41.—ON THE GREEN COLORATION OF THE GILLS AND PALPS OF THE CLAM (MYA ARENARIA).

By JOHN A. RYDER.

Mr. W. Williams, collector of the port at Stonington, Conn., recently forwarded from there five specimens of the common clam to Professor Baird, with the request that he would have them examined and report upon the nature and source of the pigment which tinged the gills and palps with a disagreeable bluish-green color. In his letter of December 31, 1884, Mr. Williams says: "I forward you this day some clams for examination, [in order to ascertain] the cause of the 'greening,' as per your letter of November 28, 1884. Parties here are afraid to use them on account of the 'greening.' Will you please report, so I can have your answer published and settle the question [raised] as to their unhealthfulness as food?"

Strangely enough—in spite of the fact that it has been repeatedly stated by competent chemists, such as Berthelot,* Endlich,† and others that chemical research had failed to detect metallic substances such as copper—dealers, oystermen, and the public still persist in holding to the belief that there is really some green metallic salt of copper present, as evidenced by the fact that oysters when "green-gilled" have a coppery taste. The experiments of Puységur and Decaisne have shown how groundless this belief is, and have demonstrated beyond a shadow of doubt that if the proper food material was selected and brought within reach of the living animals, other food being excluded, they could cause individuals, the flesh of which was known to be colorless before the experiment was tried, to become greenish. These same animals, when subsequently deprived of what might be called their *viridigenous* diet of *Navicula ostrearia*, variety *fusiformis*, lost their viridity entirely in a few days and again became white-fleshed.

This viridity I have noticed in living oysters sent me from France and England. Three species similarly affected, that is, with the gills, heart, or mantle more or less discolored by the absorption of a soluble pigment alluded to elsewhere,‡ have fallen under my observation.

MM. Puységur and Decaisne have traced the viridity which discolors the flesh of the oyster to its source, and, as stated above, have experimentally proved that it could be artifically induced and removed under the requisite conditions. The writer's share in completing the history

* See Ann. Report U. S. Commissioner of Fish and Fisheries, Part X, 1882, p. 793, "On the Cause of the Greening of Oysters," by M. Puységur.

† Bull. U. S. Fish Commission, I, 1881, p. 413, in "Notes on the Breeding, Food, and Green Color of the Oyster."

‡ Ann. Report U. S. Fish Commissioner, Part X, 1882, pp. 801–805, "Supplementary Note on the Coloration of the Blood Corpuscles of the Oyster"; also in Am. Naturalist, 1883, pp. 87, 88.

of this singular, abnormal phenomenon, and showing that the discoloration first affects the mobile tissues of the animal contained in its vessels, that is, the blood-cells and the watery serum in which they float, was the histological and physiological part of the problem. MM. Puységur and Decaisne did not apparently perceive that they were dealing with a pigment which was not truly chlorophyl. This fact the writer would again point out, giving reasons therefor which he has not hitherto stated elsewhere:

1. The discoloration is progressive in its advance from the vascular system to other parts, the gills being first affected, then the heart, and finally the mantle and body-mass. The discoloration is diffuse, not confined to chlorophylloid granules, as in plants or in other animals in which such distinct granules are actually found. Nor is it ever in any case lodged in corpuscular bodies of any sort, except throughout the whole body of the cells found in the vascular canals or the cells entering into the formation of the edible connective tissues of the oyster. This tendency gradually to diffuse itself shows that this pigment must be in solution in the blood-serum. The experiments of MM. Puységur and Decaisne show that it is not destroyed in the process of digestion, as chlorophyl seems to be by the action of the gastric juice in the stomach of vertebrates, in which case it never, at least in herbivorous forms, has been known to discolor the blood. Chlorophyl in plants is contained in intracellular plasmic bodies, which are not destroyed when the coloring matter is removed. Sachs* says: "The coloring matter contained in each chlorophyl body is itself only extremely small in quantity; after its removal the protoplasmic basis retains not only its form, but also its previous volume. The latter is always a continuous soft substance, containing extremely small vacuoles, in which the coloring matter is generally distributed universally, though not always uniformly." The diffuse coloration of *Stentor cæruleus* amongst infusorians seems to be somewhat similar to the "azure blue" color found by Puységur in the "intracellular liquid" of *Navicula ostrearia*. This brings us to the consideration of the second piece of evidence opposed to the conclusion that the pigment which discolors clams and oysters is chlorophyl.

