

# SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor. Professor J. McKeen Cattell, Garrison-on-Hudson N. Y.

## THE FRESH-WATER BIOLOGICAL STATIONS OF THE WORLD.\*

AWAY back at the beginning of the investigation of minute forms of life, which followed upon the invention of the microscope,

\* Annual address of the President before the Nebraska Academy of Sciences at Lincoln, November 25, 1898.

or shall I say discovery, for it seems to have been historically an accident, the early students searched the ditches and ponds and lakes for the organisms which constituted the objects of their study. Anton von Leeuwenhoek, whose name is familiar to you as one of the most zealous early workers among microscopic objects, enriched science by a long series of new organisms of this character. Roesel von Rosenhof, whose careful investigations on various fresh-water animals, published under the title of 'Insect Diversions' are still standard sources of information concerning the habits and structure of these forms, together with Swammerdam, Trembley, O. F. Müller, and a whole host of others, devoted their attention almost exclusively to the fresh-water fauna. But this movement seems to have culminated with the appearance, in 1838, of Ehrenberg's famous volume 'The Infusion Animalcules as Complete Organisms.'

Extended investigations had already impressed zoologists with the richness of the marine fauna. Numerous animal groups of common occurrence in the sea were apparently entirely wanting in fresh water, and the astounding richness of the sub-tropical and tropical oceans with which the European investigators came early in contact on the shores of the Mediterranean, and in the expeditions to the new lands of the Tropics, entirely over-

shadowed the life that had hitherto been found in pond or ditch. It is, in my opinion, also no small factor that many of the marine forms which were brought to the attention of scientists were dazzling in their beauty of form and in the brilliancy of their coloring. The quieter, more unassuming forms of lacustrine life in temperate regions could make no corresponding impress on the minds of the observers. So the scientific world went to the sea-shore for study and everywhere along the coast of Europe, and even in the islands of the Tropics were to be found the vacation resorts of scientists.

This diversion of attention from the study of fresh-water life was undoubtedly aided by the fact that fifty years ago all centers of education and investigation were comparatively close to the ocean, and so it was easy for the scientist to reach the point, where, as he had learned from the reports of others, life was most abundant and varied, and at the same time, appealed to his æsthetic sensibility as nothing did that he saw about him. The concentration of interest on the life of the sea led to the foundation of marine stations, among which that at Naples was the first in point of time, as it always has been and is to-day, first in point of strength. But the development of educational institutions through the large continental areas and the limitations which their location imposed upon investigators connected with these institutions, together with the natural efforts of man to find a field for investigation which should afford him a better chance than already overcrowded territory, have led again to the investigation of fresh-water life. So it was that Fritsch, in Bohemia, entered upon lacustrine investigation as early as 1871, while about the same time Forel, in Switzerland, was carrying on those studies published between 1874 and 1879 in a series of papers on the 'Fauna of the

Swiss Lakes' culminating in the crowned memoir of the Academy of Sciences on the 'Abyssal Fauna of the Swiss Lakes,' that brought to the knowledge of the scientific world a hitherto unsuspected type of existence and offered a new and enticing field for investigation.

It was also in the same year, 1871, that Stimpson, one of the enthusiastic members of the old Chicago Academy of Sciences, conducted some dredging expeditions in the deep water of Lake Michigan, while about the same time Hoy, Milner and Forbes entered upon investigations at other points on these same lakes. The Chicago Academy and its collections, together with valuable manuscripts of Stimpson, were destroyed in the great fire, the U. S. Fish Commission, under whose auspices the work of Hoy and Milner was inaugurated, did not pursue further the investigations on the lakes, and for years Forbes was the only investigator who occupied himself in this country with the study of lacustrine life. To his work and influence we owe beyond a doubt in our own country the awakened interest in limnobiology, and under his direction also was established the first general fresh-water biological station on this continent, of which more in another connection.

