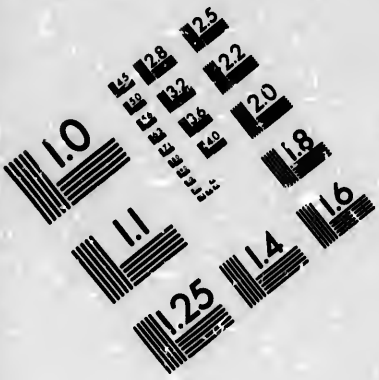

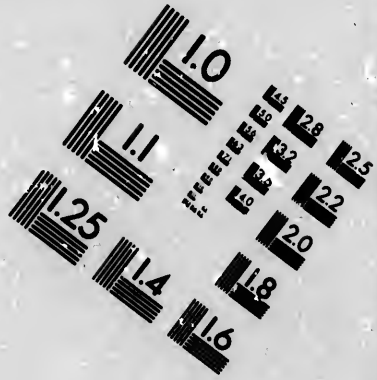

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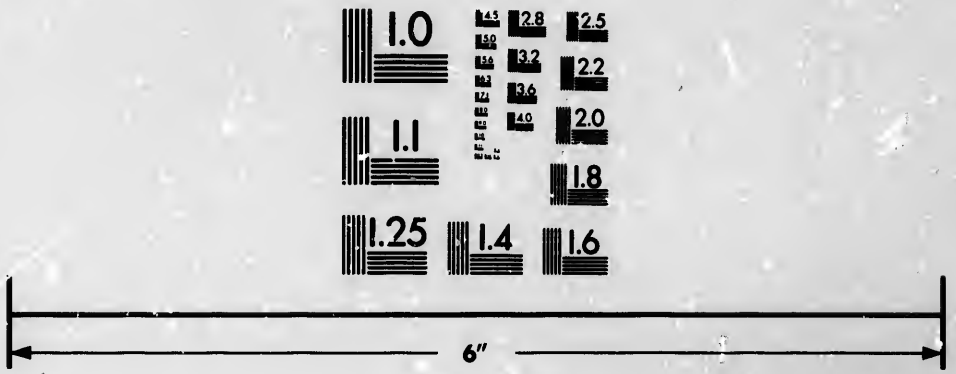

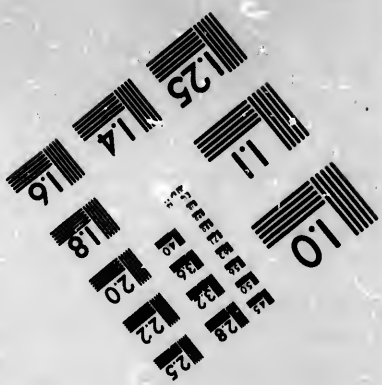

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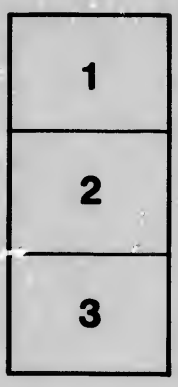

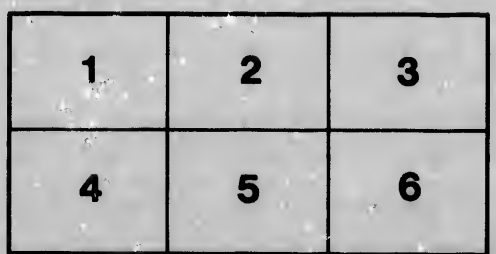

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With the Author's compliments

(Reprinted from the Annals of the Andersonian Naturalists' Society. Glasgow, 1893.)

CURIOUS PROTECTIVE FEATURES IN THE YOUNG OF VERTEBRATES.

By Edward E. Prince, B.A., F.L.S., &c.,
Professor of Zoology in St. Mungo's College, Glasgow.

(Read 6th April, 1892.)

The great Karl Ernst von Baer was wont to gather around him successive bands of Königsberg students at the commencement of their professional course, and, holding in his hand a fowl's egg about the fifth day of incubation, he skilfully removed a lid-like portion of the shell in order to expose to their wondering eyes its strange contents. They beheld, as though modelled in miniature, the living chick upon its bed of yellow yolk, with the head disproportionately large and rounded, with fleshy stumps for wings, and with developing legs curled up beneath the naked trunk. Von Baer pointed out to them, as the embryonic heart, the pulsating bag beneath the throat, through the transparent walls of which the red blood was seen passing by in quick convulsive motions; he bade them note the curious clefts in the gullet, the "visceral slits," and, above all, drew attention to the sheets of thin membrane, full of fluid, like transparent water-cushions surrounding the immature bird. With the entrance of cold air into the warm chamber of the egg the body of the chick was seen to move very obviously, for the movements, as well as the whole general structure, of the embryo, could be seen in the midst of its strange envelopes of membrane and clear fluid.

