The Past and Present of the Cuttlefishes.

Part I.

Few groups of the animal kingdom possess a greater interest, either for the zoologist or for the general investigator, than that selected as the subject of the present article. From the earliest ages in which human curiosity concerning external nature began to develop into scientific observation, the cuttlefishes have formed subject-matter of remark. In the writings of the classic naturalists they receive a due meed of attention. Their peculiarities of form and habits attracted the notice of Aristotle and Pliny; and even their development, in its more readily observed phases, was studied in the days when biology was but an infantile

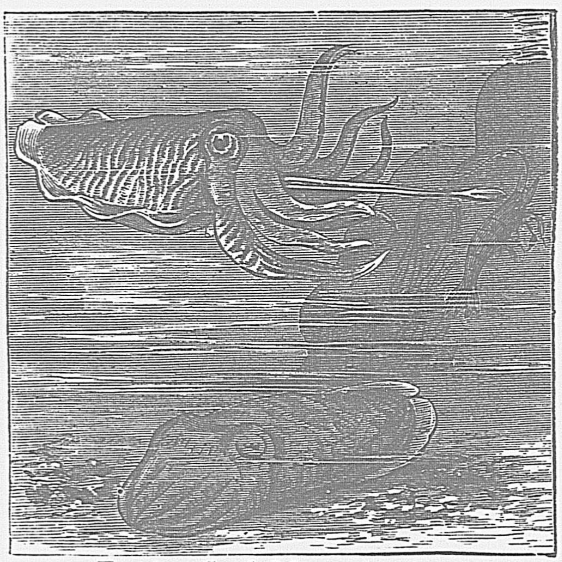

Fig. 1.—*Cuttlefishes swimming.*

science. Tracing the lines of cuttlefish lore onwards through the centuries of growing culture, we discern the mediæval spirit of exaggeration and myth seizing upon the group as a likely subject for enlargement and discussion. In the fabulous history and 'folklore' of zoology, the cuttlefishes have over and over again played a more than prominent part. In the days of their mythical history they have swallowed whole fleets of ships; they have been credited more than once with the destruction of even an armoured navy; and on more than one occasion there can be little doubt that they have played the parts of Sindbad's floating island, and of the 'great unknown,' the sea-serpent itself. To the modern zoologist, however, eager in his search after the causes which have wrought out the existing order of animal nature, the cuttlefishes present themselves as an unusually interesting group. Regarded merely as to their structural details, there is no lack, but on the contrary an overflowing amount, of instructive lore in their anatomical history. Their physiology is equally curious. The details of cuttlefish existence, from the consideration of their vital processes to that of their ordinary habits and outward mode of life, present a well-nigh endless variety of curious facts and unusual features. Not less interesting is the history of their distribution in existing seas, or their life in the oceans of the past as revealed by the study of their fossil remains. Their etiology or evolution—forming, in their case, as in that of every other group of organisms, the crowning question and focus of all scientific research—is, last of all, a part of their history that teems with special interest. Even if the materials for constructing the genealogy of the race are still of meagre amount; even if the pathways of cuttlefish descent in time past are often obscure, and sometimes completely hidden from the furthest gaze of modern biology; even if the lines of their development, as that phase of their personal history is traceable from the egg to-day, are frequently puzzling and indefinite, the evolution of the race according to the general principles of descent is yet an unquestioned fact. It is merely the exact lines and pathways of their progress in time which form matter of dispute; the fact of their evolution and progressive modification from pre-existing forms is never questioned by the modern biologist. Thus, on every hand, the group of the cuttlefishes may be said to be encompassed by circumstances which place them in the first rank of curious and in many respects abnormal forms. In this article we may endeavour to obtain a general, even if in many respects a brief and cursory, idea of the place in nature which these beings may be said to hold.

