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1910

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THE RADIOACTIVITY OF SOME SPRING WATERS AT MADISON, WISCONSIN.

HERMAN SCHLUNDT.

The radioactivity of underground waters is generally due to the presence of a very minute quantity of radium emanation. This disintegration product of radium, being a gaseous substance, can be easily separated from the water by boiling for a few minutes. By collecting all the dissolved gas in a known volume of water the quantity of emanation present may be readily determined by introducing the water gas into a suitable form of electroscope or electrometer.

During the past summer (1908) several of the spring waters in the vicinity of Madison were tested for radioactivity by making quantitative determinations of the radium emanation carried in solution. The method of conducting the tests will be outlined first and then will follow the results of the experiments and some comparative data.

As the emanation quickly escapes from running water, and to some extent from stored water, an effort was made to obtain the samples directly from the spring where the water issues from the ground. Since most of the springs were walled in, the water had to be drawn into the collecting vessel by means of tubing the intake end of which was held where the water issued. In this way the influx of water from the overflow basin was minimized. The collecting vessel was filled nearly full and was then tightly stoppered. The container used was made of galvanized iron, and served as a boiler later in the separation of the dissolved gases. Its capacity was 5.34 liters. The samples of well water tested were taken directly from the discharge pipe of the pump after about two minutes of flow.

The water samples were then taken to the laboratory where the dissolved gases were separated by boiling. This operation was carried out in a special form of apparatus described elsewhere.[1] The boiling was continued for at least 15 minutes. A few cubic centimeters of caustic soda were generally added just before boiling to fix the carbon dioxide. The separated gas was then transferred to an air tight electroscope which had previously been partially exhausted. The electroscope was supplied with a reading microscope for noting the rate of fall of the charged leaf. This apparatus had been carefully standardized beforehand by means of a known quantity of emanation obtained from a small weight of pitchblende (uraninite):

By the foregoing operations the radium emanation present in the water was separated and stored in the electroscope for quantitative measurement. Readings were then taken on the rate of fall of the charged leaf. Owing to the induced activity that results from the decay of the emanation the rate of fall of the leaf increases for fully three hours after the introduction of the gas, attaining a maximum value about 35 to 40 per cent greater than the initial value. This maximum value was made the basis for determining the quantity of emanation present.

In this country the activity of waters (and gases) is generally expressed in terms of the standard first proposed by Boltwood.[2] The standard is based upon the existence of a constant ratio between the quantity of radium associated with uranium in natural minerals.[3] The unit of activity represents the quantity of emanation associated with unit weight of uranium in a natural mineral. The activity is thus expressed in terms of uranium, and as the ratio between uranium and radium is known the activity may be expressed directly in terms of radium. When referred to waters the values of the activities represent the quantity of uranium (or radium) required to maintain in

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1 Schlundt and Moore, Jour. Phys. Chem. **9**, 320 (1905).
2 Am. Jour. Sci. (4) **18**, 381 (1904).
3 Boltwood, Am. Jour. Sci. (4) **18**, 97 (1904), Phil. Mag. (6) **9**, 599 (1905), McCoy, Ber. d. Deutsch. Chem. Gesell. **37**, 2641 (1904).

radioactive equilibrium the emanation present per liter of water. In the table of results the activities are expressed in terms of both uranium and radium. The radium values were obtained by multiplying the uranium values by 3.8×10^{-7}, the equilibrium ratio, $Ra/_U$

On the continent of Europe the activity of waters is expressed, as a rule, in absolute units. The saturation current, in electrostatic units, produced by the emanation per liter of water expresses its activity. The constants required in this system of units were determined for the electroscope used in the tests. The last column of the table of results gives the values of the activities in electrostatic units.

The electroscope used in these experiments is of the C. T. R. Wilson type. It is rectangular in form,—6.4 x 10.1 x 14.7 cms. inside measurements,—and is securely fastened on a wooden base which also carries the reading microscope for noting the rate of fall of the leaf. Its rectangular brass frame is fitted in the front and back with pieces of plate glass, and is provided with two good brass stopcocks. On the top is a circular opening with a threaded brass ring into which screws a brass cap having a central opening. Through this hole projects the brass rod to which is fastened below the blade that carries the aluminium leaf. This leaf system is fastened into the cap by means of a sulphur cast which also serves to insulate it from the case of the instrument. To protect the sulphur insulation the electroscope is provided with a small cap that slips over the screw cap.

The capacity of the electroscope was found to be 952 cc. A fall of the leaf of one division per minute represented 7.5×10^{-4} gram uranium or 28.5×10^{-11} gram radium. Each division of the ocular of the microscope, in the space where readings were always made, represented a fall of potential of 1.7 volts, and the electrostatic capacity of the leaf system was found to be 9.4 cms. the latter constant was determined by means of a Harms standard condenser whose capacity was 42.5 cms. The procedure given by Harms was carefully followed.[1] The calibration of

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[1]Physik. Z. 5, pp. 49–50.

the scale in volts was done by noting the position of the leaf corresponding to several values between 350 and 450 volts.

The method of standardizing the electroscope by means of uraninite, and other details of manipulation have been described in former publications.[2]

The computation of the activity is simple and is illustrated by the following example: In the test of Silver Spring it was found that the emanation obtained from 5.34 liters of water produced a maximum fall of the leaf of 12.65 divisions per minute. Hence the activity in terms of the uranium standard is given by,—

$$\frac{12.65 \times 7.5 \times 10^{-4}}{5.34} = 17.7 \times 10^{-4} \text{ g. U} = 67.3 \times 10^{-11} \text{ g. Ra.}$$

In E. S. units the activity is,—

$$\frac{12.65 \times 1.7 \times 9.4}{60 \times 300 \times 5.34} = 21.2 \times 10^{-4}$$

The quantitative results of the examination are given in Table I. The first column gives the name of the spring or other source, the second its location, the third the date of collection, and the remaining columns the activities expressed respectively in terms of uranium, radium, and electrostatic units. These values represent the activities of the samples at the time of collection. In several tests some hours elapsed between the collection and the electroscopic test. The decay in the activity of these samples was corrected for by the formula $I_0 = I_t e^{rt}$, expressing the decay of the activity with the time. I_0 represents the initial activity, I_t the activity observed t hours after the water was collected, and r the radioactive constant of the radium emanation. The value of r used in the calculations was 0.0077, which is an approximate mean of the values of several investigators.

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2 Jour. Phys. Chem. 9, 320 (1905), and Trans. Am. Electrochem. Soc. Vol. 8, 292 (1905).

TABLE I.

Name of Source.	Location.	Date.	Activity.		
			$g \times 10^{-4}$ U.	$g \times 10^{-11}$ Ra.	E. S. Units.
Lake Mendota..	....	Aug. 28—'08	None......	....	....
South Hall Well	University Campus.	" 9	5.6	21.3	6.64×10^{-4}
Waconia Spring	Lake Mendota	" 30	6.8	25.8	8.25 "
Merrill Springs.	" "	" 30	13.8	52.4	16.6 "
Black Hawk Spring.	" "	" 31	3.8	14.4	4.55 "
Parkinson Spring.	" "	" 31	12.2	45.4	14.6 "
Deep Well......	Hiram Smith Hall, U. W.	Sept. 1	10.9	41.4	13.1 "
Silver Spring...	Lake Wingra..	Sept. 1	17.7	67.3	21.2 "
Spring Haven...	Lake Monona.	Sept. 3	14.0	53.5	16.8 "
City Deep Well (Madison).	Cor. Patterson and Main Sts.	Sept. 3	6.2	23.6	7.6 "

That the radioactivity of the different water samples is due to the presence of radium emanation was established by the curves representing the rise in activity during the first three hours, following the introduction of the emanation into the electroscope and by the position of maximum activity on the decay curves. The sample of water from Merrill Springs was evaporated; the residue was tested, but no positive indication of activity was obtained. In this case then the activity of the water is due almost entirely to radium emanation that has diffused into the water in the course of its underground flow. The activity is not due to the presence of traces of radium salts. This conclusion will probably be found to hold for the other springs. No attempts were made to test the waters for thorium or actinium.

Although the spring waters show differences in activity still the values are of the same order of magnitude. The differences in activity are small in comparison with results obtained for waters in other areas. The results obtained by Boltwood[1] in his tests on the radioactive properties of the waters of Hot Springs, Ark., are characterized by marked variations in their

[1] Am. Jour. Sci. 20, 128 (1905).

activities. This result is all the more striking because the waters from the different springs at Hot Springs show a marked resemblance in their general chemical characteristics. The most active spring was found 500 times more active than the least active. The same result was characteristic of the activities of some natural waters in different sections of Missouri.[2] In comparison with these results the springs in the vicinity of Madison are characterized by uniformity in activity, and we may say that the similarity in geological formation of the spring area finds confirmation in the activity of the springs.

