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CONTENTS:

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THE SUMMER'S WORK AT THE WOODS HOLE LABORATORY OF THE BUREAU OF FISHERIES (FORMER U. S. FISH COMMISSION).*

THE laboratory was thrown open on the sixteenth of June last for the nineteenth summer since the establishment of its present quarters, and scientific work was in progress until the end of September, after which time there remained but a single investigator. The work accomplished during the season is summarized below, together with mention of certain important lines of work which were planned and commenced. This statement has been prefaced by a brief account of the present equipment for scientific work at the station, although this latter of course varies but little from year to year.

I. EQUIPMENT.

Rooms.—In addition to the large laboratory room with nine tables, there were fourteen private rooms at the disposal of investigators, all of which are provided with gas and electricity and otherwise equipped for research. To this list must be added the library, supply-room and aquarium, as well as the main hatching-room, which, as usual, was available for laboratory purposes from the end of the lobster-hatching season, early in July. Through the courtesy of Superintendent Locke, certain other portions of the fish-cultural plant were also at the service of investigators. Early in the summer im-

* Report to the Commissioner of Fisheries by the director of the laboratory.

portant improvements were made in the plumbing of the main laboratory, and some others have been authorized which will be carried out before the opening of the following season.

Fleet.—The steamer *Fish Hawk,* the yacht *Phalarope,* the tug *Blue Wing* and two steam launches were available during the whole or a part of the season. A catboat and an abundance of row-boats complete the list.

Fish Pounds.—Both of these were set this year in Buzzards Bay, at points not far removed from the station. A daily record was kept by Mr. Edwards of the species taken, together with a rough estimate of the number of each. Such records, which have been kept for many years past, furnish valuable data concerning the annual migrations of fishes. The pounds constitute also one of the important sources of supply for the materials of investigation.

Library.—This comprised (1) the permanent collection, including about 16,000 titles, mainly reprints donated by the authors, and reports of our own and foreign governments; and (2) the collections loaned for the summer months by Brown University and the College of the City of New York, comprising about 650 and 100 volumes respectively. A subject catalogue was commenced by the librarian, Miss R. McDonald, in addition to the author catalogue already on hand.

Residence.—One floor of the large residence building was, as usual, at the service of those who had been employed by the bureau to carry on special investigations.

II. STAFF.

The staff of the laboratory during the season comprised a director, a librarian, a secretary, five salaried investigators, working upon special problems of interest to the fisheries, an assistant in charge of the supply-room, an assistant in charge of the fish pounds, and nine assistants, mainly college and medical students, doing miscellaneous work in the laboratory and in the field. To the above list must be added a collector, who is permanently attached to the station, and the crews of the various vessels while these are in service for the laboratory.

III. INVESTIGATORS.

The total number of investigators who availed themselves of the privileges of the laboratory during the summer past was thirty, the greatest number at any one time being twenty. These men represented two government departments and sixteen educational institutions, ranging from Alabama to Vermont and west to Illinois. The average length of their stay at the laboratory was almost exactly six weeks, though a few stayed nearly or quite twice that time. A brief statement of the work done by each of the investigators is given below.

IV. COLLECTING TRIPS.

Leaving out of account the daily visits to the pound nets, about forty collecting trips were made by the smaller steam craft. The localities visited were: Wareham, Monument Beach, Quisset, Hadley Harbor, Weepecket, Penikese, Cuttyhunk, Great Pond, Vineyard Haven, Muskeget, Katama, Gay Head and various points in Vineyard Sound. To this list must be added fifteen dredging trips made by the *Fish Hawk,* whose operations were confined almost exclusively to Vineyard Sound. The work of the *Fish Hawk* will be dealt with in a separate section. Mention should also be made of four days spent in camp by Mr. I. A. Field and an assistant at Menemsha Bight, Martha's Vineyard, where they were engaged in noting the fish taken in the numerous traps at that point, and of a journey to Provincetown, also by Mr.

Field, in quest of data relating to the food of the dog-fish.

The collector, Mr. Vinal N. Edwards, continued, as usual, the collection and preservation of fishes, fish parasites and other material of biological interest.

V. SEMINAR.

A seminar or research club was established early in the season, and thereafter met weekly until near the close of the summer. It was thought possible that cooperation might be profitable in certain lines of work, and in general it was thought desirable that there should be some recognized medium by which investigators might profit by the results of one another's work. The experiment proved entirely successful and the meetings were well attended. The first few of these were devoted to a discussion of plans relating to the catalogue of local fauna and flora, and to the proposed dredging work of the *Fish Hawk*. At the later meetings, reports were presented by investigators upon their work at the laboratory.

