five o'clock the dog saunters leisurely down the road till he meets the stage, he then bounds back to the poultry-yard, catches chickens, bites their heads off, and takes them to the cook! The number of chickens he kills bears a relation to the number of passengers he saw in the stage.

A gentleman who was stopping at the hotel for a few days went into the woods one afternoon with a gun. When he returned the dog came to him in much excitement to see what game he had taken. Finding his hands and his bag empty the dog ran into the forest and returned in less than an hour with a bird, which he gave with an air of compassion to the unskilful hunter. W. D. GUNNING

Waltham, Mass., April 18

ON THE EVOLUTION OF THE VERTEBRATA[1]

SEVERAL theories of the vertebrate skeleton have been promulgated during the last century, some of which have since been abandoned, and others greatly modified. About a quarter of a century ago, three great stumbling blocks were removed from the study of animal forms, by the discovery that the cell-wall was not essential as inclosing sarcode, by the removal of the old conceptions about the origin of species, and by the rejection of the vertebrate theory of the skull in its older and grosser form. In the present course, the lecturer wishes to give both an analytic and synthetic account of the vertebrate skeleton, to see if a consistent history cannot be given of every cartilage, bone, and joint, in the higher types.

A vertebrated animal is constructed of a chain of segments similar to each other, which are obsolete in the head, and in each of which there is a smaller dorsal tube, through which the continuous neural axis runs, and a larger ventral tube, which contains the digestive organs, heart, and main blood vessels. The neural axis swells into three main vesicles in the head, giving rise to the fore, mid, and hind brain. The skeletal structures are formed on a single median axis, the notochord, which lies directly beneath the neural axis, and which is arrested in the head close behind the fore-brain. The barrier, however, which would stop the growth forwards of the notochord, is not developed when its apex shrinks. By the time the embryo is fairly formed, a fold of the palatal skin has given rise to a sac which opens into the lower and hinder part of the fore-brain. This sac is the pituitary body, the manner of the development of which has been clearly made out by Mr. Balfour, in the sharks and skates, and corroborated by the lecturer in the snake, lizard, and green turtle.

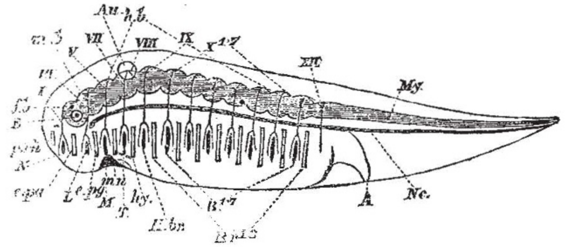
The mouth and posterior aperture do not exist at first, but are formed afterwards as involutions, which, in the latter case, at any rate, are not terminal, the alimentary tract extending behind the anus, and possibly in front of the mouth also in ancient forms. The visceral clefts appear as slits in the wall of the pharynx, and in the aquatic forms, give rise to the gills, while in the higher types (amniota), all of them close up but one, which remains as the tympano-eustachian cavity. The vertebræ alternate with the primary segmental masses. Each centrum, as it chondrifies, constricts the notochord, but there is usually some remnant of it to be seen in the adult in the invertebral spaces. The walls of the head are large and continuous, and its lower arches are generally small, clefts appearing between them. Both the arches and clefts become greatly modified in the adult, especially in the higher types. Thus the upper jaw is probably due to the modification and blending together of two or three pairs of arrested arches.

Besides the axial skeleton, a cartilaginous skeleton is developed immediately under the skin, and thus there is both a cartilaginous exo- and endoskeleton. The exoskeleton gives rise to the labial and extra-branchial cartilages, the limb arches and their limbs, and the intercalary cartilages of the median fins of fishes.

[1] Abstract of Prof. Parker's Hunterian Lectures, delivered at the College of Surgeons, commencing on February 10.