The following table gives the activity of a few well known spring waters, European and American:

TABLE II

Name of Source.	Location.	Activity, $g \times 10^{-4}$ U.	E. S. units ($i \times 10^{-4}$)	Observer.
Gräbenbäcker Quelle	Gastein, Austria....	....	1550	Mache.[1]
Schossbrunnen.......	Karlsbad, Austria..	....	174	Mache & Meyer.[2]
Ambrosius-brunnen..	Marien Bad, Austria	....	16.2	Mache & Meyer.
Johannabad..........	Baden................	....	45.4	Mache & Meyer.[3]
Hirtenbrunnen.......	Odenwald, Hessen..	....	125	Schmidt & Kurz.[4]
Vauquelin..........	Plombières, France..	....	94	Curie & Laborde.[5]
Chomel..............	Vichy, France.......	....	7	Curie & Laborde.[5]
Kochbrunnen	Wiesbaden, Germ'ny	....	23	Henrich.[6]
Imperial Spring......	Hot Springs. Ark....	266	....	Boltwood.[7]
Dripping Spring......	Hot Springs, Ark....	7.7	....	Boltwood.[7]
Sweet Springs........	Sweet Springs, Mo...	23.7	....	M. & S.[8]
Apollinaris Spring...	Yellowstone Park...	31.9	22.1	Schlundt & Moore.
Nymph Spring.......	Yellowstone Park...	6.9	4.8	Schlundt & Moore.
Merrill Springs........	Madison, Wis........	13.8	16.6	Schlundt.

1 Ber. d. Ak d. Wiss. Wien, Abt. IIA, 113, 1329.
2 Ber. Ak d. Wiss. Wien, Abt. IIA, **114**, 355.
3 Mache and Meyer, Ber. Ak. d. Wiss. Wien. Abt. IIA. 114, 545.
4 Smhidt and Kurz, Physik. z. 7, 214 (1906).
5 Curie and Laborde, Compt. rend. 142, 1462 (1906).
7 Henrich. Ber. Ak. d. Wiss. Wien, Abt. IIA, *113*. 1092.
6 Boltwood, l. c.
8 Moore and Schlundt, l. c.

The spring waters at Madison may then be regarded as moderately radioactive.

2 Moore and Schlundt, Trans. Am. Electrochem. Soc. 8, 291 (1905).

I am obligated to Professor Louis Kahlenberg of the University of Wisconsin for the use of his laboratory and other courtesies extended to me in connection with these tests.

University of Missouri,
February, 1909.

DESCRIPTION OF A NEW SPECIES OF EUBRANCHIPUS FROM WISCONSIN WITH OBSERVATIONS ON ITS REACTION TO LIGHT.

S. J. HOLMES.

Eubranchipus ornatus sp. nov.

Male: Antennae slender, extending considerably beyond the eyes. Frontal appendages irregularly oval, resembling those of *E. serratus* Forbes, the inner margin convex and dentate except on the proximal fourth, the teeth being longer on the most prominent part; outer margin convex near the base where it is furnished with six to eight long finger-like processes which gradually decrease in size distally where the margin becomes concave; the surface of the appendage is studded with small blunt projections which occur also on the teeth. Claspers long; the first joint thick, incurved, with a broad basal process on the inner side which is distally truncated and bifid and meets its fellow in a broad flat surface in the middle line; distal end of joint concave; second joint long, slender, incurved, more or less abruptly narrowed near the middle where there is a moderate convexity, and ending in a single acute point; at the base of this joint is a small blunt spine which points backward and outward.

Abdominal segments not narrowed in front or produced backward at their posterior angles, the last segment slightly wider distally than the preceding ones. Anal appendages narrowly lanceolate and setose on both sides from base to tip.

In the female the much smaller second antennae end in a slender, attenuate incurved process.

Length 12mm. General color bluish green; ventral side of abdomen, outer surface of male organ, stylets, and dorsal side of last abdominal segment orange; tip of stylets whitish. Swimming feet and claspers tinged with orange. A pair of blue spots above median eye and a blue area on outer side of egg sac.

This species which is one of beautiful coloration was taken along with *E. bundyi* in small ponds near Madison, Wis., in April, 1907 and 1909. The two species were sometimes found in the same pond or pool and sometimes in separate ones, both make their appearance at about the same time and live for only a few weeks.

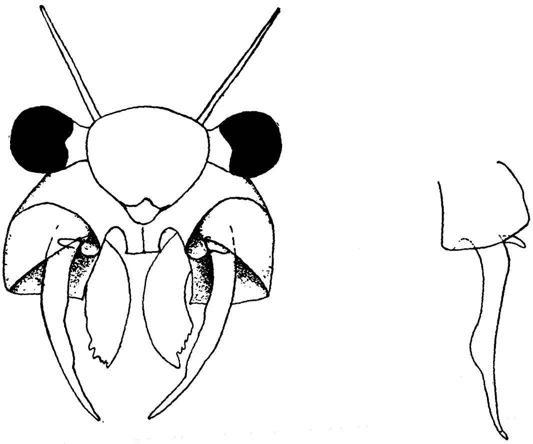
Eubranchipus ornatus differs from *E. bundyi* in its much broader and more irregularly shaped frontal appendages, and in its claspers which are long and attenuated and end in a single point instead of a truncated and dentate tip. From *E. serratus* Forbes which it resembles in its frontal appendages it differs markedly in the form of the claspers which in the latter resemble those of *bundyi,* and in the segments of the abdomen which present no appearance of serration. *E. vernalis* Verrill of the eastern states, the only other species of the genus in North America, has very different frontal appendages and claspers.

Eubranchipus in ordinary daylight or even sunlight shows little phototactic response. Individuals placed in a glass dish do not congregate to any noticeable extent either on the side toward the light or away from it, but if taken into a dark room and exposed to a sharply localized source of light they at once manifest a quite decided phototaxis. They congregate on the side of the dish toward the light and will follow the light about in all directions. This behavior is similar to that of many insects which show no tendency to fly towards the sun while in the field, yet manifest a marked proclivity to go toward a window or a lamp when brought into a room. The reason for this may be, as Radl has suggested, that when out of doors light falls upon the eyes from all parts of the sky and impulses to go in any one direction do not greatly preponderate over others; while if the light comes from one direction it is much more likely to produce orientation.

When the light is moved from side to side Eubranchipus orients itself by a sudden movement of the tail toward the light. When one such movement does not suffice others are performed until a fairly accurate orientation is secured, by moving the light very slowly to one side as the animal is swimming towards it, it may orient itself to a certain extent without this sudden movement of the tail. This is accomplished by rotating the body so that the ventral surface is more nearly perpendicular to the rays; the ventral curvature of the body soon causes its course to be deflected towards the light. The changes in the direction of swimming brought about by rolling from side to side are, however, very slight, and constitute a minor factor in the orientation of the body. One eye was cut off in a number of individuals but the shock effect prevented any response to light and in a few hours all were dead.

Swimming on the back in Eubranchipus is due in part at least to the light. If several individuals are swimming in a glass dish which is illuminated from below many of them will turn over ventral side downwards and swim close to the bottom making efforts to get as close to the light as they can. They may be caused to reverse their position repeatedly by moving the light above and below the dish. Some specimens, however, do not reverse and may not show at any time any marked phototactic response.

PLATE XCVI.



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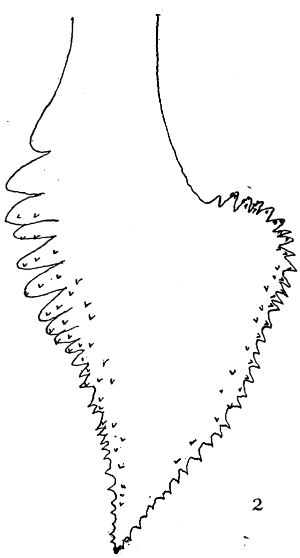

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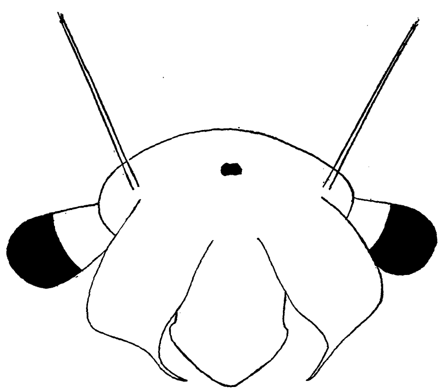

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HOLMES: —

EUBRANCHIPUS

COCKAYNE, BOSTON

SOME EUROPEAN BIOLOGICAL STATIONS.

CHANCEY JUDAY.

The first European biological stations, such as we know today, were founded some forty odd years ago. Previous to this time individual investigators visited the seashore, some lake, or river to carry on their researches on aquatic organisms, but in such cases it was necessary for them to improvise their own laboratories and to provide their own laboratory and collecting equipments. Under such conditions, of course, but few biologists could enjoy these opportunities and it is little wonder that the first permanent stations were heartily welcomed by the biologists of that time. These first laboratories were poorly equipped in comparison with the more modern stations, but they at least furnished a working place and some of the most necessary equipment. This made it possible for many more investigators to pursue researches at places where material was abundant and where work could be carried on under the most favorable conditions. It is not surprising, then, that these early stations enjoyed great popularity and rapidly increased in importance.

