SCIENCE

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THE COLOR OF FISHES.

THE skin of a fish, upon the structure of which its color depends, consists of two layers,—the outer, or epidermis, delicate, transparent, and not supplied with blood-vessels; the inner, the corium or dermis, laminated and elastic, varying in thickness in different species and in different parts of the body, and permeated by blood-vessels and nerves. Between the skin and the underlying muscles is a layer of loose connective tissue, often loaded with fat, especially in the mackerels and salmonoids and in the herring tribe. In the menhaden this layer is thick, hard, and blubber-like.

The scales are modifications of the dermis, and are ordinarily thin, transparent, horny plates, with rounded quadrangular outlines, which are partially embedded in folds or pockets in the dermis, and covered by the epidermis, through which, however, their tips protrude. The scales are usually

SECTION OF THE SKIN OF A FISH.
a, epidermis; *b*, scales; *c*, dermis.

imbricated, overlapping each other like the shingles on a roof, but are sometimes separated and embedded, and partly hidden in the skin, as in the eel.

In fishes which live near the bottom and among the rocks, such as the sea-bass, red snapper, sheephead, and perch, the scales are usually thick, hard, closely imbricated, and deeply set in their sheaths, forming an impermeable coat-of-mail.

In fishes which live in the mud, such as the tautog, the burbot, and the carp, the scales are usually covered by thick layers of epidermis and mucus.

In fishes which swim free and far from shore, such as the herrings and the lake white-fishes, the scales are attached merely by a small area of their rims, and, being but slightly covered with epidermis, are easily rubbed off. Scales thus removed are in many fishes easily renewed.

The smooth polished surface of the closely set scales offers little resistance to the motion of the fish as it glides swiftly through the water.

The exposed surface of the ordinary fish-scale is usually covered with a thin silvery coating, which derives its brilliant metallic lustre from the presence of numerous crystals of a combination of guanin and lime. This coating may readily be loosened and rubbed off, and in one European fish, the bleak or ablette, a member of the carp family, the crystals are sufficiently abundant to become the source of the metallic pigment known in the arts as *essence d'Orient*, or argentine, which is used to impart a nacreous lustre to the glass globules sold under the name of "Roman pearls." When the silvery coating is absent, scales are lustreless and transparent, as in the smelt, the abdominal cavity of which, however, has a brilliant silvery lining composed of the same substance.

CRYSTALS FROM THE SILVERY COATING OF A FISH-SCALE (MAGNIFIED 600 TIMES).

The colors of fishes are very varied, and often exceedingly brilliant and beautiful. "Aucune classe d'animaux n'a été aussi favorisée à cet égard," says Lacépède; "aucune n'a reçu une parure plus élégante, plus variée, plus riche; et que ceux qui ont vu, par exemple, des zées, des chétodons, des spares, nager pres de la surface; d'une eau tranquille et réfléchir les rayons d'un soleil brillant, disent, si jamais l'éclat des plumes du pœon et du colibri, la vivacité du diamant, la splendeur de l'or, le reflet des pierres precieux, ont été mélés à plus de feu, et ont renvoyé a l'œil de l'observateur des images plus parfaites de cet arc merveilleusement colorie dont l'astre du jour fait souvent le plus bel ornament des cieux."

The colors are often due to a simple arrangement of pigment cells, placed at different depths in the skin; but those changeable and brilliant hues which constitute the greatest beauty of fishes are dependent, as Pouchet and others have shown, upon two very dissimilar causes.

One of these, which may be well observed in the scales of the herring, shad, or mackerel, is a true iridescence, similar to that seen in the pearl or in antique glass, and due to the refraction of the rays of light as they glance off the surfaces of thin plates or ridges in the scales. This is called "lamellar coloring." There are certain bodies called "iridocytes" (rainbow plates) embedded in the epidermis which have an important function, it is said, in this iridescent play of colors.

The coloration is, however, chiefly dependent on the arrangement of the pigment-cells, or chromatophores, which lie in the lower strata of the epidermis. These are black, yellow, and red; the latter, according to Pouchet, being capable of dimorphic changes into blue and green. The combinations of the various-hued chromatophores with the metallic crystals of silver, the white of the bony scale-plates showing through the epidermis, and the iridocytes already referred to, produce the coloration of every kind of fish.

