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DAVID NUTT, LONG ACRE.

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1901.

ORDINARY GENERAL MEETING.*

PROFESSOR E. HULL, LL.D., F.R.S., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed.

The following elections were announced :—

MEMBER :—Professor Lionel S. Beale, F.R.C.P., F.R.S.

ASSOCIATES :—Joseph Brown, Esq., C.B., Q.C. ; John G. Cribb, Esq., Brisbane ; Rev. President J. A. Peters, D.D., U.S.A. ; F. A. Bruton, Esq., M.A.

The following paper was then read by the Author :—

METHODS OF PROTECTION AMONG ANIMALS.

By W. A. KIDD, Esq., M.D., B.S., M.R.C.S., F.Z.S.

PROFESSOR WEISMANN well says, "Everything is adapted in Animate Nature, and has been from the beginning."† This statement will commend itself to any person who makes acquaintance with the organic world, as much among plants as among animals. I propose to consider one phase of this universal adaptedness of Nature, viz., the various methods of protection among the groups of the animal kingdom. The conditions under which the great animal world is found existing are so diverse that abundant opportunity is offered for such a study. It is indeed so abundant that one can but glance shortly at a few notable members of the different classes as we ascend the scale from Protozoa to Man.

Animals occupy the water, the air, the surface of the earth, and even to some extent its interior. They are found in water at the depth of 3,000 fathoms, at the bottoms of the deepest oceans, and at all levels of the sea. They flourish in all regions of the teeming waters, warm and cold, in branches of trees, in the air, and on mountain tops, in

* Monday, 6th February, 1899.

† *Germinal Selection.*

torrid, temperate, and frigid zones, in rivers, lakes, and ponds, on the earth and in its crust, and in the bodies of other animals. Here, then, in so motley an assemblage of environments, is a great field in which may be displayed those multiform methods of protection which I, for one, cannot dissociate from the action of mind and will.

In considering this subject of protection one must somewhat enlarge the ordinary meaning of the word, in accordance with the common maxim in the affairs of nations that the surest way to peace and protection is to be prepared for war, "*Si vis pacem bellum para.*" This is denied by certain prominent thinkers of philanthropic bent, but it obtains much support among the higher members of the animal kingdom. We shall see many of these, in which the methods of protection are almost altogether active rather than passive in character, and in which formidable weapons of offence supply adequate protection to their possessors, otherwise feebly provided with passive methods of protection.

The varying modes in which the need for protection among animals has been met afford contrivances so diverse from one another as the outer thickened and hardened layer of an amœba, protecting the softer internal parts, the skull of man protecting his delicate brain, or the oil with which an aquatic bird preens its feathers for protection against moisture and cold.

The two most important divisions of the animal kingdom are the invertebrates or non-chordate animals and vertebrates or chordate animals. Of the former the Protozoa form the lowest group. This great group of small creatures comprises those which have no specialization of functions for the different cells of their bodies. They may be called one-celled by reason of the fact that the protoplasm of which they consist discharges indifferently the functions of *nutrition*, *reproduction*, and *relation*. The rest of the animal kingdom is marked off from the Protozoa as Metazoa, and includes creatures which range from a sea anemone to a man.

Among the Protozoa the need for protection is slight, as they are aquatic and mostly microscopic in size. But in the amœbæ, almost the lowest Protozoa, there is a provision by which the outer layer of protoplasm, or *ectosarc*, becomes relatively hardened, and serves to protect the inner portions. In somewhat higher Protozoa a substance called "chitin" is produced on the surface. It is a hard, horny, organic tissue,

and enters considerably into the protecting structure of lower animals. In the tiny foraminifera, which show an advance upon amœbæ, there is, as a rule, a shell or "test" perforated by minute protusions of the body-substance, whence their name. These "tests" are of great variety and beauty, as, for example, in the nautiloid foraminifera, with their microscopic shell fashioned like that of the higher pearly nautilus. Among this order are found the beautiful and ancient nummulites, honoured of old by entering into the "nummulite" limestone of the Egyptian Pyramids, with their small coin-shaped shells. We must not forget to notice the minute Globigerina, which go to make up with their myriad skeletons the Chalk formations of the world. The Radiolaria are another great division of the Protozoa, full of forms of beauty with varied contrivances for the protection of their bodies. Professor Haeckel was occupied for ten years in the study of the Radiolaria, brought to light by the *Challenger* Expedition, and has identified 3,500 species. The Polycystinæ also, which have contributed to form the flint all the world over, have "skeletons" of extreme beauty and variety, though microscopic in size. For example, one Radiolarian called *Ziphacantha Murrayana* (after Dr. Murray of the *Challenger* Expedition) possesses a more elaborate skeleton, passing through the body of the animal, consisting of delicate spicules arranged in a radiate form, with secondary connections, in most exact geometrical order.