VI. CATALOGUE OF LOCAL FAUNA AND FLORA.

The compilation of a catalogue of the fauna and flora of the region, as far as known, was commenced by the director in cooperation with several others. The work, as projected, contemplates much more than a catalogue in the sense of a mere list of species. Certain data of practical or scientific interest are, when available, recorded for each of these. In order to permit of indefinite expansion, the whole record is to be in the form of a card catalogue, having eleven cards for each species. The *specific name* and *common name* (*local name*, whenever such exists) find their place on the first card; then follow in order *'relative abundance,' 'geographical distribution'* (within region catalogued, of course), *'seasonal distribution,' 'habitat,' 'reproduction'* (breeding and spawning season, etc.), *'food,' 'method of collecting,' 'economic data,' 'references'* and *'remarks.'*

The first step in the preparation of such a catalogue must consist in the sifting of the various published reports and papers containing the data desired. The classical report of Verrill and Smith upon the invertebrates of Vineyard Sound is, of course, one of the first to be utilized, as are also the numerous synopses of special groups published in the 'Bulletin' of the Fish Commission and elsewhere. In addition to these strictly faunistic papers, data relevant to the present work are to be found scattered through a large part of the biological literature emanating from Woods Hole—incidental observations on spawning-time, distribution, food and the like. Add to this the wealth of facts accumulated by Mr. Vinal Edwards, during his long experience as collector for the Fish Commission, and the large stock of information, as yet unrecorded, in possession of the numerous investigators who have occasion to collect material at Woods Hole. This only awaits a recognized receptacle, such as it is hoped that the present catalogue may become.

A fair start has already been made in the work of compiling this catalogue, many of the principal reports and synopses having been abstracted, and records of about 750 species having been entered. In this work Mr. Raymond C. Osburn cooperated with the writer, and several of the temporary assistants were engaged in the clerical work involved. The notes on the fishes, based upon the list prepared in 1898, by Dr. H. M. Smith, and supplemented by abundant data furnished by Mr. V. N. Edwards, are by far the most complete.

In this work, assistance has been promised by several systematists in compiling the records relating to their respective groups, and the active cooperation

of at least one of the botanists is assured, in the endeavor to have the flora, as well as the fauna, included in the catalogue. A liberal appropriation, which has been granted by the bureau, will enable the writer to continue this work during the present winter.

VII. DREDGING WORK OF THE 'FISH HAWK.'

The *Fish Hawk* arrived at Woods Hole on the nineteenth of July, and remained until September 10, during the greater part of which period she was at the disposal of the laboratory. It was thought that the admirable facilities for dredging possessed by this vessel could be put to greatest advantage by carrying out a systematic survey of the bottom of Vineyard Sound, a task which had not been undertaken since the days when Professor Verrill and his associates gathered the material for their reports on the invertebrate fauna of these waters.

Accordingly, dredgings were made at intervals of three fourths of a mile along parallel lines crossing the sound, these lines being constructed at intervals of one mile. Various sorts of dredges were employed, according to the character of the bottom, and frequently one spot or 'station' was covered by more than one sort of dredge. The usual physical data—density of water, character of bottom, temperature, etc.—were recorded for each station. Material for a complete record of the biological data has been preserved. The more familiar species were listed as they were taken aboard, record being kept of the condition and relative abundance of each. The remainder are at present represented by preserved specimens which await identification by experts. An even approximate list of the species taken can not, at present, be given. In all 82 'stations' are recorded in Vineyard Sound, ranging from Nobska Point to Gay Head. In addition, a trip was made to Crab Ledge, a shoal about seven miles east of Chatham, on Cape Cod, where seven stations were dredged.

It is planned that this dredging of the bottom of Vineyard Sound shall be continued and shall be supplemented by thorough work upon the shore life of this region, thus completing a biological survey of these waters. It is likely, too, that some sort of cooperation with the botanists will be arranged for. Such extensive plans can not, of course, be carried into effect without the employment of several specialists as assistants. The relation which such a survey would bear to the catalogue above discussed is obvious.

A regular form of collecting record blank was adopted for work of this character, and 2,500 copies were printed at the Government Printing Office.

Acknowledgment must here be made of the valuable assistance of Mr. R. C. Osburn, in connection with the dredging work; of the services of Dr. J. P. Moore and Dr. R. P. Bigelow, who identified respectively the annelids and the crabs collected; and of Dr. B. M. Davis and Miss Lillian McRae, who identified the algæ. Finally it must be mentioned that without the able and conscientious services of Capt. James A. Smith, in command of the *Fish Hawk*, the present measure of success would have been impossible.