An embryonic fish is colorless; but the pigment-cells of black, yellow, and red soon begin to appear, as is shown in Alexander Agassiz's beautiful plates of the early stages of flounders and other species, published in the "Bulletin of the Museum of Comparative Zoölogy." When the black pigment predominates, the color is sombre, as in the adult tautog, *Tautoga onitis*. A slight admixture of yellow gives the bronze-like hue of the eel, and a little more of the same results in the brighter green of the black-bass, the blue-fish, and the cunner. In all of these there is a sprinkling also of red, giving the warmer brownish greens so often seen in these species. Red pigments intermixed with black give the dingy browns of the carp, the sculpins, and some of the cat-fishes. When the yellow and red outnumber the black cells, there result the tawny colors of the sand-dabs, the sun-fishes,

the cusks, and the ling, and of some varieties of the cod. Red chromatophores alone cause the brilliant scarlet of the red snapper and the rose-fish, and, when these are interspersed with black, the deeper colors of the mangrove snapper and the ruddy variety of the sea-raven. When the chromatophores begin to segregate into separate groups according to color, the result is the formation of bands, stripes, spots, and shadings infinite in their possibilities of mutation and combination, and quite beyond the power of words to describe.

The entire absence of chromatophores results in albinism. I have already called attention to the curious albino haddocks occasionally taken on our coast. Sometimes these are of a light golden color, and are in what Günther calls a state of "incipient albinism," the dark pigments having changed into yellow. This has been observed also in flounders, carps, and eels, and in the gold-fish, which in its native haunts in China is a dull green. The golden orfe and the golden ide have become permanent in a state of domestication. The silver-fish, a form of gold-fish, is an example of still more complete albinism; and a combination of the two conditions is very common in the breeding-ponds of the United States Fish Commission.

The blind-fish of Mammoth Cave, *Amblyopsis spelæus*, is an illustration of permanent adaptive albinism; and in the abysses of the sea, where the light is very scanty, many fishes appear to remain permanently in this condition.

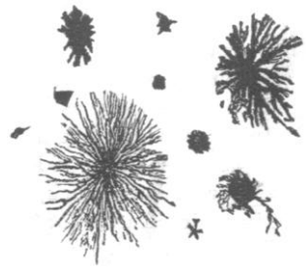
Adaptive coloration seems to be possible in quite another way, through the secretion of pigment-cells, which permanently change the color of the fish to make it harmonize with that of the bottom upon which it lives. On certain ledges along the New England coast the rocks are covered with dense growths of scarlet and crimson seaweeds. The cod-fish, the cunner, the sea-raven, the rock-eel, and the wry-mouth, which inhabit these brilliant groves, are all colored to match their surroundings; the cod, which is naturally lightest in color, being most brilliant in its scarlet hues, while the others, whose skins have a larger original supply of black, have deeper tints of dark red and ruddy brown. These changes must be due to the secretion of a special supply of red chromatophores. It has occurred to me that the material for the pigmentary secretion is probably derived indirectly from the algæ, for, though the species referred to do not feed upon these plants, they devour in immense quantities the invertebrate animals inhabiting the same region, many of which are likewise deeply tinged with red. Possibly the blacks and greens which prevail among the inhabitants of other colored bottoms are likewise dependent upon coloring-matter which is absorbed with the food. Günther believes that the pink color in the flesh of the salmon is due to the absorption of the coloring-matter of the crustaceans they feed upon. Spoonbills and flamingoes lose the brilliant pink tints of their feathers after long confinement in menageries, and it is customary for European zoölogical gardens to send them to the garden at Rotterdam to be recolored. It is not known how this is done, but it is supposed that they are fed upon some red-hued crustacean there obtainable.

The brilliant coloration of many kinds of fishes during the breeding-season may possibly have a relation to sexual selection; indeed, this can scarcely be doubted by any one who has observed the peacocking moments of male fishes. It has also a physiological significance which it is not difficult to comprehend. The increased brilliancy is usually most manifest in those parts of the body which lie close to the reproductive organs, in the belly, which is often flushed and vivid in color, in the ventral fins, and in less degree in the sides of the body and the posterior and lower parts of the head. The entire vascular system is in a condition of extreme activity at this time, as is evident from the manner in which outgrowths of the head and teguments are so rapidly developed. Every pigment-cell is receiving an unusual supply of blood, and its more abundant nutrition is, in part at least, the cause of its brilliancy.