The next division in the scale of animal life among the Zoophytes or Coelenterates is that of the sponges. At this stage the one-celled animals are passed by, and *tissues* and *organs* begin to be seen. The soft body-substance of the sponges is supported and protected by a framework of flinty, horny material. Some sponges exist in fresh water, but most of them in sea-water; some are calcareous in their skeletons, others siliceous. We should not forget how valuable a *secondary* purpose for the comfort of us human beings are the skeletons of the horny sponges found in the Mediterranean and West Indian Islands, and their beautiful elasticity and firmness. It is not necessary, because the primary purpose of these skeletons of sponges is the protection of the individual, to forget the secondary uses and purposes to which they are applicable.

Of all the sponges the famous Venus's Flower Basket, or *Euplectella*, is the most beautiful, and serves as a model of

lightness, strength, and beauty. The skeletons of the great group of corals may also illustrate these primary and secondary purposes in the building up of great islands and continents. Sea anemones have no hardened exoskeleton, but they possess an external layer of hardened tissue containing the substance "chitin" just mentioned.

The Echinodermata, or sea-urchins, starfishes, and sea-lilies, present a very hard and varied coat fashioned by the animal from the ingredients of the sea-water in which the animal lives. It is enough to mention these familiar forms of protective structure without further description, except to refer to the movable spines often found on the plates of the shell or coat, some of which are capable of bestowing painful wounds on enemies by means of a stinging apparatus. Altogether this group of sea-urchins, starfishes, and the like are well able to take care of themselves, which fact may account for their great antiquity as a family, dating from Palæozoic times.

The great group of Annulosa comprises *worms*, of various forms, *spiders*, *crabs*, *lobsters*, *shrimps*, and *insects* of all kinds.

In worms there are no such spicules forming a skeleton as in the sponges, nor any complete endoskeleton. But protection is given by an outer tough coating in some; in others the same with muscles attached to it. In sedentary annelids inhabiting the sea there is a protecting tube, sometimes further hardened by the deposition of calcareous salts, sand, mud, or other foreign substances. In some a lid is provided at the entrance to this tube, capable of closing the aperture. In certain chætopod worms some gland-cells of the outer skin secrete hard bristles, serviceable for protection. The earth-worm has also an abundant slimy secretion on the surface, serving efficiently to protect it.

The great group of insects consists of animals with the body divided into head, thorax, and abdomen, each of these parts being protected by contrivances of various kinds. The antennæ and jaws borne by the head contribute to the protection of the possessor, and the simplest well-known example of protection in the case of the jaws is that of the mandibles of the stag-bettle, resembling horns in shape. The head is also strongly protected by a chitinous covering, as is also the thorax, that of the abdomen being of a softer and more mobile character.

In addition to the dense tough covering of an insect such

as the stag-bettle, or the equally tough covering of *Pulex irritans* (or the flea), there are numerous species with delicate protecting hairs, or with appendages on the terminal portion of the abdominal segment, such as the pincers of an earwig, or the sting of a bee or wasp. Then there are *protective resemblances* in this order, marvellous cases of *mimicry*, *warning colours*, and *recognition markings*—all eminently protective to their possessors. Further details of this great group cannot be considered here. Lord Walsingham considers that only about 10 per cent. of all existing species have been described, and these are calculated to number 250,000. We may simply enumerate the better known forms—ants, wasps, bees, saw-flies, flies and fleas, butterflies and moths, beetles, dragon-flies, may-flies, white ants, crickets, grasshoppers, cockroaches, earwigs. The simple mention of the more or less familiar forms of insect life bring up before the mind a perfect wealth of contrivances for the protection of the bodies of their possessors.

In the Arthropoda (Crustacea, spiders), so called because of their pointed limbs, there is, instead of the calcareous skeleton of sea-urchins and the like, a chitinous external skeleton of the organic horny chitin, secreted by the integument. The immense variety of forms which this great family of animals exhibits will excite our admiration as showing the beautiful adaptation of their protecting structures for diverse environments—the hard carapace and armour of the limbs in crabs, lobsters, crayfish, to say nothing of acorn-shells, king crabs, hermit crabs, barnacles, shrimps, sandhoppers, water fleas among the smaller forms. The power possessed by the young among these Arthropoda of shedding their protective covering during growth is Nature's method of dealing with these young and stirring lower animals. The "jointed" young ones have a simple method of adapting their coats to their growing bodies and just shed their protecting "chiton" when it is too tight, remain quiet and in a temporarily timid state for a few days, no longer indulging in their favourite battles, and devote a little time to the secreting of a new "chiton" from their soft integument. They are then ready once more for the struggle of their life, offensive and defensive.