VIII. OTHER INVESTIGATIONS.

In the brief statements given below, the language of the investigators themselves has been used as far as possible.

Robert Payne Bigelow, Ph.D., instructor in biology, Massachusetts Institute of Technology: (1) 'Stomatopoda of the Albatross Hawaiian Expedition,' (2) 'Brachyura of the Woods Hole Region.' During the spring there was placed in Dr. Bigelow's hands a collection of stomato-

poda gathered by the *Albatross* during the Hawaiian and Samoan expeditions of 1902. This collection was brought by him to Woods Hole, and his chief work during the summer was the sorting of this material and the identification of the known forms preparatory to making a detailed study of each species, with drawings. The collection is especially rich in larvæ, and the sorting of these has been done with a view to discovering series of stages, and the identification of larvæ with adult forms.

Dr. Bigelow also identified crabs collected by the *Fish Hawk,* and collected material in connection with his report on the Brachyura of the Woods Hole region, now in preparation.

Frank C. Carlton, graduate student in Harvard University: 'The Color Changes of some Fishes.' *Fundulus heteroclitus* was found to exhibit marked changes of color, depending primarily upon differences in the illumination. The skin is of a light gray color in the daylight, but is almost black in the dark. A fish put into a porcelain bowl and set in the light was found to change to a paler color, but the same fish put into a dish lined with black cloth remained dark, even if the illumination of the latter dish were the same as that of the white porcelain one.

The spinal cord of a fish which had previously shown the normal color changes was cut, and, after recovery from the shock of the operation, the fish was placed in the light. The posterior part now remained dark under all circumstances. This experiment seemed to prove that the change from dark to light is under nervous control.

From experiments in cutting the optic nerves of fishes whose color changes had previously been normal, it was concluded that light must influence the pigment cells through the eyes, since such fish did not show the reactions above described.

Leon J. Cole, Austin Teaching Fellow in Zoology, Harvard University: 'Studies upon Carp.' Material was worked over and notes compiled, based upon field work at various places on the Great Lakes during the past three summers. The results will be embodied in a report for the bureau.

Ulric Dahlgren, M.S., assistant professor of histology, Princeton University: Engaged in collecting material for histological studies.

George Wilton Field, Ph.D., assistant, Massachusetts State Board of Health: (I.) 'The Edible Lamellibranchs as a Source of Infection.' Together with Dr. C. A. Fuller, Dr. Field carried on, from August 10 to October 15, an investigation on the relations between shell-fish and sewage bacteria, and instituted experiments for the purpose of answering the following questions: (1) Are sewage bacteria (*Bacillus coli,* the type form) normal and usual inhabitants of shell-fish? (2) How soon after the introduction of *B. coli* into the water does it appear in the clam? (3) How long does *B. coli* live in ordinary sea water? (4) How long, under normal conditions, does *B. coli* remain alive and active in the intestine of the shell-fish? (5) Is it probable that the shell-fish digest *B. coli* and thus incidentally act as purifiers of the sewage-polluted waters, and, further, that by digesting *B. coli,* shell-fish may after a time become free from sewage-bacteria, and, therefore, harmless as food for man? (6) Examination to ascertain what anatomical region is most certain to give a true index of the presence of *B. coli.*

The methods used by Dr. Field and Dr. Fuller for securing proper conditions of infection with *Bacillus coli* and for main-

taining the normal conditions of life for the clams proved satisfactory. The results are probably to be published by the Massachusetts Board of Health in its annual report, and are believed to be of considerable importance.

(II.) 'The Lobster Problem.' At the request of Capt. J. W. Collins, chairman of the Fish and Game Commission of Massachusetts, Dr. Field secured at Woods Hole and Cuttyhunk important data concerning the lobster industry, bearing upon the biological importance of preserving the adult lobsters and permitting the catching of immature ones. Figures were obtained, indicating the commercial value, in terms of edible meat, of lobsters $8\frac{1}{2}$, $9\frac{1}{2}$ and $10\frac{1}{2}$ inches long respectively; also the weights and measurements (length, weight and diameters of chelæ, thorax and abdomen) of upwards of eight hundred newly caught lobsters, coming from different sections; and some observations upon the relative numbers of mature and immature lobsters in the ocean. In connection with the recommendation of a law which would insure the perpetual protection of the adult lobster, experiments were made looking toward the adoption of a pot which would exclude lobsters above eleven inches in length, and permit the escape of those under nine inches. The result of this would be the automatic regulation of lobster catching to practically only those sizes which fell between nine and eleven inches. These results will be published as soon as possible.