The bony parts of the skeleton are classified according to their relation to the axial or extra-axial cartilaginous skeletons. All bony scales, scutes, or sub-cutaneous bony plates, or tracts, are classified as exoskeletal; ossifications of the endoskeletal cartilage or its perichondrium are, of course, endoskeletal. Unfortunately for science, the extinct lower forms of the Vertebrata had their endoskeletons but slightly ossified, and thus only the outworks of their structure are left to us, as is the case with many of the Ganoids of the old red sandstone. The lowest of these, however, were half way up the vertebrate scale, if we compare them with the lancelet. Of existing brain-bearing fishes the lamprey and hag are the lowest, but man scarcely stands at a greater distance from them than they do from the lancelet, which, as far as we know at present, stands alone in creation.

Until we can connect the known Vertebrata, or at least their embryos, with the worm-like Invertebrata, the former will continue to be a very anomalous group. The difficulty is not with man; in him we have organ for organ and part for part, and he is better than a beast only by reason of something that cannot be demonstrated by the anatomist as such.



A, anus; *Au*, auditory capsule; B^{1-7}, branchial clefts; Br^{1-8}, branchial arches; *E*, eye; *e.pa*, ethmo-palatine; *e.pg*, epi-pterygoid; *f.b*, fore-brain; *h.b*, hind brain; *H.br*, hyo-branchial cleft; *hy*, hyoid arch *L*, lacrymal cleft; *M*, mouth; *m.b*, mid-brain; *mn*, mandible; *My*, myelon; *N*, nostril; *Nc*, notochord; *p.rh*, pro-rhinal; *T*, tympanic cleft. The Roman figures indicate the nerves.

The above diagram represents an ideal vertebrate, the oral, lacrymal, and nasal clefts being taken as homologous with the post-oral clefts. This theory seems probable both from the author's researches on the visceral arches and clefts, and those of Milnes Marshall on the nerves. The seven branches of the vagus (x^{1-7}) are here shown as separate nerves, and the hind brain as a series of enlargements.

As the relation of the endoskeleton to the exoskeleton does not usually seem to be properly understood, it may be as well to say a few more words about it. On the whole the foundations of the internal skeleton are laid in cartilage, and of the external in bone, which is formed by the ossification of fibrous tracts. The cartilage as a rule also ossifies, and this inner or *cartilage* bone has, so to speak, an organic affinity for the outer or *membrane* bone. But there are several things in the vertebrate exoskeleton that are formed of cartilage, as already mentioned; and in the endoskeleton the cartilage is often suppressed in certain parts, bony substance, formed in fibrous tissue, replacing it. Indeed, unossified fibrous tracts often take the place of cartilage. The welding together of parts originally distinct makes the matter much more complicated. No inherited elements are rejected by the morphological force; they are only kept from growing into special tissues until needed. Thus the rich growth of the human brain is covered in with a stout masonry that is merely made up of the inner layer of old ganoid plates, and the cartilages of the human nostril are inheritated from some ancient sucking fish, while the outer ear once figured, speaking morphologically, as the blow-hole of some Silurian shark.

A word or two must now be said about the different kinds of ossification. When the perichondrium, or clothing of the cartilage, ossifies, it becomes the "ectosteal layer," and is directly related to the cartilage as its ossifying investment; this is a true endoskeletal lamina. Ossification of the dermis gives rise to "dermosteal" (exoskeletal) bony plates, such as the scales and scutes of fishes, and the scutes of reptiles and armadilloes. The intermediate fibrous tissue, especially in the region of the head, ossifies to form the splints, investing bones, or "parostoses" (exoskeletal). Lastly, the cartilage itself undergoes an osseous change, either by central, superficial, or subcentral "endostosis" (endoskeletal).

These species of ossification, like other species, are, however, apt to run into one another.

Fishes.—If we take a survey of the Vertebrata, beginning with the suctorial fishes, viz., the lamprey and hag, we find at first nothing but cartilage forming both the exo- and endoskeleton. The main peculiarities seen in the skeletons of these fishes are the peculiar cartilaginous labials, forming the sucking apparatus, and the basket-work of the "extra-branchials," which embrace the huge multiperforate pharynx. The Selachians (shark, skate, and Chimœra), although retaining much that is low and embryonic in their structure, are in many respects the highest and most reptilian of fishes. Their skeletal growths are uncombined; in their skin are numerous placoid grains or spines, forming the exoskeleton, while in the endoskeleton the first step towards ossification is seen in the calcification of the superficial cells of the cartilage. The labial system is now secondary, a more perfect mouth having taken the place of the sucking-apparatus. The basket-work of the sucking fishes yields bars to strengthen the mouths of the gill-pouches, the gill system being built upon large endoskeletal branchial arches. Limb-girdles, with their paired fins, appear in these fishes.