The definition of the *Cephalopoda*, or cuttlefish class, is largely a matter of commonplace observation. Linnæus, naming them 'cephalopods,' or 'head-footed' molluscs, indicated the structural feature which was calculated to appeal most plainly even to non-technical minds. The circlet of arms, feet, or tentacles crowning the head-extremity of a cuttlefish, thus presents us with a personal character of unmistakable nature. It is necessary, however, to bear in mind that the ordinary and to a certain extent natural fashion of representing a cuttlefish head upwards is, in zoological eyes, a complete reversion of its surfaces. To understand clearly why to speak of a cuttlefish head as its *lower*, and of its tail as its *upper*, extremity, is a correct zoological designation, we must enter upon a comparison of the cuttlefish body with the forms of its neighbour molluscs. The contemplation of such a familiar being as a snail or whelk, introduces us to a characteristic example of molluscan form and anatomy. The head of the snail or other gasteropod is clearly enough defined; and no less plainly discernible is the enlarged and broadened surface on which the animal walks. This surface is known as the 'foot.' In one shape or another, this 'foot' is a characteristic possession of the molluscan tribes. In a section of a mussel or cockle, we perceive the 'foot' to exist as a muscular mass developed in the middle line of the body below, and variously used in the mussel class as a spinning organ, a leaping pole, and a boring apparatus. Here we note the natural development of the foot in the middle line of the animal. Let us suppose this foot to be extended downwards, and to be broadened so as to form a surface of progression, and we may conceive readily of the modification whereby a simple foot like that of the mussel becomes developed to form the enlarged disc of the gasteropod. In the latter case, we observe that the foot occupies the floor of the body; the bulk of the body, and the head in particular, being borne above.

Cuttlefish development can be shown to run, so far, in parallel lines to those of the personal evolution of mussel and snail. But divergent paths soon appear in cuttlefish development; and these variations, whilst they indicate an ancient departure from the ordinary molluscan type, likewise give to the subjects of our present study their most characteristic features. When a mussel or snail is watched in its earlier stages of development, the embryo is seen, sooner or later, to produce an appendage highly characteristic of molluscan young at large, and named the *velum*. By aid of this ciliated fold, such an organism as a young cockle, for instance, swims freely through its native waters. This velum undergoes varied changes and alterations in the after stages of molluscan development; but when cuttlefish development is studied in its fullest details, no velum is found amongst the possessions of the larval body. Such an omission has naturally been made the subject of remark by naturalists. Some authorities—Grenacher, for instance—have insisted upon the recognition of the arms of the cuttlefish head as the representatives of the missing velum. But as the latter organ always exists on the dorsal or upper side of the mouth, and as the arms are placed originally behind and under the cuttlefish mouth, the correspondence of arms and velum has not been accepted by zoologists. On the other side stands out the opinion of Huxley, who regards the 'arms' of the cuttlefish head as more truly corresponding with the 'foot' of the mussel, snail, and other molluscs.

The margins of the foot, in this view of matters, have been prolonged in the young cuttlefish to form eight, ten, or more arms, and the front and sides of the foot, having overgrown the mouth, are united in front, so that the mouth appears to be placed in the centre of the foot, instead of in front and above it, as in other molluscs. So, also, most naturalists maintain, and with every appearance of correctness, that the characteristic 'funnel' of the cuttlefishes —to be hereafter referred to—is an organ formed by two side processes of the foot, named *epipodia*. Adopting the view thus sanctioned by competent authority, we may trace in a cuttlefish the highly modified form of a snail or whelk, and the still more modified form of the mussel tribes. The foot, instead of growing backwards and downwards as in the snail, and thus forming a broad walking disc, comes to grow over the mouth in front. So that, placing a cuttlefish in structural comparison with a whelk or mussel, we should have to set it head downwards, when the foot (or arms) would be lowest, and the great bulk of the body, with the heart uppermost, would be situated, as in the snail, above the foot.