Irving A. Field, Denison University: 'The Food of Certain Fishes of Little or no Food-value' (conducted for the bureau). The fishes chosen were the smooth dog-fish (*Mustelis canis*), killifish (*Fundulus heteroclitus*), cunner (*Tautogolabrus adspersus*) and toad-fish (*Opsanus tau*), all of which are common in the vicinity of Woods Hole. The purpose of the study was to seek for the possible economic relation which these fishes might bear to the fisheries industries. Are they destructive either to other fishes directly or to their food?

The method employed in these investigations was to take a great number of these fishes from various localities about Woods Hole and to preserve the stomach-contents of each as soon as possible after death. The various ingredients composing the contents of each stomach were ascertained quantitatively, the approximate percentage of each ingredient being estimated, and whenever possible, the total number of any given sort of animal which had been swallowed was determined. From data thus obtained a tabulated record was made out, including the date and locality of capture, number of specimens (fishes) examined, and the number of specimens containing each kind of food. A few preliminary experiments were also made with the dog-fish for the purpose of finding products that would make it of commercial value. Its food value was likewise tested. The results will shortly be ready for publication.

Caleb Allen Fuller, Ph.D., Providence, R. I: Assisted Dr. G. W. Field in the experiments above described.

Frederic P. Gorham, Ph.D., associate professor of biology, Brown University: 'Causes of Certain Fish Diseases' (conducted for the bureau). (1) An attempt to study the life-history of a fungus pathogenic to lobsters; to determine the paths by which the infection reaches the internal tissues of the lobster; to devise methods of combating the fungus. (2) With Mr. Marsh a very careful study was made of the causes operating in the production of the gas disease and 'pop-eye' in fishes kept in the aquaria (see below).

(3) Some experiments were made to determine the effects of different kinds of metal piping on fishes and other forms of life in aquaria. (4) Some experiments with phosphorescent bacteria obtained from sea water, to determine the part played by them in the production of phosphorescence in various crustacea.

John Y. Graham, Ph.D., professor of biology, University of Alabama: 'A Study of a Parasite of the Oyster (*Bucephalus cuculus* McC.).' This trematode, though very common in the region of Beaufort, N. C., and doubtless elsewhere on the southern coast, was not found in any of the oysters of the region near Woods Hole, although large numbers of the latter were examined, coming from Wareham River and Buzzards Bay. Dr. Graham was consequently obliged to confine his attention to the material which he had collected two years before at Beaufort. From a study of this, a careful account is now possible of the structure of the most advanced cercaria stages, which will perhaps give us a clue to the identity of the adult form, the latter being without doubt some species of the genus *Gasterostomum*.

Clarence W. Hahn, A.M., graduate student, Harvard University: (1) 'On Dimorphism in *Metridium marginatum*.' Regeneration experiments begun the year before and continued during the past summer led to the conclusion that the diglyphic Metridia are typical, and that the monoglyphic individuals arise by asexual budding from the base of the body or column. This method of reproduction is very common. The diglyphic condition is not transmitted asexually. The method of regeneration was also worked out. A new pair of directives is usually produced on the regenerated side of the young polyp. (2) 'On the Blood Parasites of the Turtle.' As a result of studies begun at Harvard and continued at Woods Hole, Mr. Hahn believes that he has established the existence of three kinds of adult individuals, with distinct life cycles similar to those described by Huitzi ('02) for *Drepanidium ranarum* of the frog. There was found to be an asexual form, which reproduced by a process of sporulation different from that of the sexual individual. In the sporulation of the latter, a process of mitosis was found to occur. The adult sexual hæmogregarine, which is worm-like in form, is believed by Mr. Hahn to be identical with the vermiform parasite described by Siegel ('03) in the leech, *Placobdella catenigera*.

Arthur D. Howard, M.S., graduate student, Harvard University: 'Minute Structure of the Rods of the Retina of Fishes.' Mr. Howard continued studies, previously made upon higher vertebrates, now using various fishes. Retinæ of the following forms, among others, were examined with the polarizing microscope, and confirmation of previous results obtained; butterfish, squeteague, sand-dab, king-fish, menhaden, barracuda, eel, tautog, bonita, cutlass-fish, smooth dog-fish and skate.