In the Chondrostei (sturgeon and paddle-fish (*Planirostra*), which are lower kinds of Ganoids, the slightly ossified cartilaginous endoskeleton is supplemented by outer bony plates, which, in the extinct forms, were often covered with an enameled layer. In the head, especially, these plates are conformed to the underlying parts, although they do not combine with them histologically. In this region they have also a constant tendency to a peculiar alternation of paired and unpaired elements. The scutes of the trunk, although suggesting the segments within, do not actually correspond with them.

Here we must look for the exemplars of our own investing-bones (*parostoses*) which are as yet, however, very generalized. The chondroskeleton now gets true ectosteal plates and sheaths, as well as parostoses.

But in those Ganoids that are called Holostei, the endoskeleton rivals that of the ordinary fishes in hardness, and yet the exoskeleton arrives at its highest pitch of perfection. In the head, the dermoskeleton is brought into adaptation to the more important architecture of the inner parts. The most perfect dermoskeleton is seen in the gar-pike (Lepidosteus).

The Dipnoi, which are in many respects related to the generalized chimœroids, show even less mutual adaptation of the outer to the inner skeleton than the sturgeon and paddle-fish, and, moreover, their bony skull plates are, as a rule, feeble, and few in number.

Lepidosiren and Protopterus have a few subcutaneous bones (parostoses) applied to a cranium which is almost entirely devoid of intrinsic ossifications, and scarcely advanced in development beyond that of a Chimœra. But Ceratodus has a helmeted head much like that of the lower Ganoids, the dermal scutes overlying the almost unossified cranium; it has also some sub-cutaneous bones.

The osseous fishes are the highest *as fishes*, but they are least of all related to those types which rise above them in the scale. Their metamorphosis is very great, but the elements are still uncombined. They have a copious growth of sub-cutaneous *bones*, as the Selachians have of sub-cutaneous *cartilages*, while in Ceratodus both are seen in an uncombined condition.

Amphibia.—The Amphibia are a subdivision of the Icthyopsida, which, like the Dipnoi, develop lungs as well as gills, but which often shed the latter, breathing only by the former. Their embryos, like those of fishes, develop neither amnion nor allantois. There are four orders in this sub-class, viz., the Cœcilians, the Urodeles, the Anura, and the Labyrinthodonts, the last of these being the large extinct Amphibia of the coal-measures. The living forms of Amphibia begin life as a sort of fishes, having gills; and, as a rule, they live in the water until they acquire lungs: some keep their gills, and continue to live in the water, while others shed them. The higher kinds undergo so much morphological change, and assume so many new and important characters, that they are perhaps the most instructive of all the Vertebrata.

In the Urodeles and Anura (tail-bearing and tail-less Amphibia) we find many things in common, and many more that are different. While they agree in possessing gills in their larval state, they differ in the character of their gills. The Urodeles have, some for a while, and others throughout life, three pairs of pinnate external gills, attached to the three first branchial arches, a single gill to each arch, there being generally a fourth arch which does not bear a gill. These are true *inner* branchial arches.

Amongst the frogs and toads there are three important modifications of the branchial system. In the common kinds (*Opisthoglossa*) there are at first free tufted gills growing from the two first, at least, of the four branchial arches, all of which are functional. These are soon hidden by an opercular outgrowth from the hyoid arch, which covers over and closes up all the branchial region, leaving, however, a small aperture on the left side. The primary pharyngeal wall not only splits so as to form four clefts on each side, but the wall itself becomes divided so as to form a series of pouches, each of which has a cartilage within and a cartilage without, the opercular skin loosely covering the pouches outside. The intra-branchial arches are small bars; the second and third extra-branchials are large bars, while the first and fourth are large pouches. Tufted vascular (*lophobranchiate*) growths, like those first seen outside, grow on the inside of the large pouches and bars, and also from the three branchial clefts, outside the extra-branchials. These latter correspond with the external gills seen in unhatched sharks and skate.