The group of the cuttlefishes may be said to divide itself in the most natural fashion into two main divisions. The first of these groups includes all living cuttlefishes save one—the pearly nautilus. This first division is that of the *Dibranchiates*, or two-gilled cuttlefishes. The familiar octopus (fig. 1), the loligos or squids, the sepias, and the argonauts or paper nautili, are amongst the best known of its representatives. The second group is represented by a single living cuttlefish, the pearly nautilus (*Nautilus Pompilius*), just mentioned, and by many fossil and extinct forms. These are the *Tetrabranchiates*, or four-gilled cephalopods, which, in respect of their general anatomy, their development in time, and their distribution in space, may be said to stand apart in the most marked fashion from the two-gilled cuttles which throng the seas of to-day. We shall discover that the clues to the evolution of the cuttlefish race emerge in greater part from the fossil history of the four-gilled forms. But as the two-gilled members of the group constitute well-nigh its whole living population, the general nature of these animals may be most satisfactorily investigated if, in the first instance, we deal with the common representatives of the class. Thereafter we may profitably attempt the consideration of the pearly nautilus and the general relatives of the cephalopods in time past and in the geological æons wherein lies the childhood as well as the past perfection of the race.

One of the most remarkable traits of cuttlefish existence is the curious play of 'shot' colours which takes place in their integument. I have seen a loligo, or squid, stranded on the sea-beach make glorious its dying agonies by a play of colours of the most astounding description. The natural purplish tint of the body was now and again deepened to well-nigh a dark blue; the slightest touch served to develop a patch of angry pink; and continually over the whole surface of the body the hues and tints, ranging from dark purple to light red, succeeded each other in rapid array.

The assimilation of an animal's colour to the surfaces on which it rests forms a notable circumstance of zoology, which has been denominated 'mimicry.' Under this head are included all phenomena which enable an animal to assume the form, likeness, or colour of another animal, of a plant, or of an inorganic object. That cuttlefishes possess such a power is well known. The hue of an octopus may so closely resemble that of the rock to which it attaches itself, that the observer can with difficulty say which is rock and which is animal. A flounder's colour is in the same way assimilated to the sand on which it rests, although in the fish the alteration of colour seen in the cuttlefishes is not represented.

The manner of production of the changes of hue and play of 'shot' colours in the cuttlefishes is really analogous to that whereby the famed chameleons effect their alterations of hue. Beneath the thin and transparent cuticle or outer integument, and embedded in the dermis or under-skin itself, lie certain contractile colour cells which receive the name of *chromatophores*. These, by alteration of their granular colour-granules under the stimulation of light or imitation, produce the changes of hue. Rapid diffusion and extension of these cells will produce the appearance of the diffused play of colour so familiarly seen in these animals, whilst certain highly refractive corpuscles, named *Flitterchen* by German physiologists, aid in producing the shot colours, by light-interference. It is interesting to note that in the common frog changes of colour are perceptible in the skin, and are effected by analogous methods to those which produce the variations in hue of the cuttlefishes. Thus the pigment cells of the frog's skin contract under the stimulus of light, their colour-granules are huddled into the centre of the cell, and the skin becomes blanched. When the stimulus is removed, the pigment cell expands, its granules are diffused, and the frog's skin resumes its normal coloration. It is noteworthy that in groups of animals so distinct as those just mentioned, one should find closely allied means for attaining a similar end. This remark holds good of other structures in cuttlefishes, which, although of independent origin, subserve functions allied to those performed by the structures and organs of Vertebrata, The locomotion of the cuttlefishes forms a point of interest in connection with their general structure and physiology. Any one who has attentively watched the movements of an octopus in its tank must have been struck by the literally acrobatic ease with which it accommodated itself to the exigencies of its life and surroundings. In their lithe, muscular, and flexible arms, the cuttlefishes possess an apparatus which is equally serviceable for the capture of prey, and for walking mouth downwards—that is, in their structurally natural position. They possess, likewise, the power of swimming upper side forwards—or popularly stated 'backwards'—by means of the jets of water which, by forcible contractions of the muscular mantle-sac, are projected from the tube or 'funnel,' situated on the hinder face of the body. These *jets d'eau* consist of the effete water which has been used in breathing, so that the act of expiration and the effete water of respiration together become utilised, in the economical wisdom of nature, as a means of propulsion. The mysterious backward flight of an octopus through its tank (fig. 1) when, detaching itself from its hold on the rock, it swims gracefully and swiftly through the water, is effected in the manner just described. This form of hydraulic apparatus, imitated in experiments in marine engineering, serves but to strengthen the wise man's adage concerning the utter lack of novelty in terrestrial and mundane things.