The impulse toward the investigation of fresh-water life which was inaugurated by these men, gradually attracted to itself workers, slowly at first, but approximately a decade ago, with a sudden start the ranks of such were rapidly filled up. An enormous number of ponds and lakes, large and small, scattered over the surface of the continents, afforded an almost unlimited field for investigation, and many early studies were, to say the least, decidedly desultory. There were few workers who were content to confine themselves to a single locality, or to a well-defined problem. A scanty collection was made to serve as the basis of a faunal list supposed to charac-

terize the body of water in question, and the enumeration of species was regarded as the *ne plus ultra* of many investigators.

Like the spiritless systematic zoology, which, in the work of many minor investigators, followed upon the example set by the great Linnaeus, so lacustrine investigators in considerable number, were apparently satisfied to describe, as the results of brief sojourns, the fauna of a lake or lake regions, or, perhaps, even from a couple of vials of material collected by some rich patron in the course of a journey around the world, to discuss monographically the fresh-water fauna of the Fiji Islands, for instance. Under such circumstances there could be no biological study. The chief aim seemed to be to cover as much ground as possible in a short time. And what Lauterborn said five years ago is even truer to-day in the light of our more extended experience: "For the question as to the distribution of organisms, the methods so cherished even up to the present day of fishing in the greatest possible number of lakes (which recalls, in many respects, the chase after new summits on the part of our modern high climbers—*Hochtouristen*!), really have only limited claim to scientific value, since through them but a very incomplete picture of the faunal character of a water basin can be obtained."

The earlier investigators whose work has already been mentioned, Fritsch in Bohemia, and Forel in Switzerland, had been pursuing a single problem or investigating a limited locality for nearly twenty years, and they were among the first to emphasize the necessity of a modification of the prevalent tendency, and of a more formal character for lacustrine work, if valuable scientific results were to be expected from it. Forel was first to publish, in outline, a plan for the precise formal investigation of a body of water, in which emphasis was laid upon the necessity also of continuous and extended

investigation, before satisfactory conclusions could be hoped for. This programme has suffered some modification in detail at the hands of various students, but, in its general features, remains the aim and desire of workers everywhere. With the appreciation that such work must needs be formal, continuous and extended, came naturally the desire that stations of a permanent character should be established at various points for the realization of the idea. And the first of these that were founded were of a general character, concerned with the biological investigation of water as a problem of general scientific interest and importance.

But almost immediately other influences made themselves felt which have led to the extension of the general idea along particular lines of economic importance. Improved methods of fish catching and larger demands for fish food had brought various countries to the point where the drain on this kind of food supply was becoming very evident. The fish were being destroyed more rapidly than natural means could restore their numbers, and it was felt that something must be done by governmental agency to replenish the depleted waters. The first expedient of collecting and keeping under satisfactory conditions large numbers of fish eggs until they should be hatched, and the young fry distributed through the waters, was not so successful as had been hoped. The problem was too large to be attacked in such a superficial manner, and the further knowledge, which it became clear was absolutely necessary for proper handling of the question, must needs be sought through some means for the investigation of the conditions and determination of the steps necessary for the solution of the problem, and for carrying into effect the measures which might afford the desired relief. This led, first in Europe, to be sure, in connection with private enterprises for fish culture, to the establishment of bio-

logical experiment stations with the fish hatcheries, very much as chemical laboratories are now necessary adjuncts of various manufacturing interests, or agricultural experiment stations are connected with the higher development of agricultural possibilities. There is, however, a still further demand which has led to the formation of institutions of the general type which we are considering. The water supply of our cities has always been a serious problem, and one of increasing interest in connection with crowded conditions in the more thickly settled countries of the world, and the biological examination of the water, undertaken of necessity, has led to the organization of biological laboratories connected with the water systems of great cities, both on the continent, and in our own country.