The Arachnida or spider family, in which hundreds of British forms alone of spiders are known, includes spiders, scorpions, mites, "harvestmen" and certain parasites.

In many the integument is not hardened for protection,

but most spiders have soft, flexible surfaces on the under and a harder chitinous covering on the upper part. Scorpions have a chitinous shell all over the body. In spiders the segments which represent the antennæ of insects are very efficient pincers, used for prehension. Scorpions have still more formidable nipping-claws, and have the power of stinging their prey by means of the tail, which is hooked and has two poison-glands with minute canals opening into the tips. The spider's web must ever be borne in mind as a wonderful and beautiful method of protection devised for the double purpose of protection and supply of the animal's needs. Its formation and origin need not be here described.

Centipedes and millipedes also possess a chitinous covering and glands in the integuments which secrete an acrid fluid for protection.

The remaining group of Invertebrates or non-chordate animals is the large sub-kingdom of Mollusca or soft-bodied animals. For us the interest centres on the shells, which almost all possess. They are aquatic, inhabiting sea and fresh water, and terrestrial. It is computed that 50,000 species of the former and less than half that number of the latter have been identified. The vast majority of Mollusca have shells consisting either of one piece shaped after diverse patterns, or of two valves, thus constituting the two main divisions of Mollusca, univalve or gastropod molluscs, and bivalve or lamellibranch molluscs—*e.g.*, snails on the one hand and oysters on the other. The shell is in nearly all composed of calcareous matter mixed with a small amount of animal matter, and is formed by the outer layer of the "mantle," so called. This shell is essential to the life of the animal, and it cannot, in the convenient manner mentioned among Crustacea, shed its coat and form a fresh one. Injuries to the shell can be repaired, but no new one has ever been known to be produced. Shells are described as *porcellanous* from their dense white structure, *horny*, *fibrous*, or *nacreous*, such as those of the mother-of-pearl. In addition to the ordinary protection of the hard shell, there is in many a further protection of the shell itself. This "overcoat" of the molluscan shell is called the "periostracum," and is a tough, smooth coating laid over the calcareous surface, efficiently protecting fresh water shells, in particular, from the eroding chemical action of the water, in which carbonic acid gas is dissolved. A past generation of men thought the discovery of copper coatings for the bottoms of ships a great

advance, which it truly was, on the old style of ships' bottoms, when the great seamen of old days would be obliged after a long voyage to spend weeks in "careening" the bottoms of their stout, rough little vessels that the surface might be freed from myriads of barnacles, seaweed, and such like. So the growth of knowledge produced copper bottoms, and in course of time this process was improved upon by the discovery of compositions to preserve the copper bottoms themselves. But here in a molluscan shell is this late discovery of man anticipated in an organic composition, formed from the shell itself, and reformed as required.

It only remains to remark upon the exceeding beauty of the colouring of many shells, connected with the presence of certain glands in the "mantle" of the mollusc. The colours may be white, red, green, yellow, olive, purple, slate blue, black, and marked with a marvellous symmetry. As to the forms of shells, there are those of cephalopods, such as cuttle-fishes, argonauts, pearly nautilus, octopus, and a few more. Ammonites and Belemnites, among extinct forms, come under this division. Of these, all the pearly nautilus and *Argonauta argo*, with its shell used as a boat in which the mollusc swims near the surface, are the most beautiful and familiar forms. But the protection conferred on cuttlefish is very interesting, with the dorsal plate or cuttle-bone placed under the skin of the back so as to protect the animal against collisions as it swims backwards, as also the remarkable ink-bag which can be discharged by way of self-defence against pursuers at the pleasure of the animal.

Next to Cephalopods come the bivalves, *oysters*, *scallops*, *cockles*, *mussels*, and *razor-shells*, too familiar to need description.

The largest division is that of Gastropods, such as *snails*, *whelks*, *periwinkles*, *limpets* and *cowries*, which inhabit fresh water lakes, rivers, salt water at all levels and in all regions, and the land.

Some of these have an internal skeleton, but the majority have an external skeleton, and some, such as slugs, none at all. They have spirally-coiled shells and are univalve as a rule, and nearly always they are coiled from right to left. To take one familiar example out of many as to efficient protection, we may remember the numerous and fruitless efforts made by us in the days of our youth to dislodge a well-grown limpet from its rocky home, and may thus gain an idea of the power of the muscle which retains it in

contact with the rock, and the efficient covering given by the strong little shell to the soft-bodied animal within.

The next class of animals is that of the fishes, lowest among chordate animals, for we need hardly in this short sketch consider the so-called semivertebrates, *lancelets*, *sea-squirts*, and *sea-worms*.