Lynds Jones, M.S., instructor in zoology, Oberlin College: 'The Food of Marine Birds.' The investigations were made on Weepecket, Penikese and Muskeget Islands. Stomachs of young terns were examined, and the feeding of the young by the parent, as well as the feeding of the adult birds, were carefully examined. Mr. Jones gives the following estimate of the tern population of the various islands where they nest: Weepecket, 2,000; Penikese, 10,000; Muskeget, 80,000; total, 92,000 terns. The two species (*Sterna hirundo* and *S. dougalli*) are represented in about the proportion of two to one. The feeding habits and food of the two are the same. The

estimated number of fishes eaten in this region by terns in the course of one day is estimated by Mr. Jones as follows:

	Per Cent.	
Ammodytes americanus	80	736,000
Tautogolabrus adspersus	8	73,600
Mugil curema	4	36,800
Pollachius virens	3	27,600
Clupea or *Pomolobus*	3	27,600
Pseudopleuronectes americanus	2	18,400
	100	920,000

Mr. Jones concludes that the number of food fishes consumed by terns is a negligible quantity. The food of the gulls, loons, kingfishers, osprey and ducks was not studied.

Austin P. Larrabee, A.M., graduate student, Harvard University: 'The Effect of Heredity on the Dimorphism exhibited in the Optic Chiasma of Teleosts.'

Edwin Linton, Ph.D., professor of biology, Washington and Jefferson College: 'Investigations on the Parasites of Fishes' (conducted for the bureau). From August 13 to September 6, about 150 fishes, representing 32 species, were examined. In addition to this, a preliminary examination was made of material which had been collected by Mr. Vinal N. Edwards at various times during the past four or five years, comprising parasites from 27 species of fish and two mammals. The greater part of this collection consisted naturally of comparatively large and common species of parasites. In some cases, however, where the entire viscera had been preserved in formalin, many small and rare forms were found which would certainly have been overlooked by the general collector.

The plan of investigation of the fresh material consisted in making careful search for parasites in the alimentary tract and body-cavity, on the gills and occasionally in the muscular tissue of the fish. So far as time would admit, sketches and measurements were made, especially of varying states of contraction in the soft-bodied forms. Note was also made of the color, relative abundance, place of occurrence in the host, etc.; and particular attention was given to diseased conditions resulting from the presence of parasites. The nature of the food was also noted, since the character of the food may sometimes furnish a clue to the discovery of the intermediate host.

Thus far but little has been accomplished in working out the life history of the parasites of fishes. Some hint of the source of infection may be obtained by noting the relative abundance of parasites in the different seasons of the year. For this reason, such collections as those of Mr. Edwards are especially valuable.

Of forms which are new, or at least which have not been reported before, there were found: One species of the order Acanthocephala, two of the order Nematoda, six of the class Trematoda, and four of the class Cestoda. The results of this summer's work will be made the subject of a special report.

Joseph A. Long, graduate student, Harvard University: 'The Reaction of Eyeless (Blinded) Fish to Light.' The fish used were *Fundulus majalis* and *F. heteroclitus*. By using an aquarium provided with an electric light, and covered with black cloth in such a way that one half was darkened and the other half was in bright light, it was found that normal fish in good condition were decidedly phototropic in a positive way. After observations had been made on the normal fish, the optic nerves were cut, and the previous experiments repeated. No evidence was found that in *Fundulus* there were sense organs in the skin or lateral line that were responsive to light.

M. C. Marsh, pathologist of U. S. Bureau of Fisheries: 'The Causes of the

Gas-disease of Fishes.' This work, which was carried on jointly with Professor Gorham, was directed toward discovering the cause of 'pop-eye' due to gas, and the causes of mortality among fishes in the local aquarium whether with or without 'pop-eye.' It was found that the sea water from the supply pipes of the station, when delivered below the surface of the water in an aquarium, was fatal to most species of fishes after a longer or shorter time, *Fundulus* being most resistant; that when the water delivered was first somewhat broken up, causing it to spatter or spray, the mortality tended to lessen, and 'pop-eye' to decrease; that when the deaeration process was sufficiently complete, the 'pop-eye' and the mortality were prevented completely.

By placing fishes (scup) under various air pressures greater than the atmospheric, in the same water which ordinarily produced 'pop-eye' and killed the fish, the 'pop-eye' and the mortality were found to be checked, being inhibited altogether by a pressure of between six and seven pounds per square inch.

Scup adjusted to surface pressure for one week were as susceptible as those brought directly from the fish traps, which had probably come from somewhat deeper water. Artificial reduction of air pressure produced the same gaseous lesions as those which had been shown by fishes in the aquaria under the influence of the local water supply, viz., 'pop-eye,' gas blebs, death with free gas in the blood vessels, according to the degree and the duration of the reduction. Death occurred in a few hours at a pressure reduced to less than that of twenty inches of mercury.