It is equally interesting to note that some of the squids or loligos—named popularly 'flying squids'—appear to be able to rise from the surface of the sea and to spring into the air after the fashion of the flying-fishes. Pliny in his 'Natural History' says, 'Loligo etiam volitat, extra aquam se efferens, quod et pectunculi faciunt sagittæ modo;' whilst Varro insists that the name 'loligo' is itself a corruption of 'voligo.' The initial velocity of these cuttlefishes, acquired by their rapid propulsion through the water, enables them thus to career for a short distance through the air. Instances are mentioned of the flying squids having occasionally landed themselves on the decks of ships in their atmospheric leaps.

The 'arms' or 'feet' demand, however, a somewhat detailed mention, on account of their armature. In all cuttlefishes, save the exceptional pearly nautilus, the arms are either eight or ten in number, and are provided with *acetabula*, or 'suckers.' Those cuttles in which ten arms are present—and of these the squids and sepias form good examples—have two of these appendages produced beyond the remaining eight in length. Aristotle noted in his day this peculiarity of the ten-armed cuttles. Speaking on this point, he remarks that all of these animals 'have eight *feet* provided with a double series of suckers, except in one genus of Polypi'—the genus *Eledone*, in which there is but a single row of suckers. 'The sepia, teuthides, and teuthi (that is to say, the sepias and squids) have besides two long *proboscides*, the extremities of which are beset with a double series of suckers.' The two 'proboscides' of Aristotle are the 'tentacles' of the modern naturalist; and Pliny, speaking of the uses of these tentacles, remarks that they may be used for the capture of prey at a distance, or may be employed to anchor their possessors safely amid the boisterous waters. The 'suckers,' (fig. 2, A) which constitute a most noteworthy armament of the arms, are borne on short stalks in the ten-armed cuttlefishes, but are unstalked in the eight-armed species. Each sucker (fig. 2) exhibits all the structures incidental to an apparatus adapted to secure effective and instantaneous adhesion to any surface. It consists of a horny or cartilaginous cup (*a*), within which are muscular fibres converging towards its centre, where they form a well-defined plug or piston (*b*). By the withdrawal of this plug a partial vacuum is produced, and the suckers adhere by atmospheric pressure to the surface on which they are placed. The sucker is released by the projection of the plug and by the consequent destruction of the vacuum. The number of the suckers varies, but is always considerable; and when we reflect that the array of suckers can be instantaneously applied, and that their hold is automatically perfect, the grasp of the cephalopods is seen to be of the most efficient kind. In some cuttlefishes, and most notably in the so-called 'hooked squids' (*Onychoteuthis*), the pistons of the suckers are developed to form powerful hooks, by means of which the prey may be secured with additional facility; and in the common squids the margin of the sucker is provided with a series of minute horny hooks. The 'arms' themselves, it need hardly be remarked, are extremely mobile; they are highly muscular, and can be adapted with ease to the varied functions of prehension and movement they are destined to subserve. As regards their arrangement, they are arranged in four pairs—a dorsal and a ventral pair, and two lateral pairs; the two elongated tentacles, when developed, being situated between the third and fourth pairs of arms on the ventral or lower surface.

