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MARINE BIOLOGY LABORATORIES, HISTORY OF

In the late nineteenth century, marine biology laboratories played an important role in helping to establish biology as a professional area of study. Working at the seashore allowed researchers to study a wide diversity of types of organisms initially without having to invest in expensive storage or collection facilities. Marine research in particular allowed the study of invertebrates as well as vertebrates for addressing questions about evolution and development, in addition to traditional questions about structure and function. At first the work took place at informal gathering spots, but the end of the nineteenth century brought a more formal establishment of buildings to house the research.

Earlier studies of marine life had looked to the deep seas, as with the dredging expeditions by the British naturalist Edward Forbes (1815–1854) prior to the laying of transatlantic telegraph cable, which was informed by Forbes's work. These efforts pulled up rich collections of widely diverse types of organisms and attracted public interest. In addition, one or another small group visited the shore to observe and collect specimens, often preserving them and taking them to the laboratories back home (Maienschein 1988).

One important seaside lineage began with visits by the German physiologist Johannes Müller (1801–1858) to Heligoland, an island in the North Sea off the coast of Germany. Müller took along students, including Ernst Haeckel (1834–1919), who saw amazing beauty in the colorful and varied sea life. Haeckel also began to see similarities among organisms and to connect his observations there with the new evolutionary ideas of the English naturalist Charles Darwin (1809–1882). Haeckel's own writing on evolution gained tremendous popularity in Germany and the United States, as did his beautiful drawings of marine animals. In turn, Haeckel took his own students, including Anton Dohrn (1840–1909), who went on to become a prominent German zoologist and Darwinian.

Dohrn and colleagues developed a portable aquarium, which made it possible to preserve specimens longer and to watch changes over time. Yet as they carried their collecting nets, aquaria, collecting jars, and other apparatus back and forth each season, they began to see the need for a more permanent place that would allow storage. Dohrn set up a station at Messina, Italy, but it was still not sufficiently permanent, and in 1873 the Stazione Zoologica opened in Naples to serve the purpose. This was a magnificent stone building, attesting to its permanence and serious purpose. The public aquaria attracted visitors and attention, and the placement by the bay attracted tourists and local visitors. Dohrn made sure that the Stazione offered music and art as well as science, and he started the foundations for an outstanding library. The active fishing business brought a great variety of organisms to be studied. Dohrn had attracted enough funding from Germany as well as Italy to make a statement about the importance of marine biology (Groeben 1984, 1985).

Researchers began to visit the Naples Station from around the world, subscribing to research tables for the summer and sending students and faculty members to explore the wonders of marine life. Here, indoors, the researcher could sit at a table, order the organisms he (usually he, with just a few women) wanted to study, and have access to the best available microscopes and other equipment. Study of cells, development, and physiology guided the early work at Naples.

By 1900 over fifty Americans had visited Naples, and they carried away ideas about what was possible. Even those who had visited the much simpler American facilities such as the Marine Biological Laboratory saw ways to improve and grow them. They carried the ideas and the ideals for a particular kind of experimental scientific research with them.

MARINE BIOLOGICAL LABORATORY IN WOODS HOLE, MASSACHUSETTS

One person who visited Naples and was inspired was the American zoologist Charles Otis Whitman (1842–1910), who later married one of the first women to visit the Stazione, fellow American Emily Nunn. When a group of mostly Boston trustees conceived the idea to set up a marine laboratory for research and instruction, they looked to Whitman as director and to Woods Hole, Massachusetts, for a site. The US Fish Commission already had a facility there that had attracted biological researchers, and which had established that the waters off

this tip of Cape Cod proved especially useful for marine study. The mix of warmer Gulf Stream and colder waters resulted in a diverse array of organisms. The trustees acquired a piece of property across the street from the Fish Commission and had a modest wooden building erected in 1888. Whitman arrived the first summer and began to take his students and attract others to carry out cell lineage studies.

This line of research, which involved observing eggs of marine invertebrates as they were fertilized and underwent cell division, had researchers tracking the fate of each of the cells for as long as it was possible to observe them. As the organism grew larger and more complex, it became impossible to tell what was going on inside, but the early observations revealed a great deal about how development works. Because Whitman set up students to look at different organisms and compare the results, the group began to see patterns of similarity and difference that helped interpret developmental processes, explore the dynamics of cell division, and inform our understanding of evolutionary relationships. This was just one aspect of work at the Marine Biological Laboratory (MBL), but it brought together a community of interested young people who kept returning to the MBL in future years. Other work in the early years included botany, physiology, neurobiology, and invertebrate biology.

The MBL has a rich history that has both reflected and helped lead paths in biological discovery generally. At times neurobiology has dominated, with tons of squid giving up their giant axons to laboratory analysis. At other times, physiology has dominated, with discovery of kinesin for axonal transport (Vale 2012). Ecosystems studies have taken a central place since the 1970s, and centers of molecular evolution, cellular dynamics, regenerative biology, and others have provided organizing emphases for this small laboratory focused on promoting scientific discovery for researchers and students alike. The courses remain outstanding and consistently attract an international group of future leaders to the MBL to learn techniques, share ideas, and develop lasting collaborations. In 2013 the MBL entered an agreement with the University of Chicago that offers great advantages to both institutions and promises to enrich both educational and research activities.