Having thus discussed the causes which have led to the establishment of limnobiological stations, we may now consider, briefly, the types which they present, and the particular results which may be expected from a given sort. Of course all probable variations may be found, and it is difficult to make any classification which is complete or even just, and yet, for convenience, we may divide these enterprises into a few great groups, recognizing the fact that certain of them do not belong singly to any one class, but combine features of different types. But before outlining this classification, let me say that I do not regard the existence or non-existence of a building or structure devoted to the purpose of investigation as a necessary mark of a biological station. Some of the most valuable contributions to general and special questions in this field have come from investigators or groups of investigators who have had no abiding place, while, on the other hand, stations well equipped with buildings and apparatus have in some instances, so far as can be ascertained, contributed nothing even after several years' existence, to

the progress of scientific knowledge. Material equipment is valuable, and, in general, conduces to better results, and yet it is the results themselves which finally determine the character of any enterprise and the position which it should hold in the esteem of the world.

For the purposes of this discussion I propose dividing biological stations into, first, individual resorts, second, periodic resorts, and third, permanent stations. Individual resorts are such as are characterized by the work of one or more individual investigators, working for the most part independently, and solving their problems by virtue of their individual investigations. There are, of course, a large number of such places where some investigator has made sporadic or single efforts at the determination of the faunal character of a water basin, or has paid a number of occasional visits to such a locality for the same purpose. On the whole, these stations have accomplished comparatively little, although we find striking contradictions of the general statement.

They may also be of a more regular and definite character, and some of these personal investigations have been most valuable in extending our present knowledge of fresh water life. It may be noted here that the permanence or regularity which contributes to the success may be either in the location of the point at which the investigations are carried out, or in the definiteness of the purpose which is followed; thus Imhof's investigations on the pelagic fauna of the Swiss lakes were permanent in their value, and Zschokke's investigation of the biological character of elevated lakes carried on at numerous points in the Alpine chain, has resulted in fundamentally important contributions to the lacustrine fauna of high altitudes. Yet neither of these was at all confined to a single locality, though limited by a definite purpose.

Periodic resorts are those to which groups

of individuals are accustomed to go for a certain portion or season of the year, most commonly for a vacation period in accordance with which they are denominated summer or winter laboratories. The larger number of the investigators tends towards securing a more complete idea of the biological problem as a whole, so that the results obtained from such stations are of evident value. Yet, at the same time, it must be noted that they are distinctly inferior, even to many individual resorts, since during the larger portion of the year no investigations are carried on and the results obtained are necessarily partial and incomplete in their character, and hence unavailable for the decision of the broader and more fundamental biological questions.

Permanent stations are those at which operations are conducted throughout the entire year by a definite corps of observers. The continuity of their work renders their results valuable for the decision of general biological problems, and, at the same time, the permanent force which, in part, at least, is indispensable in such an institution, implies that the undivided attention of the observer is devoted to these problems; from this we may then expect justly that greater results will be obtained than in the case even of the best of individual resorts, since the investigators who are carrying on operations at these are, so far as I know, without exception, connected with educational or scientific institutions which demand at least a part of their time, and to that extent divide their interest and their energy.

It is furthermore clear from what has been previously said that such permanent stations are of two distinct classes. First, those which may be denominated general, even though their work is of the greatest value for special purposes, and second, those which are distinctively technical by virtue of their association with specific enterprises.

It is but natural that the different conti-

nents are very unequally represented with regard to the number of stations that have been established upon them, and with respect to the knowledge that has been gained in reference to their fresh-water fauna and flora. Thus, our knowledge of the Australian fresh-water fauna is confined, at present, to the report of collections made by travelers, and to the investigation of specimens raised by Sars from dry mud which had been sent to him. Of Africa we know that fifteen years ago an expedition brought word from Lake Tanganyika that while rowing across its waters they encountered swarms of jelly-fish, while many of the gastropod shells which were brought back with them showed, in an equally striking way, their marine character. These reports have been confirmed by an expedition that has just returned, and the strikingly marine complexion of the fauna of the lake can hardly be doubted. This appears all the more strange since collections made at Lake Nyassa, which lies decidedly nearer the sea, show nothing but what is specifically lacustrine. Such facts point, of course, to the importance of the African fresh-water stations of the future.