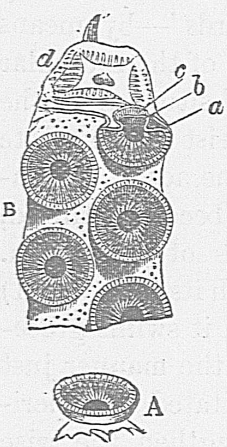

FIG. 2.—*Suckers of the Cuttlefish.*

The systematic examination of any single animal form, or of any one group of animals, resolves itself into a consideration of the various systems of organs whereby the work (or physiology) of the being or beings is carried on. Primarily, the scientific pathway conducts us to the animal commissariat or alimentary system as a fair starting-point; thence to the blood-circulating system; thirdly, to the excretory apparatus, consisting of the breathing organs, kidneys, and like glands; fourthly, to the nervous apparatus, exercising the function of 'relation;' fifthly, to the reproduction and development of the organism, as demonstrating not merely its affinities with other beings, but likewise its evolution; and lastly, to the distribution of the animal or group in the world as it at present exists, and likewise in the epochs of the past. Our study of the present of the cuttlefishes may not, for want of space, include even a brief notice of these successive features. But as incidental to our cursory survey of cuttlefish structure and physiology, we may touch now and then upon matters which have served more than once as the starting-points of a philosophy leading from the consideration of a mere group of interesting animals, to questions bearing upon the origin and modification of the whole universe of life.

The alimentary tract or digestive system of the cuttlefish race is in every respect of well-developed and complete character. Lower down in the molluscan series the commissariat department is subserved by a very perfect digestive apparatus, including representatives of most of the organs familiar enough to us in higher or vertebrate existence. In the cephalopods we should naturally expect the standard of lower molluscan organisation to be further elaborated; and this anatomical expectation is justified by the actual details of cuttlefish structure. The mouth opens on the upper surface of the head—a disposition of matters already accounted for when considering the relations of the cuttlefish body to that of other molluscs. The mouth-opening is usually bounded by a raised lip, and leads into a cavity containing an elaborate apparatus, analogous to the jaws of higher animals, and by means of which the food of these animals is triturated and divided. An inspection of the masticating apparatus of a cuttlefish readily solves the question, 'How are the hard shells of their crustacean food broken down?' There exists within the mouth, firstly, a hard horny beak, resembling closely in shape the beak of a parrot, and consisting of two chief divisions, whereof one—the front—is the smaller, and is overlapped by the hinder beak. Set in action by appropriate muscles, these beaks divide the hard parts of the food with the greatest ease. But a second apparatus of more typical nature likewise exists in these animals. This is the *odontophore*, a structure popularly named the 'tongue,' and which is common to the whelk and snail class, to the sea-butterflies, and to the cuttlefishes. It consists essentially of an elongated ribbon-like structure, bearing hooked teeth, generally disposed in transverse rows. This apparatus, set in action by special muscles, and worked after the fashion of a chain-saw, is used to rasp down the food; whilst new growths of its substance from behind serve to repair the loss caused by the friction to which it is subjected.

The gills, as already noted, number two in all cuttlefishes except the pearly nautilus, and may demand a special notice. Each gill is a conical organ, consisting essentially of a dense network of blood-vessels, in which impure blood brought by the great veins is exposed to the action of the oxygen contained in the water which is being continually admitted to the gill-chambers. Each gill is contained within a kind of chamber, to which water is admitted by the front edge of the mantle-sac. This opening being closed by a valve against the exit of the water, the forcible contraction of the body-walls ejects the water, as previously described, from the 'funnel.' The gills are themselves contractile, but they do not possess the armament of minute vibratile processes or *cilia,* so typical of the gills of other Mollusca. The need for these cilia as organs providing for the circulation of water over the gill-surfaces is of course removed, in view of the very perfect means existent in the cuttlefishes for the renewal of the water used in breathing. As a living octopus or other cuttle-fish is watched, the movements of inspiration and expiration are plainly indicated by the expansion and contraction of the body walls, and they imitate in a singularly exact fashion the analogous movements of the highest animals. Observers have likewise described in certain members of the cuttlefish class a series of minute pores, by which water enters the great veins and mixes with the blood. It is also certain that water enters the general body cavity and bathes the organs of the animal, thus converting that cavity into a physiologically active space, possessing an influence on the circulation in that its contained water presents a medium for the conveyance of oxygen into, and for the reception of waste materials from, the blood.