Dactylethra, one of the two existing *Aglossa*, shows no trace of external gills. The other, tongueless kind, *Pipa*, has probably very temporary rudiments of them. Suctorial cartilages have nearly disappeared in the embryos of Urodeles, but in the Batrachia they are nearly as much developed as in the lamprey. In the Urodeles we find no trace of a gill on the first and second arches behind the mouth, nor on the sixth, which exists in the majority of the species.

It is evident that the tailed Amphibia have been dropping from time to time parts no longer useful to them, whilst straining after a higher organisation. In them we have the beginning of the middle ear; there is a stapes and a fenestra ovalis. Here also a larynx appears for the first time, and the shoulder and hip girdles, and the fore and hind limbs are developed similarly to those of the higher types.

In neither Anura nor Urodeles is it possible to make a sharp distinction between a parostosis and an ectostosis, especially in the palate. The frogs and toads vary greatly in the intensity of their ossification; the parostoses pass into superficial dermal plates, and the bones, both superficial and deep, are apt to begin in a wild way, not keeping to the habitual landmarks. This is seen also to a less extent in Urodeles.

The mind of man is not able to invent a more wondrous transformation than that which actually takes place in the life of every frog and toad. Born almost a lamprey, it changes into a creature which is a Selachian, and something more; for it passes through the further border of the sharks and skates, in their territory, and begins in its changing growth to make the rudiments, at least, of many an important organ which comes to its perfection in man and his nearest relatives. The growth force then fetching in improvements and additions from many a quarter, and combining all things skilfully, makes a new thing on the earth.

(*To be continued.*)

THE NEWEST EXPLOSIVE

GUN-COTTON and dynamite, which have for some years past held the foremost rank among modern explosives, are no longer, it seems, to retain this honour undisputed. A compound more violent still than either of these well-known preparations has lately been given to the world by M. Nobel in the shape of blasting-gelatine, and blasting-gelatine, again, has been endowed with still greater energy by a modification in its nature, effected by Prof. Abel, the War Department chemist. So far as experiment has shown, the gelatine and modified gelatine are, without doubt, the most active explosive agents known to us, or, in other words, a given weight of these compounds will work more destruction upon metal, stone, or other unyielding mass, than any of the hundred and one bodies of a like character with which we have become acquainted during the past half-century.

It is a well-known circumstance that, with but very few exceptions, the many explosives that have lately been brought before the public under a variety of names are merely modifications of one and the same thing. They are all nitro-compounds, or modifications of them. One class owe their origin to gun-cotton and the other to nitro-glycerine, and gun-cotton and nitro-glycerine are by the chemist regarded as the same thing. Gun-cotton is made by the nitrification of a solid body, and nitro-glycerine by the nitrification of a liquid body. The methods of manufacture are similar, and the agents employed to bring about the nitrification are the same. In the one instance a woody fibre—cellulose—is acted upon by a mixture of strong nitric acid and sulphuric acid, the former liquid to perform the operation of nitrification, by substituting certain equivalents of nitrogen for the hydrogen existing in the cellulose, and the latter acid for the purpose of absorbing any moisture given off in the substitution process, and thus preventing the nitric acid from becoming dilute and inefficient. In the other, a liquid—glycerine—is permitted to combine in small quantities at a time with a mixture of the same acids, and in like manner parts with its hydrogen, to be replaced by nitrogen.