Below the true fishes is a class called Cyclostomata (lampreys or hag fishes), called also Marsipobranchii from their pouched gills, the hag fishes being not a little interesting as regards a singular form of protection they possess, viz., that of secreting enormous quantities of slimy mucus, which may even be so great as to interfere with fishing in their immediate neighbourhood.

We have now to consider the various methods of protection among vertebrates, such as *scales*, *spines*, *fur*, *hair*, *feathers*, *horns*, *poison-glands*, possessed by all below man, according to their individual needs. There are five orders of fishes described, and a few only of these can be touched upon by way of illustration. The means of protection among fishes, generally speaking, consist of *scales*, *teeth*, and *fins* and *fin-rays*. Of scales there are three kinds, "*ctenoid*" or comblike (as to their hinder edge), "*cycloid*" or circular, and "*placoid*" or plate-like, these last being often composed of structures similar to those of the teeth, viz., *dentine* and *enamel*. The fin-rays are delicate bony rods supporting the fins. There is also as a rule in fishes a gill-cover or "*operculum*" covering the gill-slits and gill-rays efficiently. The brains of fishes require protection to a great degree, and they obtain it in the delicately shaped and carefully welded bones of the skull (*e.g.*, in the skull of a perch there are thirty-seven pairs of bones enumerated), which as a rule has a pointed, tapering shape, with obvious advantage conferred thereby in the rapid passage of the fish through the water—a shape advantageously imitated by man in the construction of his ships. The same advantage in its rapid movement is obtained by the beautiful imbricated or overlapping arrangement of its scales with which we are familiar, and further assisted by the slimy abundant secretion of mucus. *Fins* are among the earliest of organs among Vertebrates, in which the beautiful double purpose of protection (offensive and defensive) and direction by one organ is supplied. Not only does the fish progress by means largely of its fins, but it at the same time steers and maintains its balanced position in the water with them, as is shown by the

experiment of cutting off the fins of one side, or of the two pectoral fins. The tail fin has this double purpose in a special manner, as if a steamer were propelled and steered at the same time by screw or rudder. The teeth of fishes are of great variety as to number, size, and arrangement, and contribute of course very largely to the protection and supply of food to the animal, especially the latter, and can be renewed indefinitely as a rule. We may notice the terrible armature of the sharks with their interlocking formation, and numerous rows of reserve-teeth which lie folded back behind those in use, also the great basking shark, sometimes 28 feet long (*e.g.*, one caught at Shanklin), shows a remarkable development of *denticles* on the surface of its body, constituting very efficient mail armour, and otherwise rather devoid of protective structures.

Other more rare methods of protection among fishes can only be enumerated, *e.g.*, the electric organs near the tail of the electric eel, found in the river sand lagoons of Brazil; the series of galvanic plates along the back of the torpedo, or electric ray; the strange modification into spines of the skin of the globe-fishes, capable of immense distension by means of air taken in through the gullet. When well filled with air it becomes nearly circular, the spines stick out at right angles to the surface, and the inflated globular creature floats along the surface of the water, and can afford to laugh at almost any hungry enemy; it is appropriately called the sea-hedgehog.

Again, some small fishes frequenting the coral reefs of the Pacific, called *Scorpanoids*, possess appendages of the skin causing them to resemble seaweeds, so that they are easily hidden. Some of these are justly feared because of their poisonous dorsal spines. The class of swordfishes forms a remarkable group of specialized animals, the well-known offensive weapon being a prolongation of the upper jaw. *This well-armed warrior of the deep not being otherwise well protected, and having neither scales nor teeth*—its active structures of offence or defence are sufficient to allow it to dispense with passive ones. Its great weapon can transfix a codfish or tunny, and even, by repeated stabs, a whale, and will even penetrate the strong timber of a ship. At the College of Surgeons Museum one may see a portion of the bow of a South Sea whaler with the end of a sword from one of these fishes embedded in it. At one blow the fish had lunged his sword through and transfixed $13\frac{1}{2}$ inches of solid timber. Another

highly specialized family of fishes are the pristidæ or saw-fishes, belonging to sharks and rays. Their terrible saw-like weapon is developed from the cartilage of the mouth, and consists of five portions strongly welded together, furnished with lateral rows of teeth in sockets. The fish itself may be 20 feet long and the saw 6 feet. They have their mouth on the under surface like sharks and have no *needlessly strong* teeth. They strike their prey sideways, thus tearing the flesh to pieces, and devour it at leisure. One of the ugliest and most singular of fishes is the British angler-fish or sea-devil, with its marvellous fishing tackle, living at small depths on the coasts. Lying at the bottom, it can move on its surface, as if walking, with its pectoral and ventral fins used as limbs, and generally hidden in seaweed. It is also protectively coloured, and all round the great head are fringes. This is not all—the angler-fish lies with its great mouth wide open and is furnished with three long filaments inserted along the middle of the head. The longest of these, the first, is able to move in all directions by way of attracting prey into its capacious maw. Flying-fish need to be remembered, and are too familiar to need description, except to state that their flight resembles that of a parachute in principle and may extend to 500 feet.