The curious enveloping structures present in the young stages of all the higher animals have been variously interpreted. Some regard them as having arisen when the yolk-matter of the ovum was much more bulky than it is now; but, whatever

their origin, their present purpose and meaning have been involved in much obscurity. It is known that slight mechanical pressure upon the immature young and alterations in the surrounding temperature produce apparently disproportionate effects. Professor Cleland's well-known experiments have furnished ample evidence of these results, usually inimical. To shield the developing organism from hurtful influences, reptiles, birds, and the higher animals are wrapped up in embryonic membranes and bathed in abundant fluid. That such structures now serve protective purposes can hardly be questioned. In the chick they are no less than seven in number:—the liquor amnii (1) contained in the true amnion (2), outside which is a serous fluid (3) retained within the false amnion (4). External to the amniotic envelopes are the inner shell-membrane (5), the air-chamber (6), and the outer shell-membrane (7), with its calcareous deposit constituting the dense outside shell. None of these really form an essential part of the bird, and by the time of hatching most have served their purpose and have degenerated. In the mammalian embryo the amniotic envelopes and fluids are discharged at the close of fœtal development. In the lower vertebrates, the fishes and amphibians, no amnion exists; but there are other embryonic structures which serve the same purpose. The frog's egg, for instance, is a small sphere, of which the upper half is tinted black, while the lower half is whitish. Before deposition in water the egg measures barely $\frac{1}{10}$th of an inch in diameter, with a thin outer coat of albumen, like a film of gelatine. The latter on contact with the water swells to more than five times its original size. Massed together these jelly-clothed eggs form the floating spawn so familiar in every wayside pond in spring. A distinguished naturalist has very happily compared the deposited eggs, each a ball of jelly with a black centre, to a number of hen's eggs removed from their shells and placed together. Each yellow yolk corresponds to the small black egg of the frog, the white represents the jelly of the spawn. The entire chick is formed from a part of the vitellus, whereas the frog is built up out of the entire tinted vitelline ball. The eggs too, as Professor Miall has pointed out, are kept apart, due aeration is facilitated, and parasitic vegetable growths prevented. The authority named says that the broad-billed duck is one of the few animals which can devour frog-spawn, other

creatures being prevented by the slippery nature of the enveloping jelly. Toad-spawn does not form irregular masses, which rise from the bottom of the water soon after deposition as in the case of the frog, but appears as gelatinous ropes, very tenacious and many yards long. The newt's eggs are similarly surrounded by a clear fluid contained in a skin or oval capsule, the central vitellus being spherical and buff-coloured. Such coverings of membrane and jelly-like fluid protect the delicate embryo during its early development in various ways, and are cast aside, like the amniotic envelopes, when free life is entered on. A gelatinous coat surrounds the lamprey's ovum, and similar mucous matter forms the huge floating egg-ribbons of the angler fish (*Lophius*). The glassy eggs of the angler are scattered through the glairy mucus, and thus shielded from the shocks of the waves.

The jelly in fish and amphibian is an oviducal secretion not an essential part of the egg and not a product of the ovary. It is absent from the eggs of many fishes, a great number being simply provided with a thin capsule or vitelline membrane, so called because it arises as a skin or pellicle upon the surface of the yolk, and when hardened forms a resistent shell provided with pores, and in numerous species with knobs, filaments, and other projections. The capsule in the eggs of the hag-fish (*Myxine*) and other forms is regarded by many authorities as a chorion secreted by the oviduct and not a true vitelline membrane. The germ and yolk do not usually fill the chamber of the egg-capsule completely, and the perivitelline space (Ransom's breathing chamber) is filled with a dilute organic fluid, which forms a protective layer within the capsule. Upon emerging from the egg the larvæ of fishes and many other vertebrates are delicate and comparatively defenceless. A larval herring, haddock, or cod is a minute worm-like creature, rarely more than $\frac{1}{5}$th of an inch long, with a translucent body, a tapering dagger-shaped tail, blunt head, and with mere rudiments of paired limbs. The skin fits as loosely as Falstaff's tunic upon a lanky starveling, and the space separating the skin from the muscle-masses of the trunk is occupied by a clear serous fluid. In the larval frog and other amphibians this lymphatic layer is present, and in some bony fishes its quantity increases to such a degree that the head and trunk are swollen enormously as with some dropsical affection. In the