Connected on the one hand with the digestive system, and on the other with the more purely glandular structures of the body, is the organ known familiarly as the 'ink-bag' of these animals. The cuttlefishes are well known to utilise the secretion of this sac as a means of defence, and for enabling them to escape from their enemies. Discharging the inky fluid through the 'funnel,' into which the duct of the ink-sac opens, it rapidly diffuses itself through the water, and enables the animal to escape under a literal cloak of darkness. The force of the simile under which an over-productive writer is likened to a cuttlefish, may be understood and appreciated when the physiology of the ink-sac is investigated. It is this feature of cuttlefish organisation which Oppian describes when he informs us that—

> Th' endangered cuttle thus evades his fears,
> And native hoards of fluid safely wears;
> A pitchy ink peculiar glands supply,
> Whose shades the sharpest beam of light defy;
> Pursued, he bids the sable fountains flow,
> And wrapt in clouds, eludes th' impending foe.

The exact nature and relationship of this ink-sac to the other organs of the cuttlefish have long been disputed. According to one authority, the ink-bag represented the gall-bladder, because in the octopus it is embedded in the liver. From another point of view, it was declared to represent an intestinal gland; whilst a third opinion maintained its entirely special nature. The ink-sac is now known to be developed as an offshoot from the digestive tube; and, taking development as the one infallible criterion and test of the nature of living structures, we may conclude that it represents at once a highly specialised part of the digestive tract, and an organ which, unrepresented entirely in the oldest cuttle-fishes, has been developed in obedience to the demands and exigencies of the later growths of the race. It is this ink-sac which is frequently found fossilised in certain extinct cuttlefish shells. Its secretion forms the original *sepia* colour, a term derived from the name of a cuttlefish genus. The fossilised sepia has been used with good effect when ground down. The late Dean Buckland gave some of this fossil ink to Sir Francis Chantrey, who made with it a drawing of the specimen from which it had been taken; and Cuvier is said to have used this fossilised ink in the preparation of the plates wherewith he illustrated his 'Mollusca.' At the present time, recent cuttlefish ink is said to be utilised in the manufacture of ordinary artists' 'sepia.'

The due regulation of cuttlefish existence is determined by the action of its nervous apparatus. Every living being exercising the functions of a nervous system may be said to perform the function of 'relation;' that is to say, it is brought, through the operation of its nervous apparatus, into relation with the outer world. The higher the nervous system, the more perfect are the relations between its possessor and the outer world. In comparing a mussel with a snail, and the latter or both with a cuttlefish, the differences between a low and a high nervous apparatus may be plainly seen. The mussel, possessing a distinct nervous system, lives, nevertheless, a vegetative existence. It exhibits little activity; it has no distinct head; its energies are cabined, cribbed, and confined within the compass of its shell; it may 'hear' dimly, it is true; but its relations with the outer world are limited to the sweeping in and to the reception of food particles in the water it receives, and to the occasional closure of its shell when alarmed. Mussel life passes, therefore, through an uneventful history. The snail, on the other hand, exhibits a livelier interest in the affairs of the universe. Possessed of head, sense-organs, and motor powers, its means of relating itself to the outer world are of an infinitely superior kind to those possessed by the mussel. It quickly retires into private life and into the cavity of its shell when alarmed; it hears and sees, and its capacities for acting and reacting upon its surroundings are of a tolerably advanced nature. The cuttlefishes in turn present us with a marked advance upon the innervation of the snails and their allies. The cephalopods are infinitely more active, in turn, than the slow-moving gasteropods, and their nervous axis exhibits additional specialisation and development, as becomes their more elevated position. The ordinary type of molluscan nervous system undergoes in the cuttlefishes a decided change of form. In a snail or whelk, for example, the nervous system exhibits an arrangement of three chief nerve-masses or 'ganglia,' connected by nervous cords. Of these three nerve-centres, one is situated in the head, a second in the 'foot' or organ of movement, and a third in the neighbourhood of heart and gills, or amidst the viscera generally. Increased concentration of this type of nerve-arrangement awaits us in cuttlefish organisation. Just as the spider possesses a more concentrated and localised nerve-axis than the insect, or as the gangliated chain of the latter becomes the fused nerve-mass of the spider; so in the cuttlefish, the molluscan nerve-system, scattered and diffused in the snail, whelk, or mussel, becomes localised in adaptation to the increased nerve-control and to the wider instincts of cuttlefish existence. This process of nerve-localisation and concentration is accompanied by certain important modifications affecting other regions and structures of cuttlefish economy. Thus the nerve-centres are found to be protected and enclosed within a gristly or cartilaginous case, that foreshadows the functions of the vertebrate skull, though in no sense connected with that structure; and the structure of the cuttlefish eye is likewise peculiar, and presents a noteworthy feature of the economy of these animals. Altogether, the disposition of the nervous axis presents us with one of the most characteristic studies in cuttlefish history, and offers at the same time, perhaps, more interesting problems in connection with the evolution of the race than any other system of organs included in the list of their bodily possessions.

