# CHAPTER X.

## ON THE PRINCIPLES OF CLASSIFICATION.

PERHAPS some one else, more fortunate than myself, may be able, even without Darwin, to find the guiding clue through the confusion of developmental forms, now so totally different in the nearest allies, now so surprisingly similar in members of the most distant groups, which we have just cursorily reviewed. Perhaps a sharper eye may be able, with Agassiz, to make out "the plan established from the beginning by the Creator,"[1] who may have written here, as a Portuguese proverb says "straight in crooked lines."[2] I cannot but think that we can scarcely speak of a general plan, or typical mode of development of the Crustacea, differentiated according to the separate Sections, Orders, and Families, when, for example, among the Macrura, the River Crayfish leaves the egg in its permanent form; the

[1] "A plan fully matured in the beginning and undeviatingly pursued:" or "In the beginning His plan was formed and from it He has never swerved in any particular" (Agassiz and Gould, 'Principles of Zoology').

[2] "Deos escrive direito em linhas tortas." To read this remarkable writing we need the spectacles of Faith, which seldom suit eyes accustomed to the Microscope.

Lobster with Schizopodal feet; *Palæmon*, like the Crabs, as a Zoëa; and *Penæus*, like the Cirripedes, as a Nauplius,—and when, still, within this same sub-order Macrura, *Palinurus*, *Mysis* and *Euphausia* again present different young forms,—when new limbs sometimes sprout forth as free rudiments on the ventral surface, and are sometimes formed beneath the skin which passes smoothly over them, and both modes of development are found in different limbs of the same animal and in the same pair of limbs in different animals,—when in the Podophthalma the limbs of the thorax and abdomen make their appearance sometimes simultaneously, or sometimes the former and sometimes the latter first, and when further in each of the two groups the pairs sometimes all appear together, and sometimes one after the other,—when, among the Hyperina, a simple foot becomes a chela in *Phronima* and a chela a simple foot in *Brachyscelus*, &c.

And yet, according to the teaching of the school, it is precisely in youth, precisely in the course of development, that the "Type" is mostly openly displayed. But let us hear what the Old School has to tell us as to the significance of developmental history, and its relation to comparative anatomy and systematic zoology.

Let two of its most approved masters speak.

"Whilst comparative anatomy," said Johannes Müller, in 1844, in his lectures upon this science (and the opinions of my memorable teacher were for many years my own), "whilst comparative anatomy shows us the infinitely multifarious formation of the same organ

in the Animal Kingdom, it furnishes us at the same time with the means, by the comparison of these various forms, of recognising the truly essential, the type of these organs, and separating therefrom everything unessential. In this, developmental history serves it as a check or test. Thus, as the idea of development is not that of mere increase of size, but that of progress from what is not yet distinguished, but which potentially contains the distinction in itself, to the actually distinct,—it is clear, that the less an organ is developed, so much the more does it approach the type, and that, during its development, it more and more acquires peculiarities. The types discovered by comparative anatomy and developmental history must therefore agree."

Then, after Johannes Müller has combated the idea of a graduated scale of animals, and of the passage through several animal grades during development, he continues:—"What is true in this idea is, that every embryo at first bears only the type of its section, from which the type of the Class, Order, &c., is only afterwards developed."

In 1856, in an elementary work,[3] in which it is usual to admit only what are regarded as the assured acquisitions of science, Agassiz expresses himself as follows:—

"*The ovarian eggs of all animals are perfectly identical,* small cells with a vitellus, germinal vesicle and germinal spot" (§ 278). "*The organs of the body are*

[3] 'Principles of Zoology.' Part I. Comparative Physiology. By Louis Agassiz and A. A. Gould. Revised Edition. Boston, 1856.