From various lakes of Asia, all the way from Ceylon to Siberia, numerous more or less extensive collections have been made by travelers, though there is hardly anything sufficiently extended to warrant the statement that a station has been located, even for a limited time, at any point, especially since the collections have not been investigated by men who had made them, but have been turned over as alcoholic material to European investigators for study. We do know, however, that Lake Baikal, which is situated almost in the center of the continent, harbors a rich molluscan and crustacean fauna that is characteristically marine in its form, and is further distinguished by possessing many sponges clearly of marine type, and at least one species of

seal (*Phoca*), a genus which is typically oceanic. A discussion on the meaning of these features lies far from the purpose of the present paper, but certainly such facts do point out most strikingly that the field of limnobiological investigation is not lacking in topics of extreme interest.

From South America reports concerning the fresh water fauna are perhaps most scanty of all. Frenzel, a German investigator who lived many years in Argentine Republic, has published some interesting studies made while there on the Protozoa; a few isolated notices of the lacustrine fauna from various regions complete the list.

From these statements it is apparent that the work done thus far outside of Europe and North America is exceedingly limited, and that for our judgment of the results in formal limnobiological investigations, we must look to the laboratories of these two continents. Among all European countries, Switzerland has furnished perhaps the greatest number of investigators and stations for limnobiology, together with the most extended and valuable results, although even yet there is not in that country, so far as I can ascertain, a building exclusively devoted to the purposes of this investigation. First and foremost among these investigators may be mentioned Forel, of the University of Lausanne,\* to whom reference has already been made. His investigations have been carried on for more than thirty years on Lake Geneva; to him we are indebted for the first knowledge of the abyssal fauna of a fresh-water lake, for the first extended program and plan for the investigation of such a lake, and for the first effort towards the realization of such a plan, which finds its full expression in his '*Lac Léman*,' a monograph at present in the course of pub-

lication; the volumes which have appeared thus far treat of physical, chemical, and meteorological conditions on the lake, and are to be followed by others which will complete, with the flora and fauna, the entire limnologic investigation. The series will make a magnificent and permanent contribution to lacustrine investigation, and will serve as a model for the work of all times.

The work of Zschokke, professor at the University of Basel, has been directed as already mentioned towards the elucidation of the faunal aspect of elevated lakes. It has been carried on through many years at different points, including the lakes of the Jura to the westward, as well as those in various regions of the Alps proper, and his papers on the fauna of elevated lakes contain the only general statement of the problem as well as of the characteristic features of such localities that has yet appeared. Lake Constance has been the scene in recent years of the work of numerous investigators under the guidance of an association for the investigation of the lake, which has its headquarters at Lindau. The published accounts of these investigations have thus far been preliminary in character, and I am unable to learn whether there is a building devoted to the purposes of investigation, and whether the work is carried on throughout the entire year.

This lake was the scene of early investigations by Weismann in 1877, and the present work which was inaugurated about 1893 is under the direction of Hofer, of the University of Munich.

To Bohemia belongs the honor of having had the first definite building for lacustrine investigations in the form of the Bohemian Portable Laboratory which was constructed, in 1888, under the direction of Professor Fritsch, of the University of Prague. Reference has already been made to the early work of this investigator, who, in 1871,

\* In a sense the laboratory of the University, which is located near the shore of the lake, is the building of the station, as in Wisconsin, mentioned below.

reported to the Academy of Sciences, in Prague, the results of the investigations of Black Sea, a small body of water in the Bohemian forest, with reference to the distribution of animals according to the depth of the water and their relation to the shore. These investigation which were extended to other lakes in the same year, are, I believe, the first at least to be recorded that were carried out in this way. It was, however, in 1888 before Fritsch succeeded in obtaining funds for a small portable zoological laboratory having some twelve square meters of floor surface. The station remained at its first location four years, and was replaced by a permanent structure when it was removed to another locality. This portable laboratory has been regularly visited at brief intervals of time by the director and his associates in the three localities at which it has been situated during the last ten years, and the contributions from this work constitute most valuable studies on the lacustrine biology of Bohemia.