This growth in popularity and importance resulted not only in increased facilities at the earlier stations, but led to the establishment of others and the number is still gradually growing in spite of the fact that almost every European nation now has a liberal quota of such laboratories. The coast line has become dotted with marine stations and many fresh-water ones have been established on lakes and rivers. The constant increase in the number of both kinds furnishes ample testimony of the continued interest in such institutions. The modern stations owe their popularity to the fact that they are such excellent places for carrying on research work. Here the investigator is supplied with the most necessary comforts and conveniences which will make his work most pleasant and profitable. He is free from all duties which might detract from the work in hand and fresh material may be had in abundance. In other words he enjoys good laboratory facilities while he is practically in the field. At the larger stations, also, the investigator will generally find himself associated with biologists from various quarters of the globe and his results will be more fruitful in consequence of the discussions, criticisms, and suggestions of his co-workers.

Zoologists have taken a much more active interest in the establishment of these stations than botanists and they deserve the chief, if not the entire credit for the founding of practically all of them, many of them being called zoological rather than biological stations. Yet the botanist is heartily welcomed at all of them and is accorded the same privileges and facilities for his work as the zoologist.

In addition to the regular laboratory facilities, several of the marine stations possess important adjuncts in the way of supply departments from which both living and preserved material is sent to the various universities for study in the class room, for museum demonstrations, or even for research work. Material destined for the latter will even be carefully prepared by special methods if so desired. By rendering such services, these supply departments greatly enhance the usefulness of such stations and also widen their influence very much. Several of the stations themselves are adjuncts of universities, thus not only serving as supply depots but also offering excellent opportunities for work to their students of biology.

For the past few years, extensive and elaborate international investigations have been in progress on the North sea. The various governments taking part in this work, have assigned their allotted portions of the researches to their respective marine stations, thereby stimulating a greater interest in these laboratories and adding greatly to their usefulness. While these investigations were undertaken with a practical end in view, that is, the improvement of the North sea fisheries, yet they are being conducted along broad scientific lines and so far they have yielded results which are very interesting and valuable from a purely biological standpoint.

The various marine and fresh-water stations of Europe have become such important factors in biological investigations because so much valuable work has been and is now being done at them, that a brief account of some of them may prove interesting to biologists.

England.

The Plymouth Laboratory was founded by the Marine Biological Association of the United Kingdom. The present stone building was completed in 1888. It is located on a prominent bluff on a military reservation near the head of the bay and commands a fine view of the bay. A public aquarium occupies the ground floor of the main part of the building. It is equipped with large, well lighted aquaria in which the habits of the larger marine animals may be studied. The laboratory proper is located on the second floor, just above the aquarium. The main room contains 12 well lighted compartments which are at the disposal of investigators for a small fee. The center of the room is occupied by a number of small tanks which may be used for studying the smaller animals. The west wing of the building contains an apartment for the care-taker, the library, the museum, and chemical, photographic, and specimen rooms, together with the engine room and pumps. The east wing contains the director's apartment, and two small working rooms. The laboratory staff is taking part in the North sea investigations and two ships have been chartered and equipped with dredges, trawls, and nets for this work. The station offers no instructional work whatever but it offers opportunities to universities to conduct summer classes here.

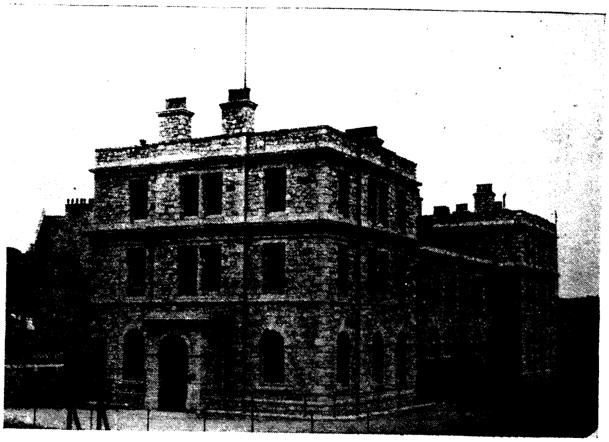
The Port Erin Station was established by the Liverpool Marine Biology Committee which was organized in 1885, largely through the efforts of Dr. W. A. Herdman, who is now director of the station. The present laboratory is the third that has been built by this committee. It is a stone building pleasantly located at the southwest corner of Port Erin bay, Isle of Man. It stands at the base of a cliff on the side of which are the two large tanks which supply the hatchery and aquaria with water. The building consists of three parts. The central one is occupied by the aquarium which has several large, well lighted concrete tanks arranged along three of the walls, with smaller tanks in the center of the room. A gallery around this room contains a number of museum cases in which specimens of the local fauna and flora are exhibited.

On the ground floor of the east wing, there are six small work rooms on one side, which may be rented for 10 shillings a week each, and on the other side are the library, dark room, store room, and a general work room. The second floor of this wing consists of a large laboratory which is used as a general class room for students. The fish hatchery occupies the ground floor of the west wing and above this is a large room in which various types of fishing and scientific apparatus are exhibited. The ponds in which plaice are kept for breeding purposes are located just west of the building.

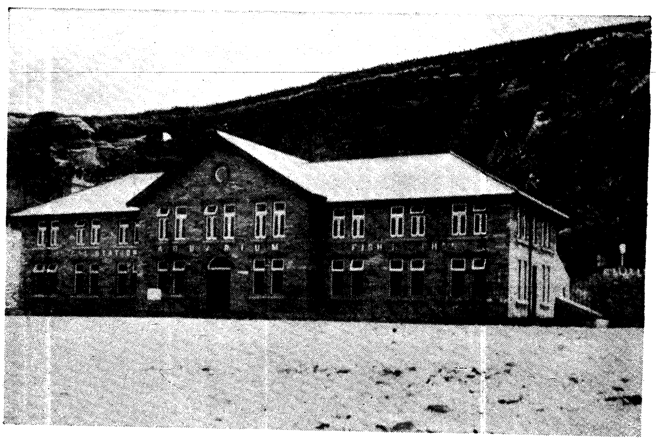
The private steam yacht of the director is used for dredging and plankton work. There is a rich fauna and flora in the immediate neighborhood, and, since the maximum difference between tide levels is about 6 m. much interesting material may be obtained at extreme low tide.

Through the munificence of Mr. W. H. Hudleston another English station was erected in 1908. It is located at Cullercoats near Newcastle-on-Tyne, and is an annex of Armstrong College at Newcastle.

In the autumn of 1901, Mr. Eustace Gurney built a freshwater laboratory at the edge of Sutton Broad about a kilometer and a half from the village of Stalham. It is a substantial brick building and is large enough to accommodate four or five investigators. The laboratory is provided with all necessary glassware, chemicals, and collecting apparatus, including a small motor boat and other collecting boats. This Broad—a term used locally for bodies of water having an area of two hectares or more—was a large sheet of open water until comparatively recent times but it is now filled with reeds and many other kinds



PLYMOUTH.



PORT ERIN, I. O. M.

SUTTON BROAD LABORATORY.

JUDAY:—

EUROPEAN BIOLOGICAL STATIONS

COCKAYNE, BOSTON

of aquatic plants. There is scarcely any open water except the channels which are kept free for navigation. The shores of the Broad are ill defined, consisting of low, level marshes, large areas of which are submerged by a very slight rise of the water. The greatest depth of water does not exceed two meters. Although forty kilometers from the sea, high tides sometimes affect the level of water in Sutton Broad and during these times there is an appreciable rise in salinity. There are five other river valleys with their Broads all within easy reach of the laboratory.

Mr. Robert Gurney is director of the Station and the work at present is directed toward acquiring a general knowledge of the fauna and flora of the region as a preliminary for more detailed investigations into bionomical problems. So far a fairly complete knowledge of the Crustacea, Coleoptera, and Odonata has been obtained and, to a less extent, of the Rotifera and Hydrachnida. Chemical analyses have been made also to determine the effect of the tides. No charge is made for the use of the laboratory.

Scotland.

The Millport Laboratory was established by the Marine Biological Association of the West of Scotland. It is situated on the Isle of Cumbrae in the midst of the extremely rich and varied fauna of the Firth of Clyde, and is within easy reach of Glasgow. The building consists of a main portion and a wing, each two stories in height. On the ground floor of the former, there are several research rooms and above them are the Robertson Museum and the library. The museum contains the interesting and valuable Robertson collection of Ostracoda. The public aquarium occupies the ground floor of the wing and above this is a large, well lighted general laboratory. The station is well equipped with compound and dissecting microscopes, microtomes, and apparatus for physiological work. It also possesses a small collecting steamer.

During the summer, courses in biology are given which are adapted to the needs of both teachers and students. Along research lines it is the aim of the laboratory to make a detailed physical, chemical, and biological survey of the Clyde Sea Area.

Tables may be had in the research rooms for a nominal rental.

The marine laboratory at Saint Andrews is a stone building, one story high. There is a large, well lighted acquarium room and work places in an adjoining room for a dozen persons. It is under the direction of Professor MacIntosh of the University of St. Andrews.

The Scottish Oceanographical Laboratory at Edinburgh has also played a very prominent role in marine investigations. Dr. W. S. Bruce, its director, had charge of the Scotia Antarctic expedition and he has also made explorations in Spitzbergen. In this way the laboratory has obtained much valuable material from these regions. Part of this material has been studied by specialists and their results published, but much of it is still being studied or remains untouched.

A small marine laboratory is also maintained in connection with the fish hatchery at Aberdeen.