If an abundant supply of blood results in an increase in brilliancy, its withdrawal from the teguments, on the other hand, causes an immediate decrease. I have often watched the large brightly striped "groupers," *Epinephelus striatus*, confined in the crystal fish-pools in Bermuda. When one of these had swallowed a large morsel of food, its color became almost instantly lighter and duller. This was evidently the result of the rush of blood to the stomach, to take part in the work of digestion: in like manner a man's face often becomes paler after he has eaten a hearty dinner.

The dulness and pallor in the color of fishes after death are due to the absence of living blood from the chromatophores. If, however, a fish not long dead is placed in the sun, its color will soon become almost as deep and bright as in life. In a few seconds it fades again, and cannot again be brightened.

This phenomenon leads to the consideration of another peculiarity in the arrangement of the pigment-cells, which renders rapid changes in hue possible in certain species. In these the pigments are associated with oily matter, and are arranged *areolæ*, which favor their approach toward or retreat from the surface of the skin. The accompanying diagram, drawn by Professor Benecke, shows how they may sometimes show as small, irregular spots upon the skin, and soon after become conspicuous star-shaped markings with far-reaching arms. Such changes may be effected by stimulation of various kinds, and even by the reflex action of the nerves under the influence of impressions of color received by the eye of the fish.



CHROMATOPHORES VARIOUSLY EXPANDED.

Every angler knows that trout inhabiting stagnant pools or dark bottoms are deep-colored, while those from deep, sunny waters are brighter. The same is true of many other fishes. I have often seen the common flat-fish change its color to that of the gravel and sand in which it was trying to hide, the hue varying as rapidly as that of the landscape when the sunlight is suddenly cut off by a passing cloud.

These changes of color are directly connected with the impressions of color received by the eye, and brought about by the reflex action of the nervous system. In no other way can changes such as those already referred to in flounders be accounted for. I have seen the tropical squid in Bermuda change color rapidly, and at will, while being pursued. This was evidently through the influence of emotion or fear, since it can hardly be supposed that there was definite purpose in the act; which, however, seemed at first sight to be intended to baffle its pursuers.

Pouchet experimented with young turbots, and found that if their eyes were blinded they did not change, thus proving that the color-cells were under the control of the

nervous system. Day records that young hybrid salmon raised at Howietoun, in which vision was more or less deficient, were observed to be generally lighter in color than their fellows.

The fishes of the sea are more often brilliant than those of the river or the lake. Warmth and light are favorable to brightness and variety of hue. The fishes of circumpolar regions, and those living at considerable depths, are therefore usually sombre, though occasionally they have iridescent scales or plates of great brilliancy.

In temperate regions, as along the coasts of the United States, sombre tones are most common, but in summer many sunny-hued strangers come up from the south.

In the tropical seas, however, the greatest beauty is to be found; and in some groups, such as the parrot-fishes and the wrasses, the most bizarre and astounding combinations of masses of brilliant color. Harsh and inharmonious as they seem, however, when imitated by the brush, they are never unpleasing in the living creatures. The West Indian fauna has many wonderful fishes,—such as the angel-fish, *Holacanthus ciliaris;* and the Spanish lady, *Bodianus rufus*,—but the utmost possibilities of beauty are to be found only in the Southern Pacific and the Indian Oceans.

As Count Lacépède has so eloquently shown in the passage already quoted, no class of animals has been so richly endowed with color as the fishes, except it may be the insects; and the effect of brilliancy in a fish is much greater on account of its larger size. Birds appear at a disadvantage in comparison, because, except in the metallic patches on the throats of the humming bird and a few similar instances, the surfaces of their feathers are not so well adapted to display as the broad burnished sides of fishes, kept constantly moist and lustrous by contact with water.