angler even the tail, in most of our common fishes as slender as the blade of a knife, is rendered thick and club-like. Delicate strands appear to pass across this fluid-filled sub-epidermal space, as in the lamprey, the angler, and other fishes. It is not difficult to surmise that this gelatinous layer around the delicate trunk serves a purpose identical with that of the amnion and other cushion-like coverings in the reptilian, avian, and higher vertebrate embryos. Buffeted about in the surface waters of the sea, or carried hither and thither by strong currents in lakes and rivers, minute larval fishes might suffer severely were it not for these surrounding coats of membrane and abundant fluid. Like the fatty blanket or blubber of the cetacean's skin, these layers preserve the larvæ from hurtful alterations of temperature. Most of our marine food-fishes, such as the cod, haddock, mackerel, sole, plaice, etc., exhibit "sub-epidermal" enlargements of this character, and over the head-region, where the sensitive brain, the delicate ears, eyes, and other important organs are located, they serve to shield these parts from the shocks of the surrounding water. The larval sole exhibits curious enlargements in the anterior region, and in the small Irish sole, recently described by an able scientific observer, Mr. E. W. Holt, they have the form of a huge bladder protruding from the forehead. But in the angler (*Lophius*) these enlargements, as already stated, reach a most extraordinary stage of development. Thus the cavity over the spinal cord and brain, enclosed by the arachnoid sac, probably the "subdural space" of higher forms, is extremely large. It is roofed over by the coloured serous membrane, external to which is a "peri-neural" space limited externally by a delicate membrane, the last forming the floor of a third or "sub-epidermal space" proper, common to all young fishes and outwardly limited by the integument. The delicately organised central nervous system is thus shielded from pressure and external agitations by this triple envelope of fluid-filled chambers and protective membranes. No doubt these have some interesting phylogenetic meaning, if we could only discover it; but they may without hesitation be regarded as amongst the most interesting and important protective provisions for securing the welfare of the frail organisms possessing them during larval life. Their minuteness

and glassy translucency, as in all pelagic animals, protects them, moreover, from sharp-eyed predaceous foes.

Hosts of the lower animals—starfishes, annelids, molluscs, etc.—are likewise pelagic, and when young possess this translucent character. "Pelagic animals," said the late Professor Moseley, "generally seem to be colourless or specially coloured with a view to protection from enemies both above and below the surface of the water. Probably the blue colour of *Ianthina* and *Velella* is protective as resembling that of the ocean water. . . . There are numerous other pelagic animals thus coloured blue for protection, such as the mollusc *Glaucus*, *Porpita* (allied to *Velella*), and some *Salpæ* in which the nucleus is blue. There are also blue *Medusæ*." While animals, young and adult, vertebrate and invertebrate, may be thus protected by their extraordinary transparency, which renders them practically invisible in the surface waters, they are frequently armed also with deterrent spines and defensive thorny projections. Many larval fishes are now known to possess parallel structures. The young angler, the gurnard, and other familiar fishes in our own seas have a formidable array of transient spikes and protuberances upon the body. A larval angler, five days after hatching, shows a finger-shaped knob in the middle of the dorsum. It is the rudiment of a larval spine. Two oar-like organs are also rapidly pushed out below and behind the small pectoral fin-pads. They are hardly recognisable as ventral fins, though they really are such. On the fifteenth day no fewer than three formidable spines appear on the back—two of enormous length, just behind the head, curving backward like lengthy tapering whips, while a third erects itself as a blunt protuberance half-way along the dorsum. The head becomes flattened and exhibits angular projections, the gape widens, and the ventral fins now resemble lengthy tentacles hanging below the trunk, and subsequently they become bifurcate and deeply tinted with black. All these spiny projections are supported by strong central rods of cartilage connected with the axial skeleton and limb-girdles. Thus they are somewhat rigid, and impart to the young fish a most formidable and grotesque appearance. Many other curious examples of such structures might be instanced: the ling and rocklings with their enormously long ventral fins, the gurnard and pogge with their huge expanded pectoral fins and

complex array of larval spines along the trunk, are typical illustrations. The young sharks, dogfishes, and rays are too familiar to demand more than a passing notice. Those not born alive —and many selachians are viviparous—are safely packed in a dense horny case secreted by a special gland in the oviduct, and comparable to the calcareous shell of the fowl's egg. This squarish egg-case is lined by a silky membrane enclosing abundant fluid, in which the young fish, attached to a large ball of yolk, floats securely. There is no amnion, such as reptiles, birds, and mammals possess, nor do large epidermal spaces develop beneath the larval skin, as in many bony fishes and cyclostomes, for these cartilaginous fishes remain during a long period within the egg-case, and are robust and even predaceous immediately on hatching out. Like young partridges they are well able to look after themselves at the moment of leaving the egg and entering upon their independent life in the outer world.