Misaki Marine Biological Station. On the wall at the MBL is a treasured statement from the Misake Marine Biological Station at Moroiso Bay in Japan. At the end of World War II, American naval forces occupied that area and came across this statement on a building. The Japanese researcher Katsuma Dan (1905–1996), along with his wife, Jean Clark Dan, had spent summers at the MBL studying embryology and cell biology. At the University of Tokyo, he spent time at the Misake Station.

Katsuma Dan. **"KATSUMA DAN." HISTORY OF THE MARINE BIOLOGICAL LABORATORY. HTTP://HPSREPOSITORY.MBL.EDU/HANDLE/10776/3123. 1931**

His Japanese graduate student Shinya Inoue (1921–) joined him there; Inoue then moved on to a distinguished career at the MBL, using exceptional light microscopic techniques to study cellular structure.

The Misaki Marine Biological Station was founded in 1886 and then moved in 1897, reportedly to take advantage of the richer marine life in the location where it has remained since. A part of the University of Tokyo, the Misaki Station welcomes visitors and focuses also on training of graduate students. The station has retained a connection with the MBL in Woods Hole.

In 1975, when the Japanese Emperor Hirohito (1901–1989) visited the United States, he was asked where he wanted to visit. One of those places was the MBL, where he spent his time looking at the hydroids and related

organisms that he studied himself and that he summarized in *The Hydroids of Sagami Bay* in 1988 and 1995.

EUROPEAN LABORATORIES

As the United States biological community expanded, the Bureau of Education in Washington, DC, encouraged a study of biological stations in Europe. The American zoologist Charles Kofoid (1965–1947) and his wife Julia visited a number of marine stations, both freshwater and salt water, in 1908 and 1909, assessing the strengths and activities of each. He photographed the stations and documented the equipment used and organisms studied in each, while also learning about techniques and acquiring equipment to take back home to the laboratory in San Diego, California (at that time known as the Marine Biological Association of San Diego).

Kofoid provided a preface to the volume that he transmitted at the request of the American educator Elmer Ellsworth Brown (1961–1934) in Brown's role as Commissioner of Education for the Bureau of Education, which was then part of the US Department of the Interior. Kofoid explained, in reference to his visits to freshwater and marine stations:

> Special attention has been given to the economic or applied scientific phases of their activities in the firm belief that biological stations and their methods of attack upon biological problems are destined not only to add greatly, and, in a unique way, to the advance of knowledge but are also of prime economic importance. They are laying the foundations for a scientific aquiculture that will make possible the conservation of the aesthetic and economic resources of lakes and streams from threatened pollution and destruction, and that will facilitate the reaping eventually of the annual harvest of the sea without destruction to its sources.
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> KOFOID 1910, P. XIII

Kofoid followed this very modern-sounding call for the United States to learn from European stations with a description of nearly one hundred facilities and projects. The Plymouth Station in England, the Station Biologique de Roscoff in France, and the station in Monaco (which later became the Scientific Center of Monaco) were just three examples of very different kinds of places. He included maps, photographs, and descriptions that demonstrate that he was paying very close attention to what worked and what did not work so well in different locations. Clearly, he learned a great deal about how to help build the Scripps Institution for Biological Research and advice for other US stations.

US MARINE STATIONS

In 1890 the Brooklyn Institute for Arts and Sciences set up a program on New York's Long Island for training high school and college teachers in biology. This required a place to collect specimens and then to examine them in a laboratory. When John D. Jones gave his buildings and land to the Brooklyn Institute, it made possible this facility. At first the lab taught general biology. Then in 1898 the institute hired the American zoologist Charles Davenport (1866–1944) from Harvard as the director, and he began the path to focusing on genetics. Davenport persuaded the newly founded Carnegie Institution of Washington to set up a Station for Experimental Evolution at Cold Spring Harbor, and this funding shaped the organization for many years. The lab became known for its eugenics program, which brought together research, policy, and advocacy. It also began programs of research in molecular genetics and genetics more generally, cancer research, and in 1968—under the directorship of the American zoologist, molecular biologist, and geneticist James Watson (1928–)—to broader research programs. The Cold Spring Harbor Laboratory (CSHL) has hosted many leading conferences while providing advanced training. It was never specifically a marine laboratory, but it was at the shore and took advantage of collecting opportunities as a result.

Beyond the East Coast, a number of inland facilities grew and attracted researchers throughout the US interior as states and local groups sought to understand and manage their aquatic resources at lakes or river systems. One of these, the Illinois River Biological Station, hired Kofoid with a teaching position at the University of Illinois in 1897. Kofoid stayed until he was lured to the University of California in 1903 by the biology department chairman, the American biologist William Emerson Ritter (1856–1944), who had been Kofoid's fellow graduate student at Harvard. Ritter wanted to build a permanent marine station