The beauty of fishes can only be known to those who have had the good fortune to see them swimming at ease, bathed in the limpidest of water and the brightest of sunshine. Aquaria are always dark and gloomy, and their glass walls seem more prison-like than the bars of a menagerie cage. Museum preparations do not tell of the vanished beauty even so well as the lifeless bodies of the fishes themselves, and every angler knows how suddenly the dead fish loses its attractions of texture and color. This change has been well described by Dr. Badham in the following lines:—

"While blazing breast of humming-bird and Io's stiffened wing
Are bright as when they first came forth new-painted in the spring,
While speckled snake and spotted pard their markings still display,
Though he who once embalmed them both himself be turned to clay,
On fish a different fate attends; nor reach they long the shore
Ere fade their hues like rainbow tints, and soon their beauty's o'er.
The eye that late in ocean's flood was large and round and full
Becomes on land a sunken orb, glaucomatous and dull;
The gills, like mushrooms, soon begin to turn from pink to black:
The blood congeals in stasis thick, the scales upturn and crack;
And those fair forms a Veronese, in art's meridian power,
With every varied tint at hand, and in his happiest hour,
Could ne'er in equal beauty deck, and bid the canvas live,
Are now so colorless and cold, a Rembrandt's touch might give."

G. BROWN GOODE.

NATURAL HISTORY GARDEN AND AQUARIA FOR BOSTON.

AT the meeting of the council of the Boston Society of Natural History previous to that held on Wednesday last, it was voted to recommend to the society, at its meeting of April 2, a resolution to the effect, that, in pursuance of the policy recorded in the vote of March 28, 1888, and adhering to the conditions therein required, the society authorizes the council, as soon as one-third of the final sum required for the establishment of its natural history garden and aquaria has been raised, to proceed with the establishment of the aquarium at City Point, in accordance with the plans laid down in the letter to the park commissioners of Dec. 31, 1889, which has received their approval. These plans will be best understood from this letter, which is in substance as follows:—

The Society of Natural History have been earnestly and constantly engaged in work upon matters connected with the foundation of natural-history gardens, since the receipt of the last letter of the commissioners, dated Dec. 30, 1887, and have finally concluded to offer the following as plans of what they deem to be best, hoping, if these are accepted, to follow up this first step very rapidly, so as to bring the matter speedily before the public. They propose to designate all the collections of living animals under their charge as the "Natural History Gardens," and to establish under this title three different divisions,—one to be called the "Marine Aquarium;" a second, the "Fresh Water Aquarium;" and the third, the "New England Zoölogical Garden;" these to be situated on grounds and to have buildings such as may be mutually agreed upon by the commissioners and by the society, in accordance with the provisions of the letter of the commissioners above referred to.

In compliance with the request of the park commissioners to present a statement of the proposed policy of the society in regard to the exhibits at the places designated by them,—namely, at City Point, near Jamaica Pond, and at Franklin Park,—the council offer for consideration the following general statement, and the outline of their plans with reference to each of the three divisions.

The attention of the commissioners is invited at the outset to the scientific and educational character of the plan of the Natural History Gardens. The three divisions of this department of the society's work, when regarded as a whole, form a connected series of exhibitions, which will, it is hoped, illustrate, more completely than has ever been done before, the relations of organisms to the four great regions of their distribution,—the sea, the fresh water, the land, and the air. The principle underlying the whole, and to which each part, however small, has been made to contribute, is the illustration of the relations of plants and animals to their surroundings. The council believe that a full exposition of the laws governing these correlations is the fittest use they can make of the opportunities offered by the commissioners, and the most valuable contribution which they and the commissioners acting together can bring to the cause of public education.

I. Marine Aquarium.

In the maps of the proposed Marine Park the lands and ponds assigned for the use of the society are admirably suited for the purposes of a large aquarial garden; and the council desire to express their satisfaction with these indications of the intentions of the commissioners, for they confirm the council in the opinion that it will be practicable to found a marine aquarium at this place which will be of unique excellence as an instrument of popular interest and education.

1. A collection of living organisms arranged and exhibited for the illustration of natural laws has a fuller effect if the minds of the students and visitors have been prepared by previous study, or, in place of this, if they have at hand a brief explanation of the general structure and relation of animals and plants to each other and to their surroundings.

The society propose to supply this explanation by means of an epitome collection, which, with a printed guide, shall explain the structure and relations of the more important subdivisions of animals and plants, the general adaptations of the structure of organisms to an aquatic existence, and the fact that under ordinary conditions, however diverse, the organisms retain their typical structures. This collection would consist of two classes of objects,—(*a*) a series of representative forms, including the principal types of animals and plants; (*b*) such general dissections and other anatomical preparations of selected types, accompanied by diagrams, as may enable the observer to grasp the fundamental points of the structure, physiology, and correlations of the animal