In Finland there exists the laboratory of Esbo-Löfö, on one of the small islands which, though primarily a marine station, is so favorably located with reference to bodies of fresh water that it has devoted a considerable portion of its energy to the investigation of the fresh water fauna with valuable results. This laboratory has been maintained since 1895 under the direction of Professor Levander. Its contributions are published in the '*Acta Societatis pro Fauna et Flora Fennica*.' One of its workers, Dr. Stenroos, has for several years individually visited Lake Nurmijärvi, one of the small inland lakes with which Finland is so plentifully supplied, a body of water, which though it is about two and five-tenths kilometers in length by one in width, has a maximum depth of only one meter; he has given us a very complete faunistic and biologic study of its life.

Russia has recently established a station

on Glubokoe Osero, or Deep Lake, in the Province of Moscow, under the patronage of the Imperial Russian Society for Fish Culture. The station is under the direction of Professor Zograf, of Moscow University, whose contributions to lacustrine investigation, have been made known especially in a paper on the lake regions of Russia from the biologic standpoint, which was read before the International Zoological Congress in 1893. I infer that the station is a permanent one, though probably of technical character, although precise information on these points has not been obtained. Hungary has maintained for some years a lacustrine station on Lake Balaton, one of the largest fresh-water bodies of Europe, having an area of over 266 square miles, though its maximum depth appears to be only 11 meters; it is surrounded by enormous marshy areas which give thus varied conditions for the development of life. Several parts of the report on these investigations have already been published. In France there exists a lacustrine laboratory near Clermont-Ferrand, which seems to have been organized in 1893; no reports or contributions from the station are recorded in the bibliographical records. At Paris, Drs. Richard and de Guerne have investigated collections from a large number of lakes not only in France and neighboring countries, but even from Algeria, Syria, the Azores and other points, and have published valuable contributions on the distribution of fresh-water crustacea, as well as systematic monographs of various groups.

In Germany all types of stations are represented, as might be expected, from the importance of scientific study in that nation. Individual investigators, not a few, have examined various lakes or lake regions, most prominent among them being undoubtedly Apstein, whose studies on Holstein lakes have extended over many years, and whose work on fresh-water plank-

ton is the first general statement of the problems and of the methods used by Hensen in the investigation of the marine life with such success, and by Apstein first applied to lacustrine investigation. Probably the best known fresh-water station in the world is that on Lake Ploen also in Holstein. This was the first permanent general fresh-water station to be established in the world. It owes its inception to the energy of its present director, Dr. Zacharias, whose plan was to establish for fresh water an institution similar to the Naples marine biological station. The station opened in 1891, and since that time it has been in continuous operation, and has afforded opportunities for investigation to a large number of scientific workers both German and foreign. It is the most pretentious of all fresh-water stations, having a building two stories in height, with numerous laboratory rooms and equipped with abundant apparatus for collecting and investigating. From it has been published yearly, since 1893, a volume of studies, and the director has also contributed largely to other journals on these problems. Two other stations in Germany owe their inception to the fishery problem, and have for their purpose more particularly the investigation of those limnologic questions which deal particularly with the life of the fishes. One of these is located at Müggelsee, near Berlin, and is conducted under the auspices of the German Fishery Association. The other, at Trachenberg, is under the auspices of the Silesian Fisheries' Association. Both have made important contributions to the biological questions concerned in fish culture.

All the North American stations which are known to me lie within the limits of the United States, and they represent all the various types of such institutions. A considerable number of workers have reported isolated investigations of lakes in all parts of the country from Maine to California.

Among the most important of these occasional observations are those made by Forbes on the fauna of elevated lakes in the Rocky Mountains. The observations which he has recorded were made in the course of a preliminary investigation of these lakes by the United States Fish Commission, and constitute the only information on record with reference to the lakes of the country west of the Missouri river. There are but two localities which may be listed, however, as individual resorts sufficiently regularly visited to entitle them to more particular mention in this place. Green Lake, in Wisconsin, has been carefully studied by Professor Marsh, of Ripon College, and his work has yielded valuable information with reference to the vertical distribution of the crustacea and with regard to the deep water fauna of the lake. Here he was able to confirm the observation of Stimpson, on Lake Michigan, that there are found in the deep waters of our large lakes crustacea of a purely marine type. At Lake Mendota, in Wisconsin, on the shores of which is located the State University, a careful investigation, extending over a very considerable number of years, has been carried on by Professor Birge of the University. The results which he has obtained with reference to the distribution, both vertical and seasonal, have been published by the Wisconsin Academy and are not only the most extensive, but beyond all comparison the most precise investigation which has been made on this problem.

