THE SKELETON OF INVERTEBRATA.

A great and fundamental distinction exists, however, between those lowly organisms known as *Protozoa* or *Hypozoa—*which are generally reckoned as animals—on the one hand and all the higher forms, both Vertebrate and Invertebrate, on the other. It is a dis­tinction which renders it difficult to regard any skeletal structures of the *Hypozoa* as answering to, in the sense of being the homologues@@1 of, any of the skeletal structures of higher animals. This great funda­mental distinction consists in the fact that the bodies of all the higher animals are made up of distinct “tissues,” which are derived from three different layers of cells, of which the embryos of all@@2 of them are for a time composed, whereas the bodies of the *Hypozoa* either consist of but a single cell or else of a smaller or larger number of cells more or less loosely aggregated and not forming any distinct tissue. It follows of course that their reproduction does not take place by means of embryos formed of cellular layers.

Nevertheless the *Hypozoa* or *Protozoa* may exhibit very distinct protective structures. Thus the outermost layer of the substance of an *Amoeba,* called its ectosarc, is of a firmer consistency than its interior, and it may in allied forms take on a chitinous character or become quite hard through the deposition within it of calcareous salts (as in the sometimes singularly complex shells of the *Fora- minifera)* or form symmetrical cases of silica.

In the *Radiolaria,* the skeleton of the *Protozoa* attains its maxi­mum of beauty and complexity. It consists of spicules which are generally siliceous, but may consist of a peculiar firm organic substance termed “ acanthin. ” The spicules arrange themselves in an extraordinarily symmetrical manner, generally radiating from the central portion of the organism and being connected with one or more series of encircling spicules which may constitute a series of concentric spheres.

Among the *Infusoria* we also find examples of a hardening of the external cuticle, as in *Tintinus lagcnula* and in some other forms.

When we pass to that vast group of animals—the *Metazoa—* which includes all but the *Protozoa* (and all those therefore the bodies of which are formed of tissues derived from the three primitive layers), a distinction again requires to be drawn between the Sponges *(Porifera),* which constitute its lowest group, and all higher forms. The three primitive or germinal layers of the *Metazoa* are termed respectively—(1) the epiblast, (2) the mesoblast, and (3) the hypoblast. Of these three layers the epiblast and the hypoblast are to be regarded as primary.@@3 The epiblast is essentially the primitive integument, and its cells give rise to the epidermis and cuticle and to the organs of sense. The hypoblast is essentially the digestive layer, and gives rise to the epithelium lining the aliment­ary canal. The mesoblast seems to originate from one or both of the two preceding layers, and gives rise to the general substance of the body—including that part of the skin which is beneath the epi­dermis, the muscles, and the blood-vessels. It may divide into two layers, whereof the more external is distinguished as “somatic,” while the more internal is called “splanchnic. ” Such is the general condition of the three germinal layers in the *Metazoa.* In the Sponges, however, it seems probable@@4 that the germinal layers have a different nature—the epiblast and mesoblast being respectively the digestive and sensory layers.

The skeletal structures of the Sponges have the form of spicules, which may vary greatly in different genera as to their form, while they may be siliceous, calcareous, or horny. Sometimes they con­stitute structures of singular beauty. They appear to be formed in or on the cells of the mesoblast, and it does not seem that any skeletal structures arise in the epiblast or hypoblast of the *Porifera.* Should such, however, be hereafter found, then it must be borne in mind that their homologies with analogous skeletal structures of other organisms must depend on the final decision of the question of the exact relations which may exist between such germinal layers in Sponges and the epiblast and hypoblast of higher *Metazoa.*

In the great group of the *Cœlentera,* the skeleton may be either epiblastic or mesoblastic in nature. Thus in the *Hydrozoa—*where it mostly has the form of a horny investment, but may be (as in the Millepores) calcareous—it is epiblastic. In the *Actinozoa—* which includes the true coral animals—it is generally mesoblastic, although it is formed from the epiblast in the *Gorgoniæ, Isidinæ,* and *Pennatulidæ.*

In *Isis* the skeleton curiously consists of a series of segments which are alternately horny and calcareous.