2. The discoloration of the flesh of the clam and oyster is not distinctly green, but bluish-green. Only at times have I observed that the blood-cells lodged in the heart were of a light pea-green color in the latter. This bluish-green color I have seen very strongly expressed in *Ostrea angulata* and in specimens of *O. edulis*. It is, therefore, reasonable to conclude that the pigment, which is imbibed by the plasma of the parts affected, is truly something different from ordinary green chlorophyl. Phycocyanin, or a kindred vegetable pigment, as elsewhere stated, seems to be the substance which is absorbed by the tissues affected.

* Text-Book of Botany, 2d Eng. ed., p. 45.

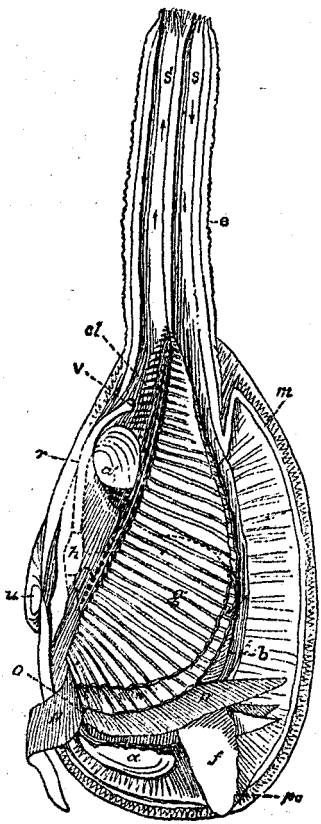
The only organic pathological changes which the writer has hitherto observed to accompany this discoloration, as one of its effects, is the lodgment of the tinged blood corpuscles in the depressions between the muscular trabeculæ of the cardiac walls. Sometimes these corpuscles, thus arrested in the ventricular chamber of the heart, form a thick adherent coating over the inside of the ventricle. The arrest of corpuscles, and their accumulation in cysts developed in the vicinity of vessels in the mantle, also occur, but this condition seems to be a rare one. When freed from the cavities in which they have been arrested, these blood corpuscles are very easily dissociated, if the animal has been previously hardened in alcohol or chromic acid. Microscopic examination shows them to be blood corpuscles, which belong to the animal in which they are found, and not foreign parasitic bodies of a vegetable nature, as is proved by their size, structure, and non-possession of cellulose walls.

What has been said above relative to the source and nature of the discoloring pigment abnormally present in the tissues of the oyster as a diffusable substance applies also to the substance which has discolored the gills and palps of the specimens of clams sent from Stonington, Conn. During the last three years the writer has frequently been told by fishermen and oystermen, at different localities along the eastern coast, that the flesh of clams was sometimes discolored much in the same manner as that of oysters; but until recently no opportunity has presented itself to study this condition in the clam. Skeptical at first, the Stonington specimens demonstrated very clearly to the writer that the nature and source of the discoloring pigment are very similar, if not identical, in the cases of both the oyster and the clam.

The researches which have been made upon the Stonington specimens were conducted as follows: A pipette was thrust into the mouth and stomach, to get some of the food materials; some of the contents of the rectum of several individuals was also examined. The result was that very little could be determined as to what had been the food of the animals, except that diatoms had been consumed in moderate quantity. There was no great abundance of empty diatom frustules, such as is sometimes observed in the oyster. These diatoms were all navicular in form, but belonged to several different species, so that it was impossible, with the material at hand, to find out which one had supplied the coloring matter, because the soft material had been dissolved out of the frustules entirely, leaving them colorless and empty. Other *débris* among the contents of the rectum showed that fragments of small arthropods had been swallowed.

The investigation of the soft parts which had been discolored was more satisfactory, because in these cases the method of microtomy was applicable. But before entering upon a discussion of this aspect of the investigation it may be well to describe the condition in which the specimens reached the writer, and in what way they were affected.