Amphibia.—This class of animals is not of sufficient importance from our present point of view to detain us long, and it will only be necessary to mention a few characteristics of the group, of which frogs, toads, or the tailless amphibians, and newts, salamanders, or tailed amphibians, are the chief. They would appear in general to be very little protected against the various dangers of animal life, with their soft, naked skin. But in them a considerable element of protection is bestowed by their coloration, which strikingly resembles the colours and appearance of their surroundings, and which is able in a wonderful manner to change according to those surroundings. Their skin is moist and flexible and can be shed and renewed frequently. It serves the very important function of absorbing moisture from their damp, marshy homes or from the water in which they may live. This is their method of drinking. Their skin is also endowed with numerous glands secreting a milky, poisonous fluid, partly of a protective character.

Reptiles constitute a larger and more important group than *Amphibia* and include *snakes, lizards, tortoises, turtles, and crocodiles*.

They resemble birds and lower mammals in the manner of reproduction, the young being produced from eggs, but are strongly marked off from these two higher classes by the absence of hairy appendages to the skin or feathers, though certain extinct reptilian forms are believed to have possessed feathers. This point touches the much-discussed subject of the development of birds from reptiles, which is too large for present consideration. *Crocodiles* show the familiar hard, horny appendages to the skin in the form of plates arranged close to one another in rows resembling ancient armour, which are shown in all the regions most liable to injury, such as the back and tail. They are adapted both for life on land and in the water; but are unable to remain long under water. In accordance with their frequent habit of lying near the surface of water they possess a remarkable arrangement of the posterior openings of the nasal passages. These open as far back as possible in the cavity of the mouth just within a short distance of the upper opening of the windpipe, and this arrangement allows of the unusual power of taking air into the lungs when the anterior portion of the cavity of the great mouth is full of water, the external opening of the nostrils being placed at the very end of the snout and remaining barely visible above water. This constitutes a very efficient method of protection from foes and concealment from prey. The great rows of teeth and deeply-set eyes and small external ears, with their covering for protection, need only to be mentioned in the list of the armour, offensive and defensive, of the various crocodiles and alligators found in the subtropical and tropical regions of the world.

Tortoises and Turtles possess the well known exoskeleton or shell, and this constitutes their first line of defence. Their second is that of the horny, toothless beak. Their protective structures are almost entirely passive, and the form, texture, and arrangement of their carapace or shell is so familiar as not to need description here. Suffice it to say that the strong, hard substance of the plates, their firm articulation, the carefully convex shape of the whole, and the power possessed by many of the tortoises of withdrawing their head and limbs within the shelter of their movable castle, convey a high degree of protection against other than human foes. Indeed, one is not surprised at those practical old soldiers of Rome having invented or imitated the moving fort or *testudo*, on the lines of this arrangement of the protective structure of these reptiles.

Snakes present three main structures of a protective kind—*scales* developed on the integument, with which one must remember their remarkable power of frequently changing their skin, *protective coloration*, and among venomous snakes the *poison-fang* and *gland* with the muscular apparatus for ejecting a stream of the venom along the grooved fang placed in the front of the upper jaw. Time will not allow of any details being given. With these protective arrangements and their power of rapid sinuous movement snakes are not less equipped for the struggle of their life than other animals. The reserve fully developed poison-fang behind the one in use needs to be remembered. Indeed, it has been noticed that, considering the fact that non-venomous and venomous snakes get on equally well in life, the latter may be called over-equipped animals. The eyes of the snakes are provided with a thin transparent layer of skin for protection of these delicate organs, and this layer is shed with the rest of the skin and renewed.

Lizards, inhabiting mainly the land, some the trees, and some the water, are a large group of animals protected mainly by their colouring, active movements, and scaly skin. A few have a poisonous bite, but most of them are harmless. The most interesting from the present point of view are the chameleons, very sluggish, harmless creatures, mostly arboreal, but remarkably protected by their power of changing colour, not only according to their surroundings, but from yellow at night to dark green at dawn, and brighter in colour as the daylight increases. They have a singular thin tongue, several inches long, which can be protruded with lightning-like speed to any small prey, which the sticky bulbous end captures with unerring skill, while the creature itself may be solemnly seated on a bough apparently as motionless as the bough itself, with only its globular eye revolving in a weird manner. Lyddeker points out how utterly defenceless are these creatures apart from these characters mentioned.

