JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. 12 JANUARY 19, 1922 NO. 2

ZOOLOGY.—*The evolution of the animal body.*[1] AUSTIN H. CLARK, U. S. National Museum.

In a recent number of this JOURNAL[2] I gave a brief synopsis of the steps in the evolution of animals based upon the progressively increasing complexity of structure correlated with increased economic efficiency. The subject was treated in much greater detail in a later paper.[3]

Superposed upon this evolutionary line there is another having to do with the development of the body as a whole instead of with the refinement of its internal organization, and to a large extent the two are quite independent.

All the higher animals are ultimately derived from an attached animal colony within which the component zooids are more or less differentiated for the better performance of certain more or less definite functions, this animal colony being in general comparable to the colony of phytons known as a flowering plant.

In the sponges the colonial nature of the animal is evident, but there are no definite organs or tissues, and the mass is imperfectly or not at all divided. The sponges are thus comparable to certain of the so-called thallophytes.

The coelenterates have a definite body structure and are fundamentally colonial, the colony being produced asexually by budding and the component individuals usually showing more or less differentiation into (*a*) nutritive, (*b*) reproductive and (*c*) excretionary ("defensive") types, the latter bearing numerous cells containing a secretion and also a coiled tubule. Free living coelenterates occur, and these arise (1) through the assumption of a free floating existence by the colony as a whole (siphonophores), or (2) through the partial (medusae of hydroids) or complete (*Aurelia*, Trachomedusae, most actinians, etc.) dissociation of the units of the colony.

[1] Received December 16, 1921.
[2] THIS JOURNAL **11**: 207–208. May 4, 1921.
[3] Bull. de l'Instit. Océanographique (Monaco), **400**: 1–24. 20 septembre, 1921.

The jointed cestodes represent the strobila stage of *Aurelia*, but are somewhat more completely unified, the proglottides sharing a common nervous and excretory system and their detachment being greatly retarded. The pronounced bilateral symmetry of most cestodes and the marked difference in the two sides of the proglottides seen in others together with certain features connected with the budding of the scolex suggest their relationship with the graptolites of which they are possibly the recent representatives.

By a further consolidation and unification of the jointed cestode body correlated with a loss of the individuality of the component segments the annelid body type was evolved, and a further consolidation gave rise to the crustaceans, within which group the tendency is to compress all of the functions of the body within the compass of a few anterior segments, and the insects, in which there are three small groups of segments each with a definite function, (*a*) the head, most unified, controlling and directing, (*b*) the thorax, less unified, locomotor, and (*c*) the abdomen, largest and least unified, enclosing the digestive, reproductive and other organs.

Most crustaceans are more or less, and many are conspicuously, asymmetrical, while in all there is noticeable a great development of the dorsal surface as compared with the ventral. Both of these features are especially characteristic of certain barnacles, become greatly accentuated in the Pelmatozoa, and reach an extreme development in the unattached echinoderms in which the body consists of five half segments only arranged in a circle and enclosed entirely by the dorsal surface, the ventral having almost completely disappeared.[4]

The evolution of solitary animals through the progressive consolidation of a colony correlated with increasing loss of individuality by the component units can thus be traced from the coelenterates through the cestodes to the arthropods and echinoderms.

Closely allied to the cestodes are the trematodes, and from them or from very similar organisms another very different line of development has arisen.

The development of the liver fluke, like that of the tapeworm, in the division of the sporocysts and the subsequent development of cercariae from sporocysts and rediae is comparable in its essential features to strobilization, but the budding takes place, so to speak, within a closed scyphistoma; that is, the sporocysts and rediae undergo

[4] Smith. Misc. Coll. **27**: No. 11, 1–20. July 20, 1921.

a sort of invaginated strobilization, the larvae (cercariae, corresponding to ephyrae) finally escaping by the disintegration of the nurse.

The unsegmented cestodes bear approximately the same relation to the tapeworms that *Lucernaria* does to the scyphistoma of *Aurelia*, and the turbellarians in their relations to the liver flukes and their allies are comparable to the Trachomedusae as compared with the colonial coelenterates; that is, they are solitary animals ultimately derived through the dissociation of the units of a primarily colonial type.