In 1897 very extensive investigations were begun on the lakes of Scotland by the Scottish Lake Survey under the direction of Sir John Murray. So far the work has been carried on without the aid of a biological station. At first attention was directed chiefly to a bathymetrical survey of the lakes and up to the latter part of 1906, when this part of the work was discontinued, 562 lakes in all had been sounded. Reports on this work and hydrographic maps of many of the lakes have already been published.

The biological phase of the work has been confined principally to making collections for a qualitative survey of the fauna and flora of the lakes. A study of the material that has been collected, has so far revealed the presence of more than 700 species of plants and animals. It has also brought out many interesting facts concerning the peculiar habits and unusual distribution of many forms. The several papers relating to the work which have so far been published, constitute a very important contribution to limnology.

Norway.

In common with the other European countries, Norway has also taken very great interest in marine stations. The importance of her marine fisheries has led to extensive investigations in the fjords along the coast and Norwegian biologists are now taking a prominent part in the international investigations on the North sea. The station at Bergen which is a dependency of the Bergen Museum, was established a number of years ago and it has grown steadily in importance. At present it is the leading station in the country. Its summer courses attract many biologists not only from Norway but from many other countries as well.

The two story building is a frame structure and is located near the head of a bay just outside one of the city parks. A public aquarium occupies the ground floor of the wing. The laboratories are located on the second floor and there are accommodations for about twenty-five individuals, but it has sometimes been necessary to provide for as many as thirty-five during the summer courses. The popularity of these courses is due in no small measure to the efforts of the director, Dr. B. Helland-Hansen.

The Michael Sars, which is the Norwegian ship taking part in the North sea investigations, is also at the service of this laboratory part of the time and is then used for explorations along the coast, especially in the fjords.

Some years ago also a marine station was established at Dröbak, a short distance south of Christiania. It is closed in winter but is visited by many biologists in summer.

Sweden.

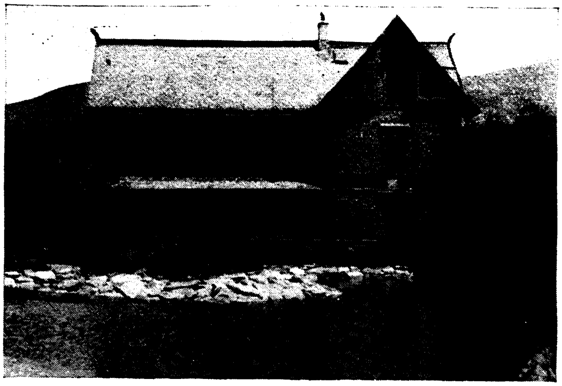
The great interest of Swedish naturalists in biological stations is well attested by the three laboratories which now exist in that country. Two of them have been established only comparatively recently, but the third, the marine station on the Kattegat at Kristineberg, is one of the oldest stations in Europe, as it was founded in 1877, and it has become widely known through the large amount of important work that has been carried on here by various Swedish investigators. The main building was erected rather recently, having been begun in the fall of 1903. It is two stories high. The first floor is occupied by a large public aquarium, three laboratory rooms, and a conservation room; the second has a stock room, four work rooms, and the library. The station possesses a fair sized collecting boat, the Sven Lovén.

In 1903 a station was established at Vassijaure, under the direction of the Royal Academy of Science of Stockholm. It is situated in Lapland, in northernmost Sweden, well within the arctic circle, and is near the northern limit of trees. The laboratory is near lake Vassijaure and is also only about 21 kilometers from the very large lake Torneträsk. The station possesses little in the way of apparatus except meteorological instruments. The building serves as laboratory and dwelling place for investigators. It was established for general scientific work but it is frequented most by biologists.

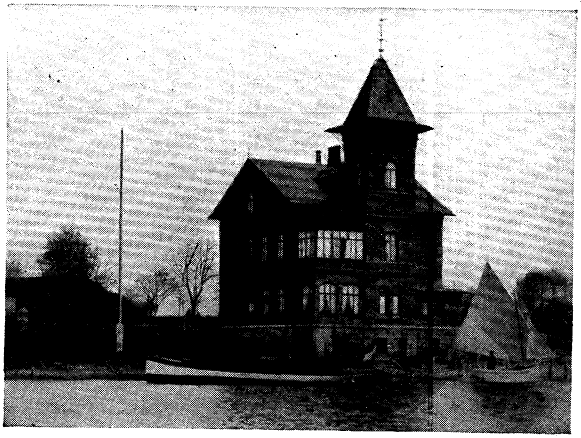
A second fresh-water station has just been built on some lakes in southern Sweden. Six tables are available for investigators. It is the aim of this laboratory to give special attention to the biology of fishes.

Denmark.

The modest laboratory of the Danish fresh-water station consists of the deck house of the ship used for the Ingolf Expedition. It was brought to Furesee in 1898 and converted into the present laboratory. The station is equipped with a good motor boat, plankton nets, and various other kinds of collecting apparatus. It is most favorably situated, being located in a district where several lakes which possess very different physical and biological characters, may be easily reached from the laboratory. As a result of the investigations of Dr. Wesenberg-Lund, director of the station, the knowledge of the biology of these lakes has grown from almost nothing at the time the laboratory was established until they now may be classed among the most thoroughly studied lakes in the world. Two very important volumes relating to the work of the laboratory have been published as well as many shorter articles. In 1906 the station was annexed to the University of Copenhagen.



BERGEN.



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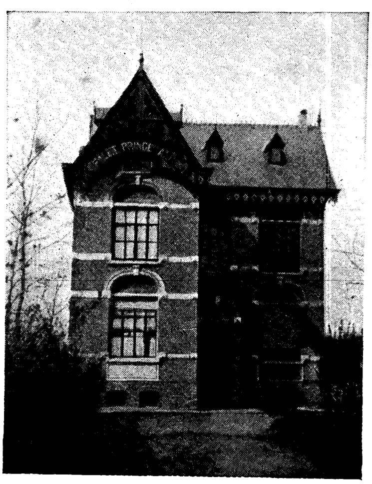


BELGIAN STATION AT OVERMEIRE.

JUDAY:—

EUROPEAN BIOLOGICAL STATIONS

COCKAYNE, BOSTON

Holland.

In 1890 a zoological station was founded at Helder, in the province of North Holland, through the influence and support of the Zoological Society of Holland. It has been maintained regularly by this Society, but at present the government pays an annual rental for one floor which is used as the laboratory for the Hollandish biologists engaged in the International North sea investigations. The building is three stories high, the first and second floors being occupied by laboratories, a museum, and a library, and the third serving as a residence for the director, Dr. Redeke.

The chief aim of the station is to furnish accommodations for research work to the members of the Zoological Society. There are tables also for half a dozen students or young investigators, but such individuals must either first become members of the society or must be vouched for by a member. The laboratory is located on one of the mouths of the Zuyder Zee so that it has the advantage of both the North sea and the Zuyder Zee for collecting purposes. Helder itself is a very interesting city. It is the chief naval station of Holland and is also noted for its huge and extensive dykes.

Belgium.

The Station Biologique d'Overmeire is an annex of the Natural History Museum of Belgium. It is located on the lake of Overmeire not far from Brussels. The laboratory was opened in April, 1907, and it occupies a large residence on the shore of the lake which is known as Chalet Prince Albert. There are five rooms, three of which are used as laboratories, one for the small but well selected and growing library, and one for a museum containing a collection of local fauna. The basement is fitted up with aquaria and a dark room for photographic work. For such a young station it is very well equipped with collecting and laboratory apparatus.

The lake on which the station is located, lies in a low, flat, level country, and it is in fact an old abandoned bed of the Scheldt river. It has an area of 85 hectares and a maximum depth of 5 meters. The fauna and flora are rich and varied and insure an abundance of material for the investigations which have been undertaken.

Germany.

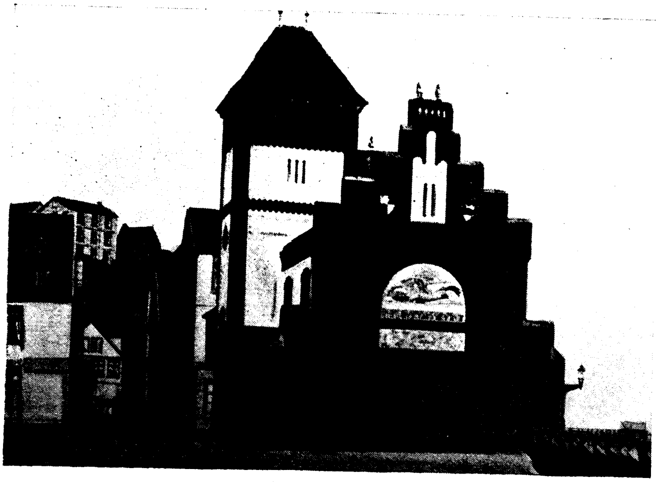
The German government established a biological station on Helgoland soon after this island was acquired from Great Britian in 1890. The island is situated about 50 kilometers out from the mainland, directly off the mouths of the Elbe and Weser rivers. Thus very diverse and interesting biological conditions are found between the island and the mouths of these rivers. Tidal currents are very strong around the island also and much interesting pelagic material is brought to this region by them. Much good shore collecting is found along some portions of the island, too.