Among birds the structures concerned in their protection are very remarkable and differ much from those of any other class of animals. The most characteristic are feathers; epidermal structures analogous to the scales of fishes and reptiles, or to the hair of mammalia. It is clear that there are two important purposes in clothing a bird with feathers. On the one hand, feathers are valuable non-conductors with the important effect of maintaining the temperature of the bird's blood in its rapid flight through cold air.

The feathers being set closely together and in different layers, one can see how a considerable bulk of warm air is retained round the main organs of the body. On the other hand, feathers, being very light themselves, assist materially in lessening the specific gravity of the body; and in addition to this they further diminish the specific gravity by retaining a certain amount of warm air, serving a purpose, in a more delicate manner, which the "swim bladder" of a fish does in its element. The construction of a feather is elaborate and marvellously complete for the purpose. It cannot be better studied from the present point of view than in the pages of Paley. One only need refer to the names of the various parts of a feather. The shaft is divided into quill and rachis, the latter giving off numerous processes called barbs. These are interlocked with one another by the delicate contrivance of barbules held together by fine hooklets. These together constitute the vane of the feather. One small point in the quill may be noticed, viz., that this tough, light structure is filled with air, and a small opening at the distal end called the "superior umbilicus" is furnished so that the air inside the quill communicates with the outer air, thus preserving the due degree of air-pressure in the cavity of the quill. All this mechanism testifies strongly, I think, to intelligence in operation, whence alone structures so light, so strong, so firm to resist pressure, so protective against heat, cold, and moisture as the commonest wing-feathers of a common bird could have proceeded. It may be added that the *distribution* of feathers is admirably adapted to a maximum of *protection, warmth, lightness, and smoothness of contour*, and a minimum of waste of tissue or size. In this connection one must mention shortly the remarkable oil-gland found in most aquatic birds. Anything more significant of design in the efficient protection of the feathers and body of an aquatic bird than this receptacle, placed in a convenient situation for the bird to reach it with its beak, it is hard to imagine. The small sac referred to lies in a sheltered, convenient position on either side near the tail of the bird within easy reach of its beak. It is well protected from pressure, and yields when squeezed a thick oily secretion, wherewith the bird "preens" its feathers, conferring upon them the necessary amount of "waterproofing," renewable as required when the bird's sensations inform it of its needs. Here is a case in which the protective structure is itself protected, reminding us

of the "periostracum" or "overcoat" of certain mollusca, to which reference has been made. Though not strictly protective structures, the air-sacs found in the bones of a great many birds may be looked upon as indirectly protective by reason of the warming effect upon the air of respiration, acting as a reserve warm-air chamber, which is of value to the bird in its rapid inspiration of cold air.

The *beaks of birds* confer necessarily protection upon them, as teeth do in other animals. The *skull* is welded together into one solid, light, strong bone in adult birds, and lightened by air spaces.

The *nasal passages* are protected by the position of the apertures, placed far back on the skull. The *external ears* are carefully protected by a tuft of hair.

The *eyes of birds* are specially protected by the "third eyelid," or "membrana nictitans," also highly developed in fishes, and much less in some mammalia. In birds and fishes this movable mucous membrane is of obvious advantage in protecting the eyeballs against the impact of foreign bodies in the air and water. It is capable of being rapidly moved across the eyeball, serving in the most beautiful manner to protect, lubricate, and cleanse the surface.

It remains only to mention the names of the leading members of this great class of highly specialized animals, and such of them as are familiar will at once suggest to our minds modifications of the protective structures given above. Lyddeker enumerates them as follows:—

Perching Birds, Woodpeckers, Cuckoos, Hornbills, Parrots, Owls, Ospreys, Eagles, Falcons, Vultures, Pelicans, Cormorants, Gannets, Storks, Herons, Flamingoes, Ducks, Geese, Swans, Screamers, Pigeons, Dodos, Sand-grouse, Fowls and Game Birds, Rails and Coots, Cranes and Bustards, Plovers, Curlews, Snipe, Gulls, Terns, Albatrosses, Petrels, Divers, Auks, Penguins, Tinamus, Ostrich, Emu, Cassowaris.

Among the great class of mammalia those characters conferred upon them for protection present to us a broad fact strikingly illustrative of design. This class includes animals of a higher organization in almost all respects than those that have preceded. Of these the most important is *higher cephalization* or increasing proportion of the size and complexity of the brain. In lower levels of life there are some remarkable exceptions to this broad rule, *e.g.*, among insects the brains of an ant so impressed Darwin

as to cause him to say, "Thus the wonderfully diversified instincts, mental powers, and affections of ants are notorious, yet their cerebral ganglia are not so large as the quarter of a pin's head. Under this point of view, the brain of an ant is one of the most marvellous atoms in the world, perhaps more so than the brain of a man."* But, broadly speaking, ascending brain-power, shown not only by proportional weight and size of brain, but by complexity as well, marks all the vertebrate or chordate classes, especially mammalia.