In the *Echinodermata* we generally have, notably in the Sea- Urchin *(Echinus),* a wonderfully complex skeleton, which is so near the outer surface that at the first glance it seems necessarily a most external form of skeleton. Nevertheless the plates which compose it are mesoblastic in nature and are independent of the epidermis.

The two valves forming the shell of the Lamp-shells *(Branchionopoda),* and the very different two valves which constitute the shells of creatures of the Oyster class *(Larnellibranchiata),* as well as the single shells of the Snail and Whelk class *(Gasteropoda),* are all epiblastic in nature, and are calcifications of the outer part of the epidermis. The same is the origin of the apparently internal shell of the Slug, which is at first external in the embryo and subsequently becomes enclosed.

Similar is the nature of both the internal and external shells of the Squids, Cuttle-fishes, and Nautili, *i.e.,* of the class *Cephalo­poda.* In the last-named class, as in some Gasteropods, there is a cartilaginous structure inside the head, which structure supports and partly protects the brain. It is unlike any skeletal part yet mentioned save in its mode of origin, which, like the skeleton of some of the *Actinozoa,* is mesoblastic.

Lastly may be mentioned the hard protecting external coat of insects and animals of the Crab and Lobster class—in short, the external skeleton of that primary division of animals which is called *Arthropoda.* This is again epiblastic, and a hardening of a cuticle on the outer surface of the epidermis—a hardening effected gene­rally by chitinization (the deposition in it of a substance termed “chitin”), or, as in many *Crustacea* and some *Myriapoda,* by calcification.

GENERAL SKELETAL CONDITIONS.

Having thus briefly glanced at the leading skeletal structures of a number of groups of lower organisms, we may make the following generalization, which will be of use to us in helping us to understand how the skeletal parts of backboned animals stand related to the skeletal parts of animals lower in the scale :—

(1) Skeletal structures may conceivably arise in parts

which are epiblastic, or mesoblastic, or hypoblastic.

(2) Skeletal structures belonging to any one of those

three categories may be further divisible into two subordinate categories according as they belong to a superficial or a deep part of the layer to which they appertain.

(3) Skeletal structures may be siliceous, chitinous, cal­

careous, cartilaginous, or horny.

(4) In certain animals the mesoblast subdivides into

two layers, one *somatic* and the other *splanchnic.* Obviously, then, there may be skeletal parts corresponding to either of these last-named layers, and conceivably to a deeper or more superficial portion of either of them.

THE SKELETON OF VERTEBRATA.

The skeleton of the *Vertebrata—*that is, of the five classes of animals named *Pisces, Amphibia, Reptilia, Aves,* and *Mammalia—*may in the first place be most conveniently considered as consisting of two parts—a dermal skeleton, or *exoskeleton,* and an internal framework, or *endoskeleton.* The latter, which is generally much the more considerable, is mesoblastic, and the muscles are external to it.

External Skeleton of Vertebrata.

This division of the skeleton is itself again made up of two parts. The more external of these is the epidermis and is of epiblastic origin, and dense epidermal structures may arise towards its inner or its outer surface. The more internal constituent of the exoskeleton is the dermis and dense structures formed in it, and these are from the outer portion of the mesoblast.

Epidermal hard structures formed towards either sur­face of the epidermis may become intimately united with subjacent dermal hard structures, and then again, as we shall see, with parts of the true endoskeleton.

@@@1 “Homologous parts,” or “homologues,” are parts of an organism which cor­respond in relative position, that is, in their relation to surrounding structures, whether or not they serve the same ends. They thus differ from “ analogous parts,” which are parts performing similar functions whether or not they agree as to their relations of position to surrounding structures. Thus, *e.g.,* the nail of a man’s middle toe and the hind hoof of a horse are “ homologous parts,” but the hoot, as the support of. the body and agent in locomotion, is analogous to the whole foot of a man.

@@@2 Certain Cœlenterate animals consist but of two layers.

@@@3 See F. Balfour’s *Comparative Embryology,* vol. i. p. 103.

@@@4 *Op. cit.,* vol. i. p. 122, and vol. ii. p. 285.