Of course, in one sense, this station has no building, but the scientific laboratory of the University, standing within a stone's throw of the shore of the lake, affords opportunities which are not surpassed at any fresh-water station in the world.

Quite a number of periodic resorts of the type of summer laboratories are to be found in various parts of the country. Some of these are merely summer schools, such as

the biological laboratory of the Chautauqua College of Liberal Arts, on Lake Chautauqua. Others are both for teaching and for investigation, while only a small number are exclusively devoted to the investigation of limnologic problems from one standpoint or another. The University of Minnesota has maintained at Gull Lake, near the center of the State, a laboratory for summer work by members of the University, and for the prosecution of the natural history survey of the State under the direction of Professor Nachtrieb, of the University. The State University of Ohio has conducted, since 1896, a lake laboratory near Sandusky, on Lake Erie. It occupies one of the State fish hatcheries, and is supplied with the necessary apparatus by joint action of the University and State Fish Commission. Its purpose is to afford a convenient point of work for the members of the University, and also to aid in the prosecution of the State Biological Survey, which is being carried on by the Ohio Academy of Sciences. The immense stretches of shallow water, marshy regions, and protected areas, together with the varied character of shore and the open lake within easy reaching distance, serve to make Sandusky perhaps the most favorable place on Lake Erie for the study of the fresh-water fauna and flora. The station was closed a year ago, owing to the death of the Director, Professor Kellcott.

In 1895 the University of Indiana opened a Biological Station on the shore of Turkey Lake in the northern part of the State, under the direction of Professor Eigenmann of the University; a constantly increasing number of students has visited the station each summer. The majority of them have been teachers of the State engaged in the prosecution of work to equip them for their teaching, but others have also assisted in carrying out a general survey of the lake fauna and in the collection of material to

illustrate annual variation and associated problems. For comparison, collections have been made from adjacent lakes connected with other water basins. In the coming year the station is to be moved to the shores of Winona Lake, some 18 miles from the present location, where two buildings are to be constructed for its use by the Winona Assembly. The contributions from the laboratory have been published in the Proceedings of the Indiana Academy.

For a number of years the Michigan Fish Commission maintained a force of a few scientific investigators and assistants in conducting a biological examination of the inland lakes of the State, under the direction of Professor Reighard of the University of Michigan. In 1893 it was determined to transfer the seat of operations from inland waters to one of the Great Lakes, and by virtue, both of its convenient location and of its importance as a famous spawning ground of the lake fish, which had, however, almost ceased to visit it, Lake St. Clair was decided upon as the locality for the first year and the laboratory was located on a small bay at the northwest shore of the lake. The party consisted of half a dozen scientific workers whose attention was exclusively devoted each to his particular field, and the results of the survey were published in bulletins of the Michigan Fish Commission. In 1894 the station was moved to Charlevoix, a famous fishing region on the eastern shore of Lake Michigan, and, owing to the absence of Professor Reighard, in Europe, I was requested to take charge of the work. The scientific force and the methods of work were similar to those of the preceding year, but the location brought us in contact, not only with shallow waters, but also with the deeper regions of Lake Michigan, and the party made investigations and collections of a precise character in the deepest fresh water which has as yet been investigated by such methods. The

results of the summer's work were published in a bulletin of the Commission. Unfavorable financial conditions compelled the suspension of the work on the part of the Michigan Fish Commission, but American investigators owe much to the impetus which has been given to such work through their agency.

