

Between the Macrurans and the Brachyurans there is the grand distinction that the former are long extended posteriorly, and *urosthenic*, as regards locomotion (or strong in the posterior extremity, that is, the abdomen), while the latter have short bodies, gathered in closely and compactly behind the cephalic ganglion, and are *podosthenic*, thoracic feet being the only locomotive organs. In rising from the Macruran to the Brachyuran there is a forward transfer in the general structure and in the locomotive function, and thus a great rise in degree of cephalization.

Under each of these two types of Decapods a wide range of grade is structurally indicated, illustrating degrees in cephalization.

*Isopod and Amphipod Tetradeapods.* — The Isopods and Amphipods are *brachyuran* and *macruran* Tetradeapods, for the series of Tetradeapods is closely parallel with that of the Brachyurans and Macrurans among Decapods. The Isopods have a compact body, a short abdomen, which is not used in locomotion, with relatively short antennæ, while the Amphipods have a longer body more loosely put together, usually long antennæ, an elongate abdomen, and the abdomen is the chief organ of locomotion — that by which the little animal makes its leaps. Here, again, the lower are the *urosthenic* and decephalized species, the higher the *podosthenic* and more cephalized species.

*Entomostracans.* — Below the Tetradeapods come the Entomostracans. A part of the Entomostracans are multiply species, — the Phyllopods; and in this character, both in the Entomostracans of Decapod and of Tetradeapod relations, they show out the ancestral worm, and thereby low-grade cephalization. The structure is eminently primitive and was especially characteristic of early Paleozoic Articulate life.

Besides these there are the simply *defective* forms among Entomostracans, representative of different stages in embryonic development. Defective forms of similar character occur even among the Macruran Decapods; for some of the inferior shrimp-like species have one or two of the posterior segments of the thorax without legs, or even wanting; and in such species (called Schizopods), the thoracic legs have the form characterizing a young stage in development. But among the Entomostracans, the defective stage appears in more extreme forms. The limbs are partly natatory; the mouth organs are often either pediform or natatory, or of more abnormal forms; and the abdomen has no appendages except ovarian attached to the basal portion and a caudal pair pertaining to the sixth segment.

The preceding remarks on the bearing of the principle of cephalization on system and grade in Crustaceans cannot be true for one branch of the Animal Kingdom without having a wide significance. See, for other examples, *Historical Geology*, pages 721, 723.

This subject has much interest in connection with the successional lines in the animal life of the globe which geology has brought to light. But the preceding remarks are not to be understood as intimating anything with regard to the origin of species. There was no such reference in the author's first presentation of the views in 1852.<sup>1</sup> At that time the idea of evolution by natural causes had scarcely an advocate; for Darwin's work did not appear until 1859. Neither are the facts now to be regarded as adding to the causes of derivation. This much, however, may be learned from them: —

1. Whatever the natural causes or methods concerned in evolution, organic conditions have determined lines, limits, and parallel relations, in accordance with the principle of cephalization.

2. In the evolution of the animal kingdom a "tendency upward" is a necessary consequence of the presence of a cephalic nervous ganglion or brain.

<sup>1</sup> Report on Crustacea of the Wilkes Expl. Exped. around the World, 1618 pp., 4to, with a folio Atlas of 96 plates. In the papers on cephalization published in the *American Journal of Science*, eleven to twelve years later, and subsequently a summary in 1876, the principle of cephalization was illustrated by reference to other classes of animals; but the speculative conclusions added in those papers are not all in accord with the author's present judgment.