The specimens arrived in a living condition, and appeared perfectly healthy, except that the gills and palps were discolored and had a dirty bluish-green cast, which was in striking contrast with the color of these parts in unaffected specimens. A better understanding of the parts involved by this discoloration may be had by reference to the accompanying figure taken from Woodward's Manual of Conchology. The gills *g* and palps *p p* of the figure were the parts to which the discoloration was confined. No other part of the tissues of the animals seemed to be in the slightest degree affected. Fresh water seemed to have a tendency to bleach the gills when the animals were placed in it for a time. Preparatory to microtomical work upon the gills, the animals were first killed in weak alcohol, then slowly hardened in the same liquid, and finally small fragments of the gills were put into absolute alcohol. During all of this treatment the gills lost but little of the color which permeated them. Subsequently the pieces which were to be cut into sections were saturated in clove-oil, then transferred to chloroform, which was changed once, with still no evident loss of the color. The pieces of the gills were then heated in a mixture of paraffine and chloroform to a temperature of about 160° Fahr., without destroying their coloration. The paraffine and chloroform were finally replaced by pure paraffine, in order that the objects might be thoroughly saturated and the more readily cut into thin sections. No staining reagent was used, because it was thought that the coloration due to the absorbed vegetable pigment would still be evident in the sections. A foreign pigment used to dye the sections would have vitiated the results and made it impossible for one to see if one set of tissues had been stained more deeply than another by the color imbibed during life. The result showed that there was but little difference in the depth of the color of different layers. The blood-cells seemed slightly darker in color, but all of the tissues of these sections, which were cut in a transverse direction, were more or less deeply stained and of a dirty greenish color.



No evidence of the existence of minute parasitic animals or plants was observable either on the outside or in the internal cavities of sections prepared from the gills.

My investigations have therefore led me to the conclusion that the

cause of the acquired green color of the clam is the same as that of the oyster; that, as in that animal, it is diffuse; is absorbed from the vegetable food consumed by the animal; that it is allied to, if not the same as, phycocyanin; that it is harmless, as has been experimentally demonstrated in the case of the oyster. There is also no reason why green clams should not be as freely consumed as food as green fleshed oysters, which are valued all the more by the epicures of Paris and London because they are so discolored, in the belief that such a change of color improves their flavor.

WASHINGTON, *January* 8, 1885.

EXPLANATION OF THE FIGURE.

Side view of the soft parts of the common clam or manuanose (*Mya arenaria*) in the position in which it is found in life, with the left valve and mantle of the left side removed and the left half of the siphon cut away, so as to expose its incurrent and excurrent canals.

a, anterior, *a'*, posterior adductor muscles; *b*, body-mass; *cl*, cloacal cavity, continuous posteriorly with the suprabranchial chamber: *e*, wrinkled horny epidermis of siphon; *f*, foot; *g*, gills; *h*, heart; *m*, cut edge of the border of the mantle where it is continuous with that of the left side; *o*, mouth; *p p*, palps or lips; *p o*, pedal opening in the mantle, through which the foot is extended; *r*, rectum; *s*, incurrent siphonal canal; *s'*, excurrent siphonal canal (the arrows indicate the direction of the current flowing in and out of the mantle chambers of the animal); *u*, umbo next the hinge of the right valve; *v*, vent or anus, which opens into the cloaca.

42.—THE MIGRATION OF SALMON (SALMO SALAR L.) IN THE BALTIC.*

By JUDGE FIEDLER.

As most people know, the salmon-fishery in Denmark is limited in territory; only at and below Bornholm and Christiansöe has there been carried on from time immemorial quite a considerable hook-fishery for great salmon. The salmon-weirs in Gudenaa and Skjernaa, at Kolding, Veile, and many places, all have greater importance for the capture of sea-trout (*Salmo trutta*) than for the salmon itself (*Salmo salar*), for which the streams of our little country are too small and shallow to furnish the desired spawning-grounds. It is only on the island of Bornholm that they are found in a little rivulet and a few larger brooks, which might furnish a refuge for the sea-trout, but are not suitable as spawning-places for the salmon, and there is no information that the salmon ever came into them for the purpose of spawning. The salmon which are caught off Born-

* Comments in *Nordisk Aarsskrift for Fiskeri*, 1884, upon "*Laxens* (*Salmo salar* L.) *Vandringar i Östersjön*," by Professor Andreas Johan Malmgren, in *Norsk Fiskeritidende*, Part II, April, 1885; pp. 210–215. Translated from the Danish by TARLETON H. BEAN, M. D. For Professor Malmgren's article, see Bull. U. S. F. C., 1884, pp. 322–328.—EDITOR.