*formed in the sequence of their organic importance; the most essential always appear first.* Thus the organs of vegetative life, the intestine, &c., appear later than those of animal life, the nervous system, skeleton, &c., and these in turn are preceded by the more general phenomena belonging to the animal as such" (§ 318). "Thus, in Fishes, the first changes consist in the segmentation of the vitellus and the formation of a germ, processes which are common to all classes of animals. Then the dorsal furrow, characteristic of the Vertebrate, appears—the brain, the organs of the senses; at a later period are formed the intestine, the limbs, and the permanent form of the respiratory organs, from which the class is recognised with certainty. It is only after exclusion that the peculiarities of the structure of the teeth and fins indicate the genus and species" (§ 319). "*Hence the embryos of different animals resemble each other the more, the younger they are*" (§ 320). "Consequently the high importance of developmental history is indubitable. For, *if the formation of the organs takes place in the order corresponding to their importance, this sequence must of itself be a criterion of their comparative value in classification.* The peculiarities which appear earlier should be considered of higher value than those which appear subsequently" (§ 321). "*A system, in order to be true and natural, must agree with the sequence of the organs in the development of the embryo*" (§ 322).

I do not know whether any one at the present day will be inclined to subscribe to this proposition in its

whole extent.[4] It is certain, however, that views essentially similar are still to be met with everywhere in discussions on classification, and that even within the last few years, the very sparingly successful attempts to employ developmental history as the foundation of classification have been repeated.

But how do these propositions agree with our observations on the developmental history of the Crustacea? That these observations relate for the most part to their "free metamorphosis" after their quitting the egg, cannot prejudice their application to the propositions enunciated especially with regard to "embryonal development" in the egg; for Agassiz himself points out (§ 391) that both kinds of change are of the same nature and of equal importance and that no "radical distinction" is produced by the circumstance that the former take place before and the latter after birth.

"*The ovarian eggs of all animals are identical,* small cells with vitellus, germinal vesicle and germinal spot." Yes, somewhat as all Insects are identical, small animals with head, thorax, and abdomen; that is to say if, only noticing what is common to them, we leave out of consideration the difference of their development, the presence or absence and the multifa-

[4] Agassiz' own views have lately become essentially different, so far as can be made out from Rud. Wagner's notice of his 'Essay on Classification.' Agassiz himself does not attempt any criticism of the above cited older views, which, however, are still widely diffused. With his recent conception I am unfortunately acquainted only from R. Wagner's somewhat confused report, and have therefore thought it better not to attempt any critical remarks upon it.

rious structure of the vitelline membrane, the varying composition of the vitellus, the different number and formation of the germinal spots, &c. Numerous examples, which might easily be augmented, of such profound differences, are furnished by Leydig's 'Lehrbuch der Histologie.' In the Crustacea the ovarian eggs actually sometimes furnish excellent characters for the discrimination of species of the same genus; thus, for example, in one *Porcellana* of this country they are blackish-green, in a second deep blood-red, and in a third dark yellow; and within the limits of the same order they present considerable differences in size, which, as Van Beneden and Claus have already pointed out, stands in intimate connexion with the subsequent mode of development.

"*The organs of the body are formed in the sequence of their organic importance; the most essential always appear first.*" This proposition might be characterised *à priori* as undemonstrable, since it is impossible either in general, or for any particular animal, to establish a sequence of importance amongst equally indispensable parts. Which is the more important, the lung or the heart?—the liver or the kidney?—the artery or the vein? Instead of giving the preference, with Agassiz, to the organs of animal life, we might with equal justice give it to those of vegetative life, as the latter are conceivable without the former, but not the former without the latter. We might urge that, according to this proposition, provisional organs as the first produced must exceed the later-formed permanent organs in importance.

But let us stick to the Crustacea. In *Polyphemus* Leydig finds the first traces of the intestinal tube even during segmentation. In *Mysis* a provisional tail is first formed, and in *Ligia* a maggot-like larva-skin. The simple median eye appears earlier, and would therefore be more important than the compound paired eyes; the scale of the antennæ in the Prawns would be more important than the flagellum; the maxillipedes of the Decapoda would be more important than the chelæ and ambulatory feet, and the anterior six pairs of feet in the Isopoda, than the precisely similarly formed seventh pair; in the Amphipoda the most important of all organs would be the "micropylar apparatus," which disappears without leaving a trace soon after hatching; in *Cyclops* the setæ of the tail would be more important than all the natatory feet; in the Cirripedia the posterior antennæ, as to which we do not know what becomes of them, would be more important than the cirri, and so forth. The most unimportant of all organs would be the sexual organs, and the most essential peculiarity would consist in colour, which is to be referred back to the ovarian egg.