The station buildings at present consist of a large and substantial brick structure erected in 1904, and four dwelling houses which have been converted into laboratories. The ground floor of the brick building is occupied by a large public aquarium and above this are some laboratory rooms. The dwelling houses will soon be replaced by a large, modern station building, as a sum of money has recently been appropriated for this purpose by the German government. The library contains an unusually good collection of literature on both marine and fresh-water biology.

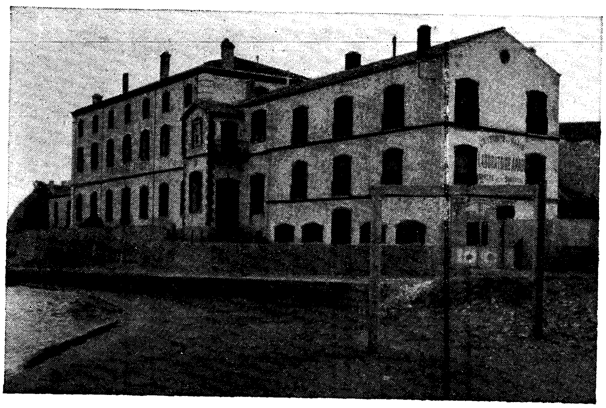
The local museum which is a dependency of the station, contains an excellent collection of birds which have all been captured on the island, as well as a good collection of local fishes and invertebrates.

The station is taking a very prominent part in the North sea investigations, Dr. F. Heincke, its director, and Dr. Ehrenbaum having charge of some of the most important fields of this work.

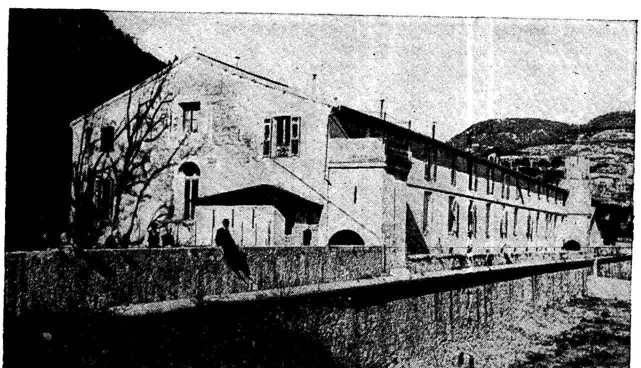
While there is no regular biological station at Kiel, the University, which is located directly on the shore of the Baltic, and the laboratory of the investigators taking part in the international studies on the North Sea may be regarded as marine stations. At the university one finds Dr. Hansen, the father of mod-



HELGOLAND.



BANYULS-SUR-MER.



RUSSIAN STATION AT VILLEFRANCHE-SUR-MER.

JUDAY:—

EUROPEAN BIOLOGICAL STATIONS

COCKAYNE, BOSTON

ern marine planktology, still actively engaged in such work in spite of his advanced age, and Dr. Brandt who has made many valuable contributions to our knowledge of marine biology.

The laboratory of the staff engaged in the International Investigations is situated in a residential portion of Kiel, some distance from the university. Dr. O. Krümmel is director of the laboratory and two other members of its staff are the well known planktologists, Dr. Apstein and Dr. Lohmann.

The German government built a special ship, the Poseidon, for the North sea investigations. It is ewll adapted and splendidly equipped for this work. Most of the material which is obtained during the regular cruises of the Poseidon, is brought to the Kiel laboratory for the subsequent chemical and biological studies that are made thereon.

One of the most widely known fresh-water biological stations in Europe is the one located on the shore of Grossen Plöner See, in the quiet, picturesque town of Plön in Holstein. This station was founded in 1892 chiefly through the efforts of Dr. O. Zacharias, its present director. The brick building is two stories high, the second floor serving as a residence for the director. On the first floor, there is a large, well lighted general laboratory on one side of the central hall which affords accommodations for a number of students and investigators, and on the other side there is a small room for research work and a library. One room in the basement is supplied with aquaria and another is used for storing apparatus.

The station is equipped with boats and an abundance of collecting apparatus, such as dredges and various types of plankton nets. The work is carried on during the entire year, the chief part being done, of course, in the summer. Courses are offered during the summer and these attract many students and investigators. Every student of limnobiology is familiar with the journal coming from this station, a volume of which has appeared each year since 1893.

A biological and fish-culture station is located on Müggelsee at Friederikshagen near Berlin. A large, new three-story building was completed and occupied early in 1908, so that the laboratory now possesses much greater facilities for both biological and fish-culture work. The station is conducted under the auspices of the German Fishery Association.

Important plankton investigations have also been made on the Elbe river in the vicinity of Hamburg. This work has been carried on by Dr. Richard Volk under the auspices of the Hamburg Natural History Museum. The plankton has been studied both qualitatively and quantitatively and chemical analyses of some of the crustacea have been made to determine their value as fish food.

Switzerland.

Strictly speaking there is no regular biological station on any of the Swiss lakes, yet the biologists of this country have been among the leaders in limnological work for many years. The classic work of Forel on lake Geneva has served as a model for very much of the work that has been done since its appearance. In 1887 a Limnological Commission was organized as a department of the Swiss Natural History Society and this commission drew up a comprehensive program for physical, chemical, meteorological, and biological studies on the lakes. As a result the various lines of work have been well co-ordinated and unified. Thorough and systematic studies have been made on four lakes for a number of years and some of the results have been published from time to time. Also Professor Zschokke of the University of Basel has devoted a number of years to a thorough and comprehensive study of the fauna of the typical Alpine lakes.

France.

The extended coast line of France offers some splendid opportunities for marine stations and the biologists of that country have availed themselves of some of these advantages by establishing a number of laboratories. Most of the stations are affiliated with universities and receive government aid but some have been founded by local scientific societies. Two are specially concerned with practical problems relating to the fisheries.

The largest and most important French station is the one that was founded by de Lacaze-Duthiers at Roscoff in 1872. Since the death of its founder it has been named the "Lacaze-Duthiers

Laboratory." It is situated on the English Channel and collecting opportunities are most excellent here for there is a maximum difference of twelve meters between tide levels. The station is an annex of the Sorbonne. The buildings are located on a large plat of ground containing some 6,000 square meters and partially enclosed by a large, beautiful garden which contains many exotic plants, some of which are sub-tropical, this being made possible by the very mild climate.

The aquarium extends parallel with the shore line and is thirty meters long by ten wide. In the middle there are two large granite basins and along the walls of the two sides there are forty aquarium tanks. Between the aquarium and the sea, there is a large *vivier,* a basin which is used both for experimental work and to retain a supply of water for the laboratory.

A large addition to the laboratory was built in 1907 and 1908 which increased the work places to more than three times the original number. Formerly there were only twelve rooms for investigators but this number was increased to thirty-seven. Besides these, there is a general laboratory containing twelve work places and this number can be increased to eighteen if necessary. One room is reserved for the study of animal psychology, another for library, two for dark rooms, and one for physical and chemical investigations. There are also sixteen living rooms which are at the disposal of students and investigators for a very nominal rental.

The twenty-five investigators' rooms that have recently been added are available for both foreign and French states, universities, and biological societies for an annual rental of 1,500 francs. It is the purpose of the present director, Dr. Y. Delage, to make the station international in character. Accordingly the stranger is given every privilege accorded the French biologist, that is, a table, reagents, microscope and other apparatus, as well as material, all gratis. It is open to investigators from April 1 to September 30. There are two summer sessions during which students are admitted. The first extends from July 15 to August 15 and the second from August 15 to September 15. The station possesses a collecting sloop twenty meters long which is equipped with plankton and dredging apparatus.

The Sorbonne is unusually fortunate in having a second annex, the Arago Laboratory, which is situated on the side of a small bay at Banyuls-sur-mer, a small town on the Mediterranean coast only a short distance from the Spanish border. The three-story building contains a large public aquarium, a machine shop fully equipped for making the various kinds of apparatus needed, and a museum on the first floor. The second floor is devoted to laboratory rooms and a well equipped library, and the third chiefly to living rooms. A small building especially for photographic work has been erected recently. Beneath this building there is an underground chamber for experimental work in total darkness. It is so arranged that the animal or animals experimented on can be removed from this chamber and quickly photographed.

The station at Cette, founded by the late Professor Sabatier in 1879, is an annex of the University of Montpelier. The central portion of the large stone building is two stories high, with the aquarium and the museum on the first floor and large, well lighted laboratories on the second. The three-story end portions have not been entirely completed as yet.

One of the most productive stations is that which was founded by the late Professor Giard at Wimereux on the Straits of Dover in 1874. In 1867 a laboratory was built at Arcachon by a local scientific society but this station has since become affiliated with the University of Bordeaux. The marine station at Concarneau is devoted largely to practical fish culture but one floor of the building is reserved for scientific researches. The station at Marseilles is concerned primarily with fish culture, also. There is also a small station at Villefranche-sur-mer under the direction of Dr. Barrois.

The Russian station at Villefranche-sur-mer was established more than twenty years ago. The small, rather shallow bay on which it is located possesses a rich pelagic as well as a rich shore fauna. Very deep water is found a short distance off the mouth of the bay, so that a good variety of collecting territory is within easy reach. These advantages together with the mild climate of the French Riviera make this an admirable place for a biological laboratory.

