is still more different from the second valve of a shell.—*Comptes Rendus*, January 28, 1884, p. 236.

A Fungus infesting Flies.

Prof. Leidy directed attention to a vial filled with flies adherent to fragments of leaves. He stated that on the 1st of August, the last summer, he had noticed that from the swarm of flies that were attracted by the ripe fruit of a black mulberry, *Morus nigra*, many settled on the underside of the leaves, and there became fixed and died from the invasion of a fungus, in the same manner as the

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