"*The embryos, or young states of different animals, resemble each other the more, the younger they are*," or, as Johannes Müller expresses it, "*they approach the more closely to the common type.*" Different as may be the ideas connected with the word "type," no one will dispute that the typical form of the penultimate pair of feet in the Amphipoda is that of a simple ambulatory foot, and not that of a chela, for the latter occurs in no

single adult Amphipod; we know it only in the young of the genus *Brachyscelus*, which therefore in this respect undoubtedly depart more widely than the adults from the type of their order. This applies also to the young males of the Shore-hoppers (*Orchestia*) with regard to the second pair of anterior feet (*gnathopoda*). In like manner no one will hesitate to accept the possession of seven pairs of feet as a "typical" peculiarity of the Edriophthalma, which Agassiz, on this account, names Tetradecapoda; the young Isopoda, which are Dodecapoda, are also in this respect further from the "type" than the adults.

It is certainly a rule, and this Darwin's theory would lead us to expect, that in the progress of development those forms which are at first similar gradually depart further from each other; but here, as in other classes, the exceptions, for which the Old School has no explanation, are numerous. Not unfrequently we might indeed directly reverse the proposition and assert that the difference becomes the greater, the further we go back in the development, and this not only in those cases in which one of two nearly allied species is directly developed, and the other passes through several larval stages, such as the common Crayfish and the Prawns which are produced from Nauplius-brood. The same may be said, for example, of the Isopoda and Amphipoda. In the adult animals the number of limbs is the same; at the first sight of a *Cyrtophium* or a *Dulichia*, and even after the careful examination of a *Tanais*, we may be in doubt whether we have an

Isopod or an Amphipod before us; in the newly-hatched young the number of limbs is different, and if we go back to their existence in the egg, the most passing glance to see whether the curvature is upwards or downwards suffices to distinguish even the youngest embryos of the two orders.

In other instances, the courses which lead from a similar starting-point to a similar goal, separate widely in the middle of the development, as in the Prawns with Nauplius-brood already described.

Finally, so that even the last possibility may be exhausted, it sometimes happens that the greatest similarity occurs in the middle of the development. The most striking example of this is furnished by the Cirripedia and Rhizocephala, whether we compare the two orders or the members of each with one another; from a segmentation quite different in its course (see figs. 61–64) proceed different forms of Nauplius, these become converted into exceedingly similar pupæ, and from the pupæ again proceed sexually mature animals, differing from each other *toto cœlo*.

"*If the formation of the organs occurs in the order corresponding to their importance, this sequence must of itself be a criterion of their comparative value in classification*," THAT IS TO SAY, SUPPOSING THE PHYSIOLOGICAL AND CLASSIFICATIONAL VALUE OF AN ORGAN TO COINCIDE! Just as in Christian countries there is a catechismal morality, which every one has upon his lips, but no one considers himself bound to follow, or expects to see followed by anybody else, so also has

Zoology its dogmas, which are as universally acknowledged, as they are disregarded in practice. Such a dogma as this is the supposition tacitly made by Agassiz. Of a hundred who feel themselves compelled to give their systematic confession of faith as the introduction to a Manual or Monographic Memoir, ninety-nine will commence by saying that a natural system cannot be founded upon a single character, but that it has to take into account all characters, and the general structure of the animal, but that we must not simply sum up these characters like equivalent magnitudes, that we must not count but weigh them, and determine the importance to be ascribed to each of them according to its physiological significance. This is probably followed by a little jingle of words in general terms on the comparative importance of animal and vegetative organs, circulation, respiration, and the like. But when we come to the work itself, to the discrimination and arrangement of the species, genera, families, &c., in all probability not one of the ninety-nine will pay the least attention to these fine rules, or undertake the hopeless attempt to carry them out in detail. Agassiz, for example, like Cuvier, and in opposition to the majority of the German and English zoologists, regards the Radiata as one of the great primary divisions of the Animal Kingdom, although no one knows anything about the significance of the radiate arrangement in the life of these animals, and notwithstanding that the radiate Echinodermata are produced from bilateral larvæ. The "true Fishes" are divided by him into Ctenoids

and Cycloids, according as the posterior margin of their scales is denticulated or smooth, a circumstance the importance of which to the animal must be infinitely small, in comparison to the peculiarities of the dentition, formation of the fins, number of vertebræ, &c.