The building was formerly a Sardinian prison and through the efforts of Dr. Korotneff, the present director, it was acquired by the Russian government and transformed into a biological station. On the ground floor there are two general laboratories, the aquarium, the library, the museum, and a room for assorting, and preserving the material that is collected. Above the laboratories there are some living rooms, and a small research room. The station possesses a naphtha motor boat twelve meters long which is equipped with apparatus for dredging and plankton collecting. The laboratories are supplied with gas and both fresh and salt water. The station is open throughout the year. In March and April each year a practical course in zoology is given for the benefit of students and younger investigators. The station is international in character, being visited by Russian, German, Swiss, French, and Italian biologists.

Through the munificence of the Prince of Monaco, a very beautiful Oceanographic Museum has been erected in the city of Monaco. The corner stone of the building was laid on April 25, 1899, but it has required ten years to complete the structure. It is an imposing stone building, situated at the edge of the beautiful garden of St. Martin where the rock rises almost perpendicularly out of the sea. It is 100 meters long, the central part 20 meters and the two wings 15 meters wide. The structure is four stories high, two being below the level of the main entrance.

The preparation and mounting rooms, and the large aquarium are located on the first floor. The second floor has more preparation rooms, some store rooms, the library, zoological laboratories, two large chemical laboratories, and small rooms for the accommodation of about a dozen investigators. The two upper floors are devoted to the museum and a large assembly hall which will accommodate about 500 persons.

Many years ago the Prince conceived the idea of founding a museum and he began making collections for it as early as 1885. As a consequence nearly all of the museum material has been collected by the Prince himself on his numerous scientific cruises. While the institution is nominally a museum, nevertheless researches are being carried on by a staff of investigators and the well equipped Eider makes trips regularly once or twice a week for the purpose of collecting material and making observations. The museum has recently become affiliated with the Sorbonne. Dr. Jules Richard is its present director. It was formally opened on March 29, 1910.

Austria-Hungary.

The Zoological Station at Trieste is pleasantly situated near the far end of the harbor, in a quiet residential portion of the city, and overlooks the Gulf of Trieste with its varicolored and very transparent water. The building was once a residence and belonged to the king of Spain. It has been converted, however, into a conveniently arranged and well equipped station. There are two rather large general laboratories, some smaller rooms for research work, a library, and a museum. The aquarium is rather small and is located in the basement, being somewhat dark.

The station now possesses a fair sized motor boat, especially built and well equipped for work in any part of the Adriatic. Previous to 1908, that is before the new boat was built, investigations were confined chiefly to the Gulf of Trieste and some of the shallower adjacent water. But with the present equipment, attention can now be directed to a much larger field of operations. Dr. C. I. Cori is the director of the station. It is open to research students during the entire year but naturally it is visited by the largest number of biologists during the summer.

The Zoological Station at Rovigno is located in the midst of a good collecting region on the Adriatic. The building was enlarged in 1902. It is pleasantly situated on a small, quiet bay. The first floor is occupied by an aquarium, a dining room, and a kitchen. The second floor is occupied by the laboratories and the library, while on the third floor, there are several well-furnished living rooms. During the regular summer season, board and room may be obtained at the station for about a dollar a day. There are laboratory and living accommodations for ten persons.

Formerly the station served as a supply depot for the Berlin Aquarium but recently this Aquarium was abandoned. Its chief source of income at present is a subsidy from the Prussian government. Dr. Hermes is its director. Rovigno itself is an old city of about 10,000 inhabitants, chiefly Italian speaking. The large number of narrow, crooked streets and quaint buildings make the city an interesting place to visit.

In 1905 through the munificence of Dr. C. Kupelwieser of Vienna, a Biological Station was established on some lakes near Lunz, Lower Austria, by Dr. R. Woltereck of the University of Leipzig. Dr. Kupelwieser owns a large game preserve here, in fact practically an entire mountain valley in which there are three lakes. His large summer residence, the Seehof, stands near one of the lakes, and one wing of this castle has been converted into a pleasant, and well appointed laboratory. Two basement rooms contain aquaria which are supplied with an abundance of running water. One contains large cement aquaria for fish-breeding experiments, and the other has glass aquaria of various sizes.

On the ground floor are located the library room with a well selected and rapidly growing library, a general laboratory, two rooms with tables for research work, the director's room, a store room for apparatus and supplies, and a dark room fitted up for photographic and physiological work. Above the laboratory, there are several living rooms for the accommodation of students and investigators.

Not far from the Seehof is the "Dependance" of the station which contains living rooms for the assistants, a heating plant, and two glass culture houses. These glass houses contain cement and glass aquaria of various sizes. One, the Warmhaus, is fitted with steam heating apparatus for experimental work at high temperatures, the cement aquaria themselves being supplied with steam pipes. The other, the Kalthaus, is supplied with running water from a cold spring so that experimental work may be carried on at tolerably low temperatures. By means of these two houses, experiments may be carried on at temperatures varying from about 10° to 30° or even higher, so that the range of temperature is practically from alpine to tropical.

Between the Seehof and Lunzersee, along the stream which flows down from the lakes above, there are a few large ponds and some cement pools in which fish-breeding experiments are carried on.

The three lakes which lie within the station's domain represent very different physical and biological conditions. The Untersee or Lunzersee on which the laboratory is located, is the largest. It is about 1,600 m. long, from 200 to 600 m. broad, and has a maximum depth of 34 m. Its altitude is 617 m. Further up the valley is the Mittersee, less than a quarter as large as the Untersee and having a maximum depth of only 4 m. It is fed largely by springs. Still further up the valley, at an altitude of 1,177 m., lies the Obersee. It is about 700 m. long, 300 m. broad, and has a maximum depth of 15 m. There is an abundant snowfall at this altitude in winter and the lake is covered with ice for several months each year, so that rather severe alpine conditions are found here. Also many small ponds and pools are found in this mountain valley and the surrounding country.

The beautiful and interesting mountain scenery and the well equipped laboratories make this an unusually good and attractive place for summer biological work. Tables in the laboratory as well as living rooms in the Seehof are gratis. Dr. H. Kupelwieser is the present director of the station.

The Bohemian Portable Laboratory was founded by Dr. Fritsch, its present director, in 1888. For some time after its establishment, this station was used for conducting investigations on some Bohemian lakes and lakelets. Then it was transferred to the Elbe river and has since been used as a base for making physical, chemical, and biological investigations on the Bohemian portion of this stream and its backwaters. The work is still being carried on at all seasons of the year, but chiefly, of course, in the summer. Several publications resulting from investigations pursued at this laboratory constitute most valuable contributions to the aquatic biology of Bohemia.

There is no permanent biological station on lake Balaton, but the very important limnological work that has been in progress for some years and is still being carried on here, must be mentioned in this connection. Several valuable papers dealing with the physical, chemical, and biological phases of these investigations have already been published. Much of the work has been done under the direction of Dr. von Loczy, who is president of the commission.

Although the laboratory in the "Vivarium" which is located in the Prater at Vienna is purely for experimental researches and not for limnological work, it is well worth mentioning here. The one story building stands in a large court near the center of the park. It is a large structure and has a number of rooms, some of which are designed for special investigations and others for laboratories. Among the former may be mentioned two glass houses, a room fitted with special heating apparatus for experimental work on tropical animals, some rooms with large cement aquaria for work on fishes, and an underground dark room for cave experiments. Then there are chemical, physiological, botanical, and zoological laboratories. Dr. L. von Portheim, director of the Laboratory, has charge of the botanical researches and Dr. Przibram has charge of the zoological work.

Italy.

The reputation of the Stazione Zoologica at Naples as the foremost marine station in the world is well deserved because of the conveniences, equipment, and material that are here accessible to every investigator. Even a brief visit suffices to explain why this station has become the mecca of biologists in every quarter of the globe. The three attractive stone buildings are situated in one of the city parks, the Villa Nazionale, and are surrounded by a wealth of semi-tropical vegetation. They are separated from the blue water of the Gulf of Naples only by a fashionable driveway and the balconies of the buildings command a splendid view of Vesuvius, the island of Capri, and other points of interest around the gulf.

The station was founded in 1874 by the late Dr. Anton Dohrn whose son is now its director. As a result of the founder's efforts and careful management, it has enjoyed a phenomenal growth. It has been necessary to make two substantial additions to the original building, making three buildings in all at present. The first addition was the physiological laboratory which was erected some years ago, but the second addition has been completed just recently. The first two buildings had table accommodations for fifty biologists but the third itself will accommodate fifty, thus providing for a hundred in all. A subsidiary station has also recently been erected on the island of Ischia for the purpose of studying the fauna and flora of that district.

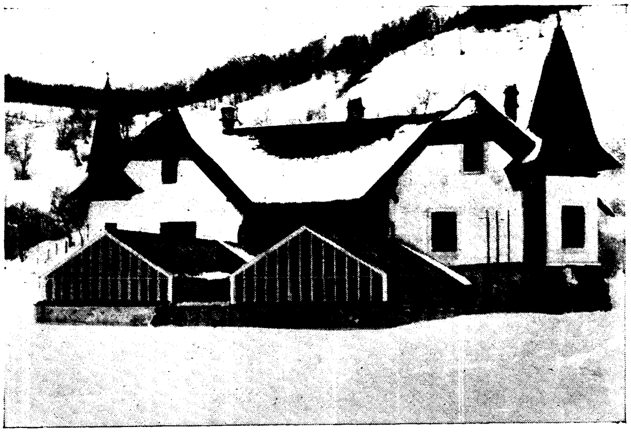
The station is gradually becoming self-supporting but it still receives subsidies from many of the European governments. Tables are rented for $500 each per year and many of them are subscribed for by governments, universities, and scientific institutions and societies.