Determinations showed that the aquarium water has a proportion of dissolved gas considerably in excess of that from the basin or harbor. This excess is believed by the investigators to be caused by the hydrostatic pressure of the supply system, in conjunction with leaks in the suction pipe which admit air to the water immediately prior to its being pumped to the supply tank. This excess of gas in solution consists of one or more of the constituents of air.

The immediate cause of death was usually found to be the presence of free gas in the blood vessels. According to the investigators, this free gas is formed in the following manner: The blood of fishes living in this supersaturated water takes up, while in the gill capillaries, more than the usual amount of gases, thus reaching nearly or quite to the saturation point. These gases are, however, liberated as soon as the blood becomes raised to a higher temperature in the systematic circulation, thus continually accumulating in the vessels.

Samuel Steen Maxwell, Ph.D., instructor in physiology, Harvard Medical School: 'Comparative Study of Muscular Tonus.' The phenomena of muscular contraction were studied in a somewhat wide range of forms. Especial attention was given to the occurrence of spontaneous or rhythmic contractions in muscles or muscle groups separated as completely as possible from the influence of nervous tissues. Among the forms investigated were *Nereis, Crepidula, Modiolus, Mytilus, Homarus, Libinia, Limulus, Carcinus, Mnemiopsis* and *Gonionemus.*

In order to retain the muscle alive for a sufficient period of time, it seemed necessary to find a solution which could be used upon the tissues of marine animals in the same way as the customary physiological salt solution is used upon the tissues of land animals, and considerable time was devoted to experiments along this line.

A full report of the experiments will be published as soon as possible.

J. Percy Moore, Ph.D., instructor in zoology, University of Pennsylvania: 'A Synopsis of the Annelids of the Woods Hole Region' (prepared for the bureau). The families Cirratulidæ, Maldanidæ, Ampharetidæ, Terebellidæ and Sabellidæ have been completed. Several new species were discovered and descriptions prepared for publication, one of the most striking of which is a large and handsome species of *Trinia*. A number of hitherto unrecorded species have been added to the known fauna, among them tropical species of *Hipponoe* and *Euphroryne* transported by the Gulf Stream on barnacle-laden logs. *Tomopteris* was taken in the tow at the Fish Commission wharf. Valuable data concerning the exact distribution of species were derived from the trawlings of the *Fish Hawk* and from shore collections.

Raymond C. Osburn, graduate student, Columbia University. Mr. Osburn cooperated, as a salaried assistant, in the compilation of the card catalogue of local fauna and flora (see above), and in the work upon the dredging material obtained by the *Fish Hawk*.

George Howard Parker, Ph.D., assistant professor of zoology, Harvard University: 'Physiology of the Lateral-line Organs' (research conducted for the bureau). Six species of fishes were tested: dog-fish, skates, killifish, scup, toad-fish and winter flounder. In each species individuals with normal lateral lines, and those in which the nerves going to the lateral-line organs had been cut, were tested. The most complete series of tests covered temperature, salinity, oxygen pressure, carbon dioxide, foulness, water-pressure, water-currents, water-vibrations of high and of low frequency. Differences between fishes with and without lateral-line organs were noticed only in relation to vibrations of low frequency (six per second). It was, therefore, concluded that the lateral-line organs are stimulated by water vibrations of low frequency.

Henry Farnham Perkins, Ph.D., instructor in biology, University of Vermont: 'Studies of the Morphology of Hydromedusæ.' Collections were made in the eel pond during a preliminary visit early in May, and many immature specimens of *Gonionema murbachii* were taken, also some *Willia ornata* and scattering specimens of other genera. Dr. Perkins's aim was to find the young of *Gonionema* in the process of transformation into the medusa form, but the earliest of the young stages found possessed all of the adult characters. Many young medusæ were preserved with a view to studying the development of the tentacles and sense organs. All of these specimens showed the remarkable scheme of origin of the tentacles mentioned in a previous paper by Dr. Perkins. A number of specimens of *Hybocodon prolifer* were taken in the deep water outside the harbor. Many of these exhibited not only the asexual reproduction by budding at the base of the parent tentacle, described and figured by Agassiz and others, but also sexual reproduction in the same individuals, larvæ being developed in the ectodermal tissue of the manubrium, and escaping as actinulæ.

July 6 to August 4, mature specimens of *Gonionema* were collected on nearly every day, and the eggs obtained from these were reared in a variety of ways with a view to having the larvæ mature in the laboratory. Many thousand polyps are now under observation. A careful study of the sexual reproduction of *Hybocodon prolifer* was made during this time and a paper was prepared for publication. Constant watch was kept for specimens of medusæ in the waters about Woods Hole,

but very few specimens were found, and none at all of unusual interest. Experiments were carried on in order to find under what artificial conditions it was possible to rear larvæ of various medusæ, and to keep the adults in good state for observation. Observations were also made upon the degeneration of tentacles in *Gonionema*.