The first modification to which attention may be directed is the massing of the nerve-centres around the gullet in the cuttlefishes. Gathered up, as it were, from the foot and viscera, we find the chief nervous masses disposed within the head region, and further enclosed within the cartilaginous case or 'skull' already mentioned. This concentration of nerve-masses in the cephalic or head region is in itself noteworthy. It teaches us that the tendency to 'cephalisation,' as Professor Dana has termed the process of head development, is largely associated with, if not directly induced by, this nervous concentration; and it likewise reveals one of the main causes of superiority and advance in the animal series. But the presence in the head of the cuttlefishes of the cartilaginous 'skull,' in addition to sundry other masses of gristle scattered through the substance of the 'mantle,' has just been mentioned as a feature of interest. No possible lines of connection, genetic or otherwise, exist between cuttlefishes and vertebrates; yet this 'skull' character would at first sight seem to indicate resemblance and relationship of a definite kind between the two groups. But the case before us merely adds one to already known instances in which structures of analogous or similar nature have originated in a perfectly independent fashion. Such a result, however, does not, as has been argued, lie outside those normal laws of progressive development through the operation of which the universe of life has become the wondrously complex thing it is. The vertebrates themselves exhibit a progress of skull development leading us from that skull-less, spineless, boneless fish the lancelet (*Amphioxus*), through the imperfectly differentiated crania of the lampreys and their allies, to the complex skulls of our common fishes, and upwards by diverging lines to crania of higher type still. Is it any the more anomalous to find in the cuttlefishes the progressive development of a protective case for the modified and concentrated nerve-centres? Considering that the cephalopods stand at the extreme limit of molluscan development, it becomes a postulate of evolution that in them we should find the cumulative increase and progress of their type. Thus cuttlefish specialisation, so far from placing any difficulties in the way of evolution, supplies additional proof of the growing applicability of that doctrine to unravel the complexities of living structures. Furthermore, as we advance from the older to newer types of cuttlefish life, the 'skull' becomes better developed. It is better developed in the two-gilled cuttlefishes, which are forms literally of the geological yesterday, than in the pearly nautilus, which presents us with a cuttlefish type of vast antiquity. In the nautilus the skull consists of two pieces, surrounding the gullet at its commencement; but in the two-gilled cuttlefishes it exhibits a middle portion, through which the gullet passes, and likewise shows side-processes that form cavities or 'orbits,' enclosing the eyes as in higher animals. Within this case the three localised nerve-masses exist. Here, again, we discover that in the later cuttlefishes the nervous axis is more concentrated than in the earlier forms—modification of, and progress in, structure accompanying development in time. A large nerve-mass, consisting of the three closely connected centres, thus subserves the function of a cuttlefish brain. Not the least interesting feature of this localised mass of nervous matter is the fact that it exhibits the same arrangement of grey and white nerve-matter that is seen in the highest brains. An outer grey and an inner white layer are discernible in the nerve-ganglia of cephalopods, as in the cerebrum of man; and, as in the highest animals, the cuttlefish grey matter is found to consist of nerve-cells, whilst the white matter is chiefly composed of nerve-fibres. Thus the laws of developmental progress affect the microscopic and intimate structure of the living form as well as the more obvious details of structure. From the main nerve-mass of the cuttlefishes nerves arise to supply the body at large. Nerves of special sense supply eyes, ears, and olfactory organs; whilst the viscera and the 'mantle' or general body-covering are also well provided with the means of innervation.