A large public aquarium is located in the basement of the main or original building. The large display tanks are especially well lighted from above, so that the material that is on exhibition is seen most advantageously. The wealth and great variety of animals exhibited in the various tanks make the aquarium one of the chief attractions of Naples and it is regularly sought by large numbers of visitors.

The library has grown rapidly also and recently it became necessary to assign more room to it. It has long been regarded as one of the very best working libraries in marine zoology.

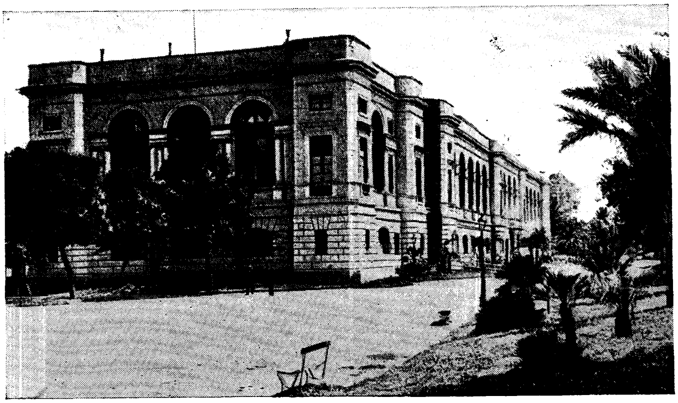
Another interesting feature of the station is the supply department. Much material is constantly being brought in and that which is not needed for immediate use in the laboratories, is killed and prepared for sale to universities, museums, or individual investigators. The methods used for preparing this material yield excellent results so that there is a good demand for these preparations. In addition to smaller boats, the station possesses two steamers which are equipped for deep-sea dredging.

A building has just recently been completed for a new biological station near Cagliari on the island of Sardinia. The work places and living rooms are at the disposal of investigators of all nations. The Sardinian coast possesses a rich and varied



ANNEX OF STATION AT LUNZ, AUSTRIA

ROVIGNO



NAPLES

JUDAY:—

EUROPEAN BIOLOGICAL STATIONS

COCKAYNE, BOSTON

marine fauna which insures an abundance of material for the laboratories. Dr. Ermanno Giglio-Tos of the University of Cagliari is the director of the station.

Bulgaria.

The new kingdom of Bulgaria has already established a biological station at Varna, on the Black Sea, with Dr. T. Mornow as director.

Russia.

Russian biologists have long taken great interest in such laboratories and they were among the first to establish a station. One was founded at Sebastopol on the Black Sea in 1871, by the Royal Academy of Science of Sebastopol. A new building was erected in 1897 which contains laboratories that will accommodate seventeen investigators, a public aquarium, a museum room for local fauna, and a library. The station possesses a fair sized motor boat which is equipped with collecting apparatus. The laboratories are open to foreign as well as Russian biologists.

In 1899 a station was opened near Alexandrowsk on the Murman coast of Russia. It is situated on Catherine Harbor which lies well within the Arctic Circle.

Some years ago a biological station was established at Saratow by a local natural history society for the purpose of studying the fauna and flora of the Volga River in that vicinity.

Just recently a laboratory was founded at Astrachan for the purpose of making a special study of the fauna found in the delta of the Volga River and in the neighboring parts of the Caspian Sea. Dr. S. A. Mitropolsky is director of this station.

THE GRAVIMETRIC DETERMINATION OF TELLURIUM.

VICTOR LENHER AND A. W. HOMBERGER.

Of all the methods proposed for the precipitation of tellurium perhaps the one which is most used is a modification of the original method of Berzelius. He used sulphurous acid as a precipitating agent.

The method of procedure as commonly carried out consists in adding to the hydrochloric acid solution of tellurium a strong aqueous solution of sulphur dioxide and allowing this mixture to remain in a warm place for a few days in order to effect complete precipitation. It has been shown by Schroetter,[1] Brawner,[2] Norris and Fay,[3] Crane,[4] Frerichs,[5] and others that the precipitation by means of sulphur dioxide is far from satisfactory. Brawner has pointed out that part of the precipitated tellurium undergoes oxidation in the liquid becoming converted into the tetrachloride in which form it remains in solution. Crane has suggested that the main cause of the incomplete precipitation by means of sulphur dioxide is the very rapid increase in the ratio of the acids to the unprecipitated tellurium in solution, two-thirds of this being due to the hydrochloric acid set free, and one-third to the sulphuric acid formed. He thought if these could be removed the reduction would be complete. The hydrochloric acid could be eliminated by evaporation, but the continuous increase in sulphuric acid would soon interrupt the reaction. This might, however, be kept under control by the addition of sodium or potassium hydroxide.

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1 Chem. News 87, 17.
2 Jour. Chem. Soc. 55, 392.
3 Amer. Chem. Jr. 20, 278.
4 Amer. Chem. Jr. 23, 408.
5 Jr. für pr. Chem. 66, 261.

Whitehead has suggested a remedy in the use of sodium acid sulphite. He advises a moderately concentrated solution of the sulphite and that the quantity added to the tellurium solution be sufficient only to just neutralize the acids present and that formed during the reaction. When the solution is thoroughly agitated and then allowed to stand in a warm place, the precipitate will form and settle evenly. He states that "while sodium acid sulphite does not completely remove all of the tellurium from the solution in the cold, that if not used in great excess and the mixed solutions be raised to the boiling point, toward the end of the action the precipitation will be perfect, and the tellurium will be obtained in a state of aggregation favorable to easy filtration."

Frerichs has worked on the basis that hydriodic acid and sulphur dioxide cause immediate and complete separation of tellurium from a tellurous solution even in the cold, and McIvor[1] has confirmed this method.

Norris and Fay[2] have demonstrated that under ordinary working conditions precipitated tellurium increases in weight about 0.5 per cent, owing to oxidation and that this increase is balanced by the quantity of the elements left behind as tellurium tetrachloride in the strongly acid solution in which the precipitate was formed by sulphur dioxide. They believe that it is more accurate to weigh tellurium dioxide than to weigh tellurium in the elementary state.

McIvor[1] and Donath[2] have studied the precipitation of tellurium by hyposulphurous acid. This method possesses the disadvantage of a precipitate of tellurium contaminated by more or less sulphur. The method hardly possesses any advantages over the sulphurous acid percipitation.

Stolba[1] in 1873 and later Kastner[2] have proposed the precipitation of tellurium from an alkaline solution by means of grape sugar.

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1 Chem. News 87, 163.
2 Amer. Chem. Jr. 20, 278.
1 Chem. News 87, 163.
2 Zeit. für Angew. Chem., 1890, 214.
1 Zeit. für Anal. Chem. 11, 437.
2 Zeit für Anal. Chem. 13, 142.

Later, Gutbier[3] described the precipitation of tellurium by means of hydrazine as a method for its determination. His mode of procedure is to dissolve telluric acid in warm water in a porcelain dish covered with a glass cover and add by means of a pipette a 10 to 20 per cent solution of hydrazine hydrate. A dark blue almost black color is noted and after heating a short time, elementary tellurium is precipitated in a flocculent condition, the liquid becoming colorless. He continues the addition of hydrazine hydrate until the fluid is no longer colored by further addition of the reagent.

Experimental.

Precipitation by hydrazine.—In our hands the method of Gutbier gave fairly good results. The facts were noted, however, that the addition of an excess of the hydrazine does not at once precipitate all of the tellurium. It is preferable to add a small amount of the precipitating agent from time to time. This necessitates several hours for complete precipitation. The following results were obtained by Gutbier's method in hydrochloric acid solution:

TeO_2	Te required	Te obtained
.2247 gm.	.1795 gm.	.1790 gm.
.1988	.1588	.1577
.2006	.1603	.1596
.2056	.1643	.1637

Precipitation by sodium acid sulphite.—In order to completely precipitate the tellurium by this reagent from a hydrochloric acid solution of a tellurous compound, the solution must contain excess of the reagent and must be allowed to stand in a warm place for twenty-four hours. In the following experiments the sodium acid sulphite was prepared freshly for this purpose by passing sulphur dioxide into a solution of sodium carbonate. It has been our experience that when sodium acid sulphite which has not been freshly prepared is used for the precipitation of tellurium, that the precipitated element frequently contains sulphur.

[3] Ber. 34, 2724.

That it is necessary for the solution to stand a considerable length of time is apparent from the following experiments, all of which experiments were made under exactly the same conditions. The solution of the dioxide in hydrochloric acid was brought to boiling, a saturated solution of sodium acid sulphite was added, the solution allowed to stand the requisite length of time, then brought on a Gooch platinum filter, washed with water until the filtrate no longer showed chlorides, after which it was washed with 15 cc. of alcohol and dried at 105°.

Solution allowed to stand two hours.

Te required	Te obtained	error
.1609 gm.	.1586 gm.	—.0023 gm.
.1609	.1590	—.0019
.1767	.1744	—.0023

Allowed to stand six hours.