To speak of the invertebrates is beyond the scope of this paper, but reference must be made to one group of creatures, long classed as near relatives of the mollusca, viz., the tunicates, popularly known as the ascidians or sea-squirts, but now grouped by the more exact zoology of to-day in close intimacy with the *Vertebrata*. Amongst the solitary ascidians, *Appendicularia* (also called *Oikopleura*) is interesting, not only from the fact that certain vertebrate features are especially well-marked in it, but from a transient larval structure which it possesses, and which recalls the layers of membrane and fluid briefly described in the foregoing remarks. From the eggs of *Appendicularia* a strange little tailed creature like a wriggling gnat emerges. It is of glassy transparency, and undulates actively through the surface waters of the sea by the vigorous movements of its long blade-like tail. It possesses, as close examination reveals, an oval body with mouth, gill-slits, eye, ear, heart, and rod-like backbone—features which entitle it to rank high in the scale of animal life. An animal so perfectly organised would be in constant peril in the open sea, and the larva secretes, probably from the integument, a loose mass of clear jelly, which completely envelopes the body and leaves merely the muscular tail free. In this translucent blanket, usually called the "house" of the ascidian larva, it is protected from many dangers, though it pays

apparently one penalty for its safety, for it is much incommoded in its progress through the water. Violently lashing its tail it rushes hither and thither, up and down, through the surface water, with its head in its "house" much as a terrified cat with its head in a bag. The jelly so loosely clings to the ascidian that it frequently drops off.

But the curious protective features in larval vertebrates form a subject so varied and so new that more cannot be attempted in these notes than to point out some of the more salient features which recent researches have made known to us. Amongst the vertebrates we find embryonic structures often resembling in detail the analogous organs in larval invertebrates; nay, even in the vegetable world, in the embryonic stages of plants, and in the young growing parts of adults, corresponding provisions occur. The stipules, the bases of leaves, the more or less broadened proximal part of the petiole, the pedestal of the petiole, scales, spines, hairs, and gummy matter, all subserve the same important protective purposes. Sir John Lubbock, referring to the presence of stipules, declares that the most general reason for their existence seems to be the protection of the young and tender bud, though they may take at times the function of leaves, while they may be spiny for the protection of the whole plant, sometimes glandular, and so on; but their protective function explains their frequent transiency. It is precisely so in the animal kingdom. We see in the highest groups, in quadrupeds, birds, reptiles, amphibians, fishes, and ascidians, examples of the curious care which is exercised in nature to ensure the safety of the tender and otherwise defenceless young. Doubtless the absence of colour in the case of typical pelagic larvæ is one of the most remarkable provisions; but hardly less so is the presence of peculiar colours in other larval as well as adult forms. The late Professor Moseley looked with little less than amazement at the strange colours exhibited by the inhabitants of the gulf-weed in the Sargasso Sea. "The shrimps and crabs which swarm in the weed are," he wrote, "exactly the same shade of yellow as the weed, and have white markings upon their bodies to represent the patches of *Membranipora*. The largest shrimp occurring has a dark-brown colour with sharply defined areas of brilliant white upon its surface, thus closely resembling the older darker-coloured pieces of weed,

which are also most thickly covered with *Membranipora*. The small fish *Antennarius* is in the same way coloured weed-colour with white spots. Even a planarian worm is similarly yellow-coloured, and also a mollusc (*Scyllæa pelagica*). The white patches in some of the crabs, no doubt, represent also, to some extent, the white shells of barnacles, though these are not very abundant in the weed." Professor Moseley instanced a tunicate, a glassy *Salpa* of which the nucleus was of a dark red-brown colour in imitation of the tint of the floating sea-weed.

But many of the vertebrates, especially our common marine fishes, furnish striking instances of protective coloration. The sole in an advanced larval condition is patched in the most grotesque and erratic manner with warm ochreous blotches, and resembles a minute shred of floating weed, for the transparent parts of the fish are invisible. The definite transverse bands of the newly hatched cod and the longitudinal stripes of the late post-larval ling may be persistent traces of ancestral coloration not now of much protective significance; but the post-larval lump-sucker (*Cyclopterus*), the father-lasher (*Cottus*), and other common shore fishes are grotesquely blotched with the most diverse shades of black, brown, green, and yellow, while irregular patches of gleaming white may occur on the head or trunk and perfectly mimic fragments of corallines and encrusting polyzoan colonies. The protective coloration of immature and mature animals is, however, a familiar subject, and the object of this short paper is to point out protective structures less familiar and less obvious, and in many instances not hitherto observed or fully described. It is interesting to find that in the highest and lowest vertebrates alike there occur these curious embryonic and larval wrappings, differing so much in structure and origin, but subservient to the same protective purposes.