For many years the U. S. Fish Commission has been urged to establish on the Great Lakes a biological station similar to that which has long been maintained on the ocean, at Woods Hole, Mass. Finally, a year ago, a preliminary survey was undertaken with a view to deciding the advisability of such a movement and Professor Reighard was requested to assume the leadership of the enterprise. The U. S. Fish Hatchery at Put-in-Bay, a small island in the center of the west end of Lake Erie, was selected as the seat of operations and a party of scientific workers spent two months in studying the fauna and flora of the adjacent waters. It is to be hoped that this work may develop into a permanent experiment station on the Great Lakes.

Among permanent American stations of a technical character, the Experimental Filter Station of the Massachusetts Board of Health, located at Lawrence, is the best known as it is also, perhaps, the most famous of its kind in the world. It has been in continuous operation since 1887 and has conducted extended experiments on the biological examination of drinking waters; the methods worked out in connection with them are now standard for such purposes. Similar technical laboratories are in operation in Boston, Lynn, Worcester and other cities; but in most of them the biological examination of waters is only a secondary function. The Mount Prospect Laboratory, organized recently in connection with the Brooklyn Water Works, and placed under the direction of Mr. G. C. Whipple, whose contributions to limno-

biologic questions are well known, is more particularly devoted to the investigation of questions connected with the character of the water supply. Numerous samples taken from all the sources of the city's supply are subjected each week to physical, chemical, microscopical, and bacteriological examinations, and the quality of the water controlled thereby, since the reports made to the chief engineer serve to guide him in the choice of the sources from which the water is drawn. The results of such studies are also of great importance in general limnologic questions.

The University of Illinois was extremely fortunate in having associated with it, by statute, a state laboratory of natural history which has been engaged for many years in a natural history survey of the State. Under the direction of Professor Forbes, whose pioneer work on the lake fauna has already been noted, particular attention was paid to such questions as the food of fresh water fishes, and the distribution of various groups of fresh water organisms, so that both by preliminary work, and in the person of its director, the state laboratory was peculiarly fitted for the successful inauguration of an Illinois Biological Station which became possible under state grant in 1894. The laboratory secured a permanent superintendent in the person of Dr. Kofoid a year later, and work has been carried on continuously by a permanent force since that date. The laboratory was unique in its inception since the director, Dr. Forbes, conceived the idea of locating it on a river system rather than as all previous stations on a lake, and it was not only the first in the world, but is yet the only station which has peculiarly attacked the problems of such a system.

The Illinois river and its dependent waters were selected as the field of operations and Havana, Ill., as the center of work. The river here presents in its cut-offs, bayous, shallow, marshy tracts, sandy

areas with wooded margins and regions of spring fed waters, and with the enormous extent of land covered at high water, a variety of conditions which it must be confessed could not be surpassed, and hardly equalled elsewhere. The abundance and variety of the flora and fauna, both in the higher and lower forms of life, demonstrate the good judgment exercised in the choice of locality. A noteworthy feature in the equipment of this station, and so far as I know, one that is unique, is the floating laboratory which enables an easy transfer of operations to other points, where work can be carried on for comparison or contrast, with equipment and environment as satisfactory as that which exists in a permanent building, but with the flexibility and facility of movement which characterizes field studies. The work has been conducted uninterruptedly for more than three years, and the results include studies on the insects and their development, on the earthworms, on the Protozoa and rotifers, on various groups of crustaceans and general investigations on plankton methods and on the distribution of the plankton, while some work has also been done on the plant life of water. These studies have been published in the Bulletin of the Illinois State Laboratory of Natural History.

Let us consider, in conclusion, the function and future development of these institutions. It is perfectly clear that the work of the different types of fresh-water stations will vary somewhat with the class, and Zacharias has outlined carefully the differences in the work of the fixed and of the movable stations. But these are, after all, minor differences. All stations, whether fixed or movable, have really three objects: teaching, investigating, experimenting, objects which may be subserved directly or indirectly, or in both ways, by each one of them. It is unquestionably true that the tendency within recent years has been to

make the university trained scientist a laboratory man, unacquainted with work out of doors and among living things. This has reacted unfavorably upon his teaching powers, and thus indirectly upon the entire school system. Not that subjects in natural history are not better taught in our secondary schools than they were twenty years ago, when, in truth, they were hardly taught at all, but that the naturalist to-day is not trained as an outdoor observer and is little capable of handling himself and his work in a new environment. As Forbes says: "It is, in fact, the biological station, wisely and liberally managed, which is to restore to us what is best in the naturalist of the old school united to what is best in the laboratory student of the new." Thus, both through the influence of the investigators in the case of those stations which do not carry on directly any educational work, and through the teaching of those which do conduct summer instructional courses, new life will be instilled into the teaching of natural history throughout our country.