Of the remaining acoelomate Eumorphozoa the Polyzoa and Calyssozoa are clearly comparable to colonial coelenterates; the rotifers in their asexual and direct development suggest a fragmented colony while the round worms and the Acanthocephala are solitary, like the Trachomedusae, some cestodes, and the turbellarians.

All other animals agree in the possession of that structure known as a coelome. The coelome, which arises by budding from the enteron, consists of three sections, (*a*) the perivisceral, forming a body cavity, (*b*) the gonadial, and (*c*) the nephridial. There is thus a curious correspondence between the three divisions of the coelome and the three classes into which the polyps of the coelenterates naturally fall, and this suggests the possibility of coelomate animals having arisen through a gastruloid structure resembling a redia by the budding off from the enteron of three units which remained within the gastruloid and there became differentiated into the three types characteristic of the externally budded coelenterate polyps, subsequently undergoing further development.

The priapulids, sipunculids, molluscs, nemerteans, phoronids, brachiopods, chaetognaths, enteropneusts, tunicates, cephalochordates and vertebrates would thus be explained as colonial animals derived from a coelenterate-like colonial type through a process of invagination by which the additional units were produced within the original gastruloid ancestor by budding from the enteron instead of externally as in the coelenterates and polyzoans.

Such an interpretation would account for (1) the entire absence in these groups of that external segmentation so characteristic of the cestodes, the annelids, the arthropods and the echinoderms; (2) the entire absence, except in the enteropneusts and tunicates, which stand quite apart from the other phyla, of all forms of asexual reproduction, this being here represented by internal budding; (3) the almost complete absence of parasitism (occurring only in a very few molluscs and nemerteans), since the transference of the asexual bud-

ding to the interior prevents that prolific asexual reproduction by budding and fission, by parthenogenesis, or by polyembryony always present in those groups in which parasitism is a prevalent condition; and (4) the almost complete absence of attached forms which, except for secondarily attached molluscs, are found only among the brachiopods and the tunicates.

The annelids, in addition to their dominant external segmentation, also possess a coelome, but this becomes greatly reduced in the crustaceans and insects. In the echinoderms, however, the curious distortion leads to a relatively considerable average length for each of the five segments represented, and with this annelidan feature the coelome reappears in a highly perfected form.

The development of the annelids indicates a very close relationship with the molluscs. These two groups thus carry onward the essential differences, as well as the essential similarities, between the cestodes and the trematodes. Similarly the arthropods and the echinoderms appear to be structurally parallel to the nemerteans, phoronids, brachiopods and chaetognaths, the former representing the cestode-annelid, the latter the trematode-priapulid-sipunculid-mollusc type.

The enteropneusts, the tunicates, the cephalochodates (*Amphioxus*, etc.) and the vertebrates are quite unrepresented in the externally segmented line, which culminates in the arthropods and echinoderms. They differ from all other animals in the possession of gill slits or pores. These structures represent the final step in the organization and centralization of the respiratory function and its connection with the endoderm. This is obviously a minor structural detail, presumably of late origin, and as such it suggests that while the other major animal types probably all appeared almost or quite simultaneously the evolution of the forms with gill apertures was considerably delayed.

GEOPHYSICS.—*The latitude of Ukiah and the motion of the pole.*[1]

WALTER D. LAMBERT, U. S. Coast and Geodetic Survey.

In January, 1921, Professor A. C. Lawson of the University of California published an article on earth movements in California.[2]

[1] Presented before the Philosophical Society of Washington, November 19, 1921. Received December 7, 1921. The substance of this paper was also presented at a meeting of the American Astronomical Society at Swarthmore, Pa., December 29, 1921. This paper is based on a longer article by the author entitled *An investigation of the latitude of Ukiah, California, and of the motion of the Pole*, which will appear as a Special Publication of the U. S. Coast and Geodetic Survey.

[2] *The mobility of the Coast Ranges of California, an exploitation of the elastic rebound theory.* Univ. Calif. Publ., Bull. Dept. Geol. **12**: No. 7. Jan. 11, 1921.