Amos W. Peters, Ph.D., instructor in physiology, University of Illinois: 'Studies on the Phosphorescence of Ctenophores.' Efforts were directed toward the following ends: (1) To follow the phenomenon back through the ontogeny of the animal; (2) to the determination of the influence of light upon the deposition of eggs; (3) to the relations between phosphorescence and various stimuli.

W. O. Richtman, expert in pharmacognosy, U. S. Department of Agriculture: Assisted Dr. True in his experiments upon artificial sea waters.

G. F. Ruediger, M.D., Memorial Institute for Infectious Diseases, Chicago (Rush Medical College): 'Bactericidal Properties of Sera of Marine Animals.' The object of this work was to find a normal blood serum, in cold-blooded animals, which would be destructive to streptococci. Sera from butter-fish, dog-fish, conger-eel, flounder, mackerel, dusky shark, sand-shark, scup, squeteague, butterfly-ray, sting-ray, common skate, squid, lobster, spider-crab, king-crab, snapping-turtle, painted turtle and spotted turtle were used. Streptococci were found to grow well in all of these sera, excepting those of the painted turtle and spotted turtle. These two sera seemed to kill off large numbers of organisms from some cultures of streptococci, other cultures, however, not being affected. Heating the serum destroyed its bactericidal properties. An attempt was also made to immunize dog-fish, but lack of time prevented conclusive results.

Geo. G. Scott, M.A., tutor in the College of the City of New York; assistant in charge of supply-room, at the laboratory: 'Studies of the Gregarines.' Numbers of invertebrates were examined for gregarines. None were found in the blue-crab, lady-crab, spider-crab, king-crab, squid nor *Phascolosoma*. In the lobster, specimens of the gregarine, *Porospora gigantea* were found, almost every lobster having cysts of this parasite in the folds of the rectum. Gregarines were also found in *Cirratulus*, *Nereis* and *Clymenella*. In *Cynthia*, the movements of a gregarine were observed carefully and camera drawings were obtained, representing the changes of shape. Several specimens of *Amphitrite* showed pathological enlargements beneath the ectoderm of the body wall. These are as yet undetermined.

John A. Shott, A.M., professor of biology and physics, Westminster College: 'Phototaxis in Copepoda' (in cooperation with Dr. Parker). The problem was to determine the reactions of the copepods in a graded field of light when they were started toward the source of light. The work was done during the last two weeks of July, at which time the copepods were difficult to obtain, so that the results were not conclusive.

Grant Smith, graduate student, Harvard University: Assisted Dr. True in experiments upon artificial sea water, also carried on experiments upon phototactic responses of star-fish.

Francis Bertody Sumner, Ph.D., instructor in zoology, College of the City of New York; director of laboratory: (1) 'Card Catalogue of Local Fauna and Flora,' commenced, with cooperation of Mr. R. C. Osburn (see above); (2) 'Dredg-

ing Survey of Vineyard Sound' (see above); (3) 'A Statistical Study of *Fundulus majalis* with a view to the determination of selective characters.' During the preceding summer large numbers of this fish were placed in aquaria from which the water was turned off. When about half had died, the living and the dead, *i. e.*, the survivors and non-survivors, were preserved. This year, nearly a thousand of these fish were carefully measured by two assistants, Messrs. C. R. Metcalf and W. H. Curtiss. Nine measurements were made for each fish. The rather formidable task of making the desired computations from these figures has scarcely been commenced, but enough has been done to show the existence of certain measurable characters of selective value.

Millett T. Thompson, Ph.D., instructor in zoology, Collegiate Department, Clark University: (1) 'Crustacean Metamorphosis'; (2) 'Studies of the Head and Alimentary Canal of Diptera.'

Rodney H. True, Ph.D., physiologist of Bureau of Plant Industry: 'Artificial Sea Waters as tested in Aquaria' (assisted by Mr. W. O. Richtman). At the suggestion of Mr. W. De C. Ravenel, representative of the Bureau of Fisheries at the St. Louis Exposition, experiments were made under the authority of the Secretary of Agriculture, and of the Commissioner of Fisheries in order to determine, if possible, in how far it may be practicable to make artificial sea water, capable of sustaining marine plant and animal life.