There is, however, this wide difference in the application of the two compounds. Gun-cotton may be employed as it stands, and the Abel gun-cotton that is used by our soldiers and sailors for torpedoes and mining work is simply a pure pyroxilin, pulped fine to permit of its being thoroughly washed, and compressed into *papier-maché* sort of blocks, for the sake of convenience. Nitro-glycerine, on the other hand, being a liquid, is difficult to handle in that form, and for this reason it is that Nobel and others cast about for suitable vehicles to contain the preparation. A siliceous clay called Kieselguhr, which will absorb three times its weight of the liquid, has been found the most favourable substance, and dynamite, generally speaking, may be said to consist of 75 per cent. of nitro-glycerine and 25 per cent. of this inert substance. In lithofracteur, other substances besides, are employed, such as powdered charcoal and nitre, and there now exists a whole family of such combinations, none of which contain, however, more than 75 per cent. of the active explosive, nitro-glycerine.

In blasting gelatine, which, by the way, contains no gelatine at all, the objection to employing an inert material is got rid of altogether, and the mass, like compressed gun-cotton, is explosive and combustible throughout. Blasting, or explosive, gelatine is a mixture of nitro-glycerine and gun-cotton. M. Nobel, to whom is due the credit of having placed the valuable properties of nitro-glycerine at the disposal of mining-engineers, has discovered, in the pursuance of further investigations, that the liquid in question acts as a solvent upon gun-cotton. Like a mixture of alcohol and ether, nitro-glycerine is found to dissolve nitro-cellulose, and form a description of collodion, or, as M. Nobel terms it, gelatine. It is not, of course, the highly-explosive gun-cotton that will thus dissolve, but that known as photographer's pyroxilin, which does not contain so much nitrogen. Military gun-cotton, indeed, or tri-nitro-cellulose, to call it by its chemical name, should not be soluble at all, or at any rate only to a slight extent, if properly manufactured, and one of the tests to ascertain if it is of good quality is in fact to treat it with an alcohol-ether mixture to ascertain how far it will dissolve. The soluble gun-cotton, however, if not so highly nitrified, to coin a term for our purpose, is still a sufficiently explosive body, and this M. Nobel finds he can dissolve to a greater extent in nitro-glycerine than it is possible to do in alcohol and ether. Whereas the latter will dissolve no more than 4 or 5 per cent. of pyroxiline, and frequently less than 2, nitro-glycerine has been found to take up upwards of 7 per cent. The operation of dissolving is presumably done when the liquid is warm, and the result is, as we have said, a jellified mass, which has all the attributes of a definite combination. There is no separation of liquid from the mass, and cartridges may be made by simply rolling up the material in paper envelopes.

Thus, in blasting gelatine, there is no inert body, and the consequence is that weight for weight, the gelatine is superior in its destructive action to dynamite. The latter, as we have seen, contains 75 per cent. of nitro-glycerine, whereas blasting gelatine consists of from 90 to 93 per cent. of this liquid, and from 7 to 10 per cent. of soluble gun-cotton. But there exists another reason still, why the detonation of blasting gelatine should be more energetic, namely, because the combustion of the charge, from more perfect oxidation, is well nigh perfect. Prof. Abel pointed this out very clearly in his recent lecture at the Royal Institution. "As nitro-glycerine," he said, "contains a small amount of oxygen in excess of that required for the perfect oxidation of its carbon and hydrogen constituents, while the soluble gun-cotton is deficient in the requisite oxygen for its complete transformation into thoroughly oxidised products, the result of an incorporation of the latter in small proportions with nitro-glycerine, is the production of an explosive agent, which contains the proportion of oxygen requisite for the development of the *maximum* of chemical energy by the complete burning of the carbon and hydrogen; and hence," Prof. Abel concludes, "blasting gelatine should, theoretically, be even slightly more powerful as an explosive agent than pure nitro-glycerine."

By converting the gelatine into a more solid body by the addition to it of some 10 per cent. of military gun-cotton, or tri-nitro-cellulose, Mr. Abel appears to have secured a still more vigorous explosive, and one besides, that, by reason of its firmness, is more convenient to handle than the softer and pliant jelly. The destructive action of this modified gelatine upon iron plates and heavy masses of lead, has been found greater than that of any other form of nitro-glycerine or gun-cotton, and there is no room for doubt that for torpedoes and military mining, where the object is to secure the greatest degree of violence, regardless of consequences, the compound will find valuable application.

While on the subject of nitro-glycerine and its behaviour