Cuttlefish existence possesses in all probability the five 'gateways of knowledge,' through which the impressions of the outer world are received, and by which these impressions are modified and transmitted to the brain-masses as sensations of sight, hearing, smell, touch, and taste. There is little need to draw upon hypothesis in the assumption that the arms or tentacles are efficient organs of touch in Cephalopoda, or that the structures of the mouth may subserve taste, in so far as the latter sense may be required to satisfy the demands of cuttlefish existence. An organ of smell is definitely situated behind or above the eyes. There, two small projections, or, as frequently, two minute pits or depressions, occur. These pits are ciliated, and between the cilia 'olfactory cells' are situated. These cells in turn represent the similar structures which occur in higher animals, and which in man himself form the characteristic terminations to his olfactory nerves. That the cuttlefishes can literally scent their prey from afar off, is an idea confirmed by the facts of their every-day life. A well-developed organ of smell necessarily confers upon them a great advantage in the struggle for food in which, along with the other tribes of the sea, they unquestionably share.

The 'ears' of the cuttlefishes present us with two sacs—named 'auditory sacs'—which may, as in the nautilus, either be attached to the chief nerve-mass itself, or, as in the two-gilled cuttles, be lodged in special cavities in the gristly 'skull.' A cuttlefish 'ear' is essentially a sac or bag, called an 'otocyst,' containing either one or many 'otoliths' or 'ear-stones,' suspended in a watery fluid. This, indeed, is the primitive type of 'ear' we may find even in the *Medusidæ* or 'jelly-fishes' themselves. The manner in which this hearing sac exercises its functions is not difficult to trace. Vibrations of sonorous kind, transmitted to its substance, set the otoliths in motion. This motion, along with that of the contained fluid of the otocyst, is communicated to the 'end cells'—bearing delicate processes known as 'auditory hairs' —in which the fibres of the auditory nerves end. Thus the 'ear-sac' of a cuttlefish is simply a body adapted for the reception of sound-waves, and for the modification of these waves, which, as they impinge upon the fine ends of the nerve-fibres of the sac, become transformed into impressions of sound. These impressions are in due course transmitted to the brain or ganglionic mass of the animal, which, like that of other organisms, acts upon the 'information received' with an intelligence and completeness proportionate to the perfection of its structure and functions. The ear-sacs of many cuttlefishes open on the external surface of the body by two fine canals, named 'Kolliker's ducts,' after their distinguished discoverer. Occasionally these ducts end blindly, and do not open on the body surface. These facts lend additional support to the opinion that in the ear of the cuttlefish we find primitive structures proper to the ears of vertebrates, the minute canals of Kolliker corresponding with the *recessus vestibuli* of the vertebrate organ of hearing. Once again, therefore, we find the progressive development of cephalopods and vertebrates running in parallel, but nevertheless in distinct and independent, lines; and this likeness is further strengthened when we discover that not merely the ear, but the eye likewise, of these two groups of animals is formed or developed in an essentially similar fashion. The ear of the cuttlefish presents us with a permanent example of an early and transitory stage in the development of the vertebrate ear, and a common plan of ear-production is thus seen to traverse a wide extent of the animal world.

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(*To be concluded.*)