The striking fact in regard to characters for protection is the diminishing power and complexity of "passive" structures, correlated with the increasing power, through higher intelligences, of employing the "active" characters subserving protection.

The means subservient to the active protection of the body are such as the organs of movement, of sight, hearing, smell, taste and touch—claws, teeth, and horns. The various powers of burrowing, climbing, swimming, diving, walking, running, hibernating, exhibit some of the different methods adapted to the differing organizations of mammalia, and serving to protect them against a thousand and one dangers.

In regard to *passive* structures concerned in protection we find many still among mammalia, but in a markedly lower proportion to their multiplying needs than all that have gone before. The enumeration of the most common passive structures among mammalia, viz., *hairy coverings* of all degrees of thickness, *spines*, *coloration*, and *markings for protection*, and a few specialized forms, will show their comparative insignificance in this the highest class of animals. In truth a survey of this subject forces one to the conclusion that as animals ascend the zoological ladder they have increasingly to learn the art of living by their wits; an art which naked-skinned, unprotected man has been compelled to study to perfection, in the course of many bitter lessons.

We will here only mention the successive orders of mammalia, as given by Lyddeker, alluding briefly to the protective character of each.

1. *Monotremata* possess fur, strong claws, and certain of them prickly spines. *Marsupialia*, or pouched animals

* *Descent of Man*, i, p. 54.

such as kangaroos, wallabies, and opossums, have the characteristic pouch for the young, hairy coverings, strongly made, powerful tail, and configuration adapted to rapid leaping.

2. *Edentata* comprise sloths, ant-eaters, armadilloes, and pangolias, and some have a remarkable extraneous greenish growth of fungus on their thick, coarse coat, protectively coloured—*anteaters* a peculiarly tough, dense coat and hard skull, *armadilloes* a powerful cuirass of bony plates and the power of curling up into a ball and of burrowing rapidly. The South American *apar* can protect itself thus about as rapidly and efficiently on land as the “sea-hedgehog” was shown to do on the water.

3. *Sirenia* or sea-cows, with tough smooth skin, slow in movement, frequent shallow seas, rivers, and bays.

4. *Cetacea*, as whales, dolphins, porpoises, possess tough, smooth skin, “blubber” for protection against cold among whales, and large, active, quickly moving bodies.

5. *Rodentia* or gnawing animals—mice, rats, squirrels, rabbits, hares, beavers, porcupines—are mostly terrestrial, burrowing and nocturnal in habits, a few aquatic and a few arboreal. They have as defensive armour only fur as a rule, a few have spines, especially “the fretful porcupine” of Shakespeare, and as indirect means of protection strong gnawing teeth, with strong chisel-like cutting edge, and no canine teeth, as the latter would, if present, be useless to them.

6. *Ungulata* or hoofed animals, such as horses, asses, zebras, rhinoceros, tapirs, pigs, sheep, oxen, goats, deer, antelopes, giraffes, elephants, camels, possess a few passive characters, such as hairy coverings of various kinds, thickened integument, and certain special instances of protection by diverse means; and as active characters *horns, tusks, antlers* on the one hand and fleetness of pace and agility (*e.g.*, horse and goat) on the other.

7. *Carnivora*, such as *cats, hyenas, dogs, wolves, foxes, bears, weasels, racoons*, all possess hairy coverings of great value to themselves and for protection against adverse influences, also many protective markings. “*Vibrissæ*” or “whiskers” in all the cat tribe, a valuable tactile organ, each long hair being furnished at its base by a special sensory nerve; the singular papillæ on the tongue of cats, *curved backwards*, for the purpose of cleaning their fur, and licking clean the bones of their prey (in which character they differ from the dog tribe, which crush the bones with their teeth); the retractile

claws found in many Carnivora, whose beautiful mechanism and economy of force compels our admiration—these are but a few general and special contrivances for protection among this important order of mammalia.

8. *Insectivora*, such as hedgehogs, moles, and shrews, are inoffensive, burrowing, hibernating, and mostly nocturnal animals, and these show some important protective characters such as dull, *uniform colouring*, strong, coarse coats, and formidable erectile spines among hedgehogs; a delicate, velvety, strong coat among moles, which lies smooth when rubbed forwards or backwards; very strong claws, spade-like fore-feet, and elongated snout. Shrews show fur much like that of mice.

9. *Cheiroptera* or *bats* show modifications of the digits of the fore-limbs into a long framework on which is stretched the wing-membrane, enabling them to fly; the thumb being furnished with a claw, the hind-limb with hook-like claws by which the creature can suspend itself when asleep. They also have a beautifully sensitive sense of touch in the wing-membrane, nose, and external ears.