And, to return to our Class of the Crustacea, has any particular attention been paid in their classification to the distinctions prevailing in the "most essential organs"? For instance, to the nervous system? In the Corycæidæ, Claus found all the ventral ganglia fused together into a single broad mass, and in the Calanidæ a long ventral chain of ganglia,—the former, therefore, in this respect resembling the Spider Crabs and the latter the Lobster; but no one would dream on this account of supposing that there was a relationship between the Corycæidæ and the Crabs, or the Calanidæ and the Lobsters.—Or to the organs of circulation? We have among the Copepoda, the Cyclopidæ and Corycæidæ without a heart, side by side with the Calanidæ and Pontellidæ with a heart. And in the same way among the Ostracoda, the *Cypridinæ*, which I find possess a heart, place themselves side by side with *Cypris* and *Cythere* which have no such organ.—Or to the respiratory apparatus? Milne-Edwards did this when he separated *Mysis* and *Leucifer* from the Decapoda, but he himself afterwards saw that this was an error. In one *Cypridina* I find branchiæ of considerable size, which are entirely wanting in another species, but this does not appear to me to be a reason for separating these species even generically.

On the other hand, what do we know of the physiological significance of the number of segments, and all the other matters which we are accustomed to regard as typical peculiarities of the different organs, and to which we usually ascribe the highest systematic value?

"*Those peculiarities which first appear, should be more highly estimated than those which appear subsequently. A system, in order to be true and natural, must agree with the sequence of the organs in the development of the embryo.*" If the earlier manifested peculiarities are to be estimated more highly than those which afterwards make their appearance, then in those cases in which the structure of the adult animal requires one position in the system, and that of the larva another, the latter and not the former must decide the point. As the *Lernææ* and Cirripedes, on account of their Nauplius-brood, were separated from their previous connexions and referred to the Crustacea, we shall, for the same reason, have to separate *Penēus* from the Prawns and unite it with the Copepoda and Cirripedia. But the most zealous embryomaniac would probably shrink from this course.

A "true and natural system" of the Crustacea to be in accordance with the sequence of the phenomena would have to take into account in the first place the various modes of segmentation, then the position of the embryo, next the number of limbs produced within the egg and so forth, and might be represented somewhat as follows:—

CLASSIS CRUSTACEA.

Sub-class I. HOLOSCHISTA.—Segmentation complete. No primitive band. Nauplius-brood.

Ord. 1. *Ceratometopa.*—Nauplius with frontal horns. (Cirripedia, Rhizocephala.)

Ord. 2. LEIOMETOPA.—Nauplius without frontal horns. (Copepoda, without *Achtheus*, &c., Phyllopoda, *Penëus.*)

Sub-class II. HEMISCHISTA.—Segmentation not complete.

A. Nototropa.—Embryo bent upwards.

Ord. 3. *Protura.*—The tail is first formed. (*Mysis.*)

Ord. 3. *Saccomorpha.*—A maggot-like larva-skin is first formed. (*Isopoda.*)

B. Gasterotropa.—Embryo bent ventrally.

Ord. 5. *Zoëogona.*—Full number of limbs not produced in the egg. Zoëa-brood. (The majority of the Podophthalmata.)

Ord. 6. *Ametabola.*—Full number of limbs produced in the egg. (*Astacus*, *Gecarcinus*, *Amphipoda* less *Hyperia*?)

This sample may suffice. The farther we go into details in this direction, the more brilliantly, as may easily be imagined, does the naturalness of such an arrangement as this force itself upon us.

All things considered, we may apply the judgment which Agassiz pronounced upon Darwin's theory, with far greater justice to the propositions just examined:—"No theory," says he, "however plausible it may be, can be admitted in science, unless it is supported by facts."