In the second place, the fresh-water station is a center for investigation with all its stimulating effects on the individual thus brought in contact with problems of Nature and efforts for their solution, and in the contributions to the advancement of knowledge which are the fruits of a careful work on the part of its attachés. All that has been said of the advantages of marine stations applies equally well to fresh-water laboratories, together with the added advantages that their accessibility brings these advantages to considerable regions which would otherwise be entirely without them by virtue of their distance from the sea. It is unnecessary that I should emphasize further this phase of the question, or dwell upon the greater simplicity of biological conditions in fresh-water over those which exist in the ocean. These factors have been forcibly presented by many writers.

Finally, the fresh-water station should be above all things an experimental one, and in this direction the most valuable results are to be looked for, both from the general scientific and from the technical standpoint. To the scientist, this needs no demonstration; but it is essential that the importance of such work, especially for fish culture, be more widely understood. The advance in agricultural methods in the United States is unquestionably due in large part to the development of a splendid series of agricultural experiment stations in which agricultural problems have been subjected to intensive experimentation. Contrasted with this, conditions in fish culture present almost the opposite extreme. Fish eggs have been hatched in enormous numbers, but what is known of their subsequent history or what has been done to insure the safe development to maturity of the fish? Present methods have reached their limit and the subject must be attacked from a different standpoint. Fish culture should receive by the liberality of state and nation the same favors that have been extended to agriculture, the use of permanent and well-equipped experiment stations where trained workers shall devote their time and energy to the solution of its problems. Thoroughness and continuity are essential, for these problems really deal with all conditions of existence in the water. Of what does the food of each fish consist, where is it found and in what amount, how may it be increased and improved; to what extent and how can the number of fish be multiplied, and how far is this profitable; what are the best kinds of fish and what new varieties can be produced? These are a few of the many questions to be solved.

The problems outlined are indeed vast, and yet we may be confident that their solution lies easily within the power of the human intellect, for they are all paralleled in the history of the agricultural develop-

ment of the race; and man, relying upon his success in the past, may go forward with supreme confidence to the attainment of their solution in this new field.

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BRUNISSURE OF THE VINE AND OTHER  
PLANTS.

SINCE the publication, in 1892, of the papers by Viala and Sauvageau describing Brunissure of the Vine and the California Vine disease as due to *Plasmodiophora vitis* (Viala et Sauv.) and *P. californica* (Viala et Sauv.) much interest has been manifested in these supposed new parasites. F. Debray and A. Brive in *Revue de Viticulture*, 1895, claimed to have found the parasite in a large number of plants belonging to numerous families and genera. They made a new genus for the organism calling it *Pseudocommis vitis*. By far the best work, however, has been done by Viala and Sauvageau. A full discussion of their work with bibliography may be found in 'Les Maladies de la Vigne, par Pierre Viala, Troisième édition 1893, pp. 400-413. Any one who has observed for himself the peculiar structures described would most likely decide at once that they must belong, or be at least closely related, to the genus *Plasmodiophora*. The peculiar vacuolate plasmodium-like structures may be best studied, following the directions of Viala (in *Maladies de la Vigne*), by slowly clearing the sections or tissues in dilute eau de javelle. The protoplasm of the host cell is said to be dissolved, while that of the plasmodies remains for a long time unattacked. The plasmodies may then be colored with iodine or other stains, bringing out their structure very sharply. I have recently repeated these experiments very carefully and find everything described by Viala and Sauvageau in *Vitis* and also as described by