Te required	Te obtained	error
.1609 gm.	.1600 gm.	—.0009 gm.
.1609	.1603	—.0006
.1374	.1366	—.0008
.1527	.1517	—.0010

Allowed to stand twenty-four hours.

Te required	Te obtained	error
.1609 gm.	.1615 gm.	+.0006 gm.
.1609	.1618	+.0009
.1726	.1730	+.0004
.1286	.1289	+.0003

After tellurium, which has been precipitated by means of sodium sulphite and hydrochloric acid, has been washed thoroughly with water and alcohol, it oxidizes very slowly even when heated as high as 200°, as evidenced by the following data:

Length of time of heating	Temperature	Te (1)	Te (2)
15 minutes	105°	.1619 gm.	.1620 gm.
15 "	105°	.1619	.1620
1 hour	120°–130°	.1620	.1622
1 "	200°	.1620	.1623

PRECIPITATION BY MEANS OF SULPHUR DIOXIDE.

By the treatment of tellurium dioxide dissolved in hydrochloric acid with a freshly saturated solution of sulphur dioxide and allowing to stand for 24 hours, the following results were obtained:

Te required	Te obtained
.1607 gm.	.1617 gm.
.1609	.1613
.1609	.1615
.1609	.1613

Unless the acidity in this precipitation is ten per cent, the tellurium is not likely to be completely precipitated or it will be precipitated in a very fine state of division. The solution should also be hot in order to secure satisfactory precipitation.

SIMULTANEOUS PRECIPITATION BY MEANS OF SULPHUR DIOXIDE AND HYDRAZINE.

By bringing both sulphur dioxide and hydrazine into a tellurium solution the whole of the element is thrown out of the solution almost instantaneously.

The solution should have an acidity of 5 to 10 per cent and it is desirable to have the solution in a high degree of concentration. The solution is brought to boiling and 15 cc. of a saturated solution of sulphur dioxide is added, then 10 cc. of a 15 per cent solution of hydrazine hydrochloride and again 25 cc. of the sulphur dioxide solution. The solution is boiled for a few minutes when the elementary tellurium will settle in such a way that it can be rapidly washed. The liquor is then brought on a platinum Gooch filter and washed with hot water until all of the chlorine is removed. The precipitate is then washed with 15 cc. of alcohol and the crucible and contents dried at 100–105 degrees.

The following results were obtained by the process as outlined above, using a 20 per cent solution of hydrazine hydrochloride with sulphur dioxide. Tellurium dioxide was used for the analysis:

Te required	Te obtained	Error
.1731 gm.	.1735 gm.	+.0004
.2065	.2068	+.0003
.1638	.1641	+.0003
.1608	.1608	——

A 15 per cent solution of hydrazine hydrochloride along with sulphur dioxide gave

Te required	Te obtained	Error
.2212 gm.	.2210 gm.	—.0002
.1435	.1434	—.0001
.1605	.1607	+.0002
.1072	.1070	—.0002

A ten per cent solution of the hydrazine hydrochloride with sulphur dioxide yielded.

Te required	Te obtained	Error
.1658 gm.	.1656 gm.	—.0002
.1642	.1637	—.0005
.1268	.1264	—.0004
.1422	.1420	—.0002

That hydrazine must be present in sufficient quantity is evidenced by the following series of tests in which a 6 per cent was used along with sulphur dioxide and the solution boiled for a few minutes other conditions being exactly the same as in the preceding series of experiments.

Te required	Te obtained	Error
.1508 gm.	.1374 gm.	—.0134
.1701	.1443	—.0258
.1608	.1535	—.0073
.1521	.1140	—.0381
.1903	.1781	—.0122

The following two experiments were made with a large excess of sulphur dioxide water along with a 6 per cent solution of hydrazine and the solution heated six hours:

Te required	Te obtained	Error
.1680 gm.	.1545 gm.	—.0135
.1516	.1416	—.0100

The method which has been used in this laboratory for a number of years and which has proven the most satisfactory for the gravimetric determination of tellurium is as follows: The tellurium either as derivative of the dioxide or as a tellurate, should be present in a solution which has an acidity of approximately ten per cent of hydrochloric acid, and it is preferable to have the solution sufficiently concentrated, otherwise the fine state of division of the precipitate will render it unsatisfactory for washing. The solution is heated to boiling and 15 cc. of a saturated solution of sulphur dioxide added, then 10 cc.

of a 15 per cent solution of hydrazine hydrochloride, and again 25 cc. of a saturated solution of sulphur dioxide. The boiling is continued until the precipitate settles in such a way that it can be easily washed. This boiling should not take more than five minutes. The precipitated tellurium after being allowed to settle is washed with hot water on a Gooch filter until all of the chlorine is removed after which the water is displaced by alcohol and the crucible and contents dried at 105°.

AN OPERCULATED GASTROPOD FROM THE NIAGARA FORMATION OF WISCONSIN.

EDGAR E. TELLER.

As many of the gastropods of the Hamilton and the more recent formations are known to have been operculated, it would not be unreasonable to suppose that some of the earlier forms will be found to possess that character. The material of which they were composed and the delicacy of the structure of many of them was such, however, that it is not likely that in the older formations many of them will have left their fossil forms, still close investigation should show a few of them.

Fossil literature of the earlier formations contains hardly a single reference to such forms although many specimens should be found in the collections of close investigators of such objects.

The limestones of the Niagara formation at Racine, Wisconson, have furnished a few specimens of a fossil that has been of doubtful identity, they have always been found in the form of a flat impression of what might be supposed to have been that of a small and very much crushed and flattened gastropod.

No gastropod of a size that would make such an impression is known at the locality, and there are none of the other fossils found in the same layers that show any evidence of compression, neither has it ever been found in any layer except those that contain gastropods, these peculiar forms are not numerous, neither by the ordinary collector have they been considered worth the collecting on account of their evident poor state of preservation, but one side of the fossil is known, the other not having been as yet recognized.

Some years since it was suggested to other collectors that they were probably that of the operculum of a gastropod but just what one unknown, as operculated shells in the formation were evidently unknown, and there were several varieties associated in the layers where found but little consideration was given to the suggestion until at last the finding of a specimen of a gastropod with the operculum in its natural position confirmed the supposition, other forms of operculum from other localities in the Niagara of Wisconsin are now known but the species to which they belong have yet to be identified.

In the years 1860–61 the late Prof. James Hall, then the geologist of the state of Wisconsin, made large collections of fossils from the formations of the south-eastern portion of the state, many of the specimens were described in his report of the Geology of Wisconsin in 1861, and in the first volume of the Geology of Wisconsin in 1862 all without figures. In the twentieth annual report of the state cabinet of natural history of the state of New York 1867, and in the revised edition of the same report 1868, he gives a redescription of these species with figures adding several new species not previously described, among them several gastropods, to one of them on plate 15, figure 19 he has given the name Murchisonia conradi.

Genus MURCHISONIA, Phillips. *Murchisonia conradi,* N. S.

Shell turreted, somewhat rapidly ascending, consisting of about seven volutions which are distinctly carinated on the middle or scarcely above the middle. Above the carina the surface is slightly concave, and below the carina very slightly rounded; while the lower side of the last volution is regularly rounded and somewhat ventricose.

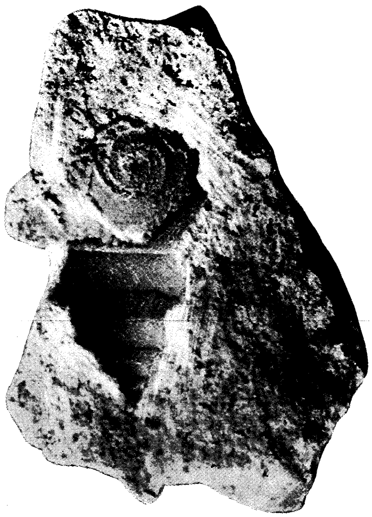
The surface has been finely striated with irregular undulations corresponding with the lines of growth where the striae have become crowded. The entire length of the shell to the base of the last volution is one and nine-tenths inches and the diameter near the base nine-tenths of an inch.

Formation and Locality.—In the limestone of the age of the Niagara group at Racine, Wisconsin.

Type.—In the American Museum of Natural History, New York City.

The figure shown on plate CI, fig. 1 is that of an external cast of the species described, showing seven volutions of the shell and which agrees in every respect with the description of the type form, a little within what was the orifice or opening of the shell is found the impression of the operculum which had closed the opening and prevented the shell from becoming filled with sediment; the impression of the operculum is circular or slightly sub-ovate and is that of the outer surface which is apparently coiled upon its own axis and has about four volutions. Fig. 2, is that of the operculum in the form of which it is usually found, this also shows the outer surface on which the volutions are plainly shown and is the best preserved of the specimens collected. Figure 3, is of a similar specimen on one side of which is shown a raised edge by which we can judge the operculum to have been about one-sixteenth of an inch in thickness. No specimens showing a satisfactory inner surface have been found, this surface, however, was probably smooth.

Feb. 10, 1908.



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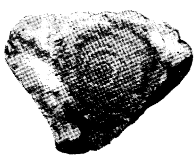

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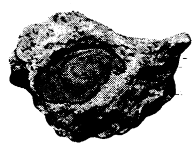

3

Teller. An Operculated Gastropod