10. The remaining order of mammalia, *the Primates*, contains lemurs, monkeys, apes, and man, the least protected of all animals, except for such help as he obtains from his elevated intelligence. The armour, offensive and defensive, of the primates below man consists of hairy coverings, some protectively coloured, strong teeth, especially tusk-teeth, prehensile tails, powerful fore-limbs, generally extreme agility of movement, all of which conduce to a considerable power of taking care of themselves.

I think this rapid survey of leading forms of animal life with the methods of protection adapted to each will tend to bear out as far as it goes the statement of Weismann that “everything is adapted in animate nature.” It is a catalogue of contrivances for the important purpose of protection of individual animals, hardly less eloquent of design than such a record as the Patent Office, for instance, affords of the multi-form inventions of the human intellect. “Means adapted to calculable ends” may well describe this varied series of protective characters. And I venture to affirm that the conception of an intellect and will and power, not human and yet in measure interpretable by the human mind, concerned in the production of these characters, cannot be avoided.

This small contribution to teleology is offered to those who, in the words of Professor Campbell Fraser, “are trying,

as many now are, to realize intellectually, whether or not we are living and moving and having our being in an essentially divine universe—that is to say, in a universe that in its final principle is morally trustworthy, and that is more or less interpretable by man, in an exertion of theistic or religious faith, as well as of physical faith.”*

DISCUSSION.

The CHAIRMAN.—Is it your pleasure, ladies and gentlemen, to return thanks to Dr. Kidd for his communication? (Applause.)

I think we have listened to an exceedingly interesting and graphic account of the modes of protection, which are often the same as those used for supplying the needs of animals from the lowest to the highest order. We might often wish that some of those forms were not so well furnished with means of protection—for instance, when Dr. Kidd came to the question of the insect tribe, bugs, fleas, mosquitoes, cockroaches, and other forms which infest hot countries, and which require curtains to keep them from persecuting unhappy individuals sleeping under them, we might wish that Nature had not been so very adaptive to their wants for the purpose of perpetuating those noxious pests. But I suppose we must feel that every animal has its use. We cannot always see what their use is. We could very well, for instance, do without some of those I have mentioned, and such forms as scorpions, or flocks of those destructive insects, the locusts; and I hope as civilization extends over the regions where those animals seem to multiply, and to develop to an extraordinary extent, that man will be able, if not to exterminate them, at any rate certainly to reduce their number for the benefit of mankind generally. In the vast majority of cases that Dr. Kidd has enumerated this evening I think we must admit that we see most clear evidence of design, both for protection and for the supply and support of the animal life.

* *Giffard Lectures for 1895-6, Series 2, p. 2.*

Professor ORCHARD, D.Sc., in response to the Chairman, said : In response to your invitation, Mr. Chairman, I am very glad to express our sense of debt which we owe to Dr. Kidd for his thoughtful and suggestive paper this evening.

The subject of the protection of animals is, of course, a subsidiary branch of the great argument of design. It is a branch, however, which has generally been very much neglected. Dr. Kidd has done good service in the cause of truth in calling attention to it this evening.

The AUTHOR, in reply, said : I am much obliged to you for your very kind reception of this paper, which I am afraid was rather hurriedly written and is imperfect in parts.

I did not refer to anything in regard to the protection of man because that to deal with this subject would require a paper itself. It is well worthy of study—the subject of the protection that is given to almost every part and organ of the human body, the veins and arteries and those structures, apart from his own powers of taking care of himself. I often think that one of the most wonderful things is the little tube called the thoracic duct, conveying the lymph from the abdominal regions to the venous organs. It is in a most elaborately and carefully arranged position, so that it is never pressed upon by any large organ, and a wound in that tube or a stoppage is quite a rare case in medicine; illustrating the way in which this means of communication from one portion of circulation to the other has been thought out and protected. I can see no other view than that it is a matter of infinite and perfect knowledge and design. The substance is softer than a vein and far more important than a main vein, simply because there are no other means of communicating this immense supply of lymph to the body than by this little channel provided with valves.

The CHAIRMAN.—Perhaps Dr. Kidd may be induced some day, either this session or next, to give us a paper on this particular subject. (Applause.) He referred to Mr. Lyddeker's work. I suppose that is the *Royal Natural History*?

Dr. KIDD.—Yes, and Dr. Sclater?

The CHAIRMAN.—Yes, and Dr. Sclater's. I have been recently turning over its pages with the greatest admiration. I think it is one of the most beautiful works on Natural History that was ever

published, and I am very glad that Dr. Kidd has referred to it this evening.

Dr. KIDD.—I ought to say, perhaps, that I obtained a good deal of my information from that book that I have brought forward this evening.

The meeting then closed.