Experiments were made with artificial sea water prepared in two ways: (1) By dissolving in distilled water the complete salts of the sea, obtained by evaporation; (2) by dissolving in distilled water chemically prepared salts in proportions determined by analysis. The *Challenger* analyses by Dittmar were used. Aquaria were provided with artificial waters prepared according to each of these methods and with sea water dipped up from the current at the end of the wharf at the Woods Hole station. Two sets of such aquaria were prepared: (1) Standing aquaria kept at constant salt content by the addition of fresh water; (2) aquaria through which a small stream of water was kept flowing, providing thereby a system of closed circulation.

Aquaria thus prepared were stocked with both plant and animal life; the plants most used being green forms common at Woods Hole: *Cladophora, Enteromorpha, Ulva* and *Aghardiella tenera.* Many types of animal life were studied, including, especially, sea-anemones (*Metridium*), star-fish (*Asterias*), medusæ (*Gonionemus*), squid (*Loligo*) and fish (silversides, scup, pipe-fish, etc.).

The general result may be summed up as follows: Sea-anemones seemed to flourish during the period under observation in all media. Star-fish survived and behaved normally in the water made from evaporated sea salt, in cases, however, showing symptoms of injury in the synthetic solution. *Gonionemus* survived for several weeks in both solutions, but appeared to suffer from other forms of life with which it came in contact. The squid could not be made to survive for more than a few days in any medium, artificial or natural. They died in the synthetic solution in less than ten minutes with violent symptoms; they survived in the other artificial solution as long as in the natural sea water. Fish seemed in all cases to live as well in the artificial solution as in the natural, including delicate forms, like *Menidia.* Several other forms of fish and invertebrates were tested in various ways, with the general result that the artificial solution made from the salt obtained by evaporation permitted survival to a degree

not clearly different from that seen in sea water. The synthetic artificial solution seemed equally favorable to most forms, but distinctly less so to a few.

FRANCIS B. SUMNER.

SOCIETY OF THE VERTEBRATE PALEONTOLOGISTS OF AMERICA.

THE second meeting of this society was held at Philadelphia, December 29, 1903, in the Biological Hall of the University of Pennsylvania. In the absence of the president, Professor S. W. Williston, the chair was taken by Professor H. F. Osborn.

The following are abstracts of papers which were read and discussed:

A Remarkably Preserved Specimen of a Pelycosaur Collected During the Last Summer in Texas: DR. E. C. CASE.

The specimen has afforded a nearly complete skull and the anterior part of the vertebral column, with the incomplete fore limbs of both sides. The most important addition to our knowledge is in the anatomy of the articular region of the skull and lower jaw. The specimen shows that the author, in collaboration with Dr. Baur, was in error in ascribing to the articular region of the skull what belongs to the articular region of the lower jaw. The quadrate is, therefore, not a depressed bone largely covered by the bones of the temporal region, squamosal and jugal, but it is elevated and very similar in appearance and relations to the same bone in *Sphenodon*. There is a foramen between the lower end of the quadrato-jugal and the quadrate, as in *Sphenodon*. The finding of this foramen removes the last possible question as to the position of the Pelycosauria in the order Rhynchocephalia. There are two temporal arches present.

In the Matter of Menaspis: DR. BASHFORD DEAN, Columbia College.

Professor Bashford Dean discussed the relationship of the puzzling Permian fish, *Menaspis*, pointing out that on the evidence of an unfigured specimen in the Berlin Museum, which, thanks to the courtesy of Professor Jaekel, he had recently had the privilege of examining, there were grounds for regarding this form as distinctly chimæroid. The present specimen retains the dental plates, and from their size leads us to conclude that the region of the fossil regarded by earlier writers as the hindmost trunk region (terminating in blunt spines) is in reality the occiput. He compared the tuberculated spines of *Menaspis* with those of *Myriacanthus*, referring especially to an unfigured specimen of this form to which Professor E. T. Newton called his attention in the Paleontological Museum in Jermyn Street. The puzzling non-tuberculated spines of *Menaspis*, on the other hand, best correspond to the so-called lip cartilages of *Squaloraja*. Such structures, moreover, would be apt to take a position dorsal to the antero-ventral lateral head spines during fossilization. Accepting this comparison, *Menaspis* indicates that in matters of dermal defenses and teeth the Permian chimæroid resembled contemporary cestraciont sharks.

On Some Famous Old Collections and Early Studies of Monte Bolca Fishes: C. R. EASTMAN.

This paper reviewed the pre-Linnæan discussions as to the nature and origin of the famous fossil fish fauna of Monte Bolca, in northern Italy, with a notice of the principal contributions to the literature made during the last century. The history was given of several large Veronese collections containing important type material, and where the latter had become dispersed, the present location was indicated of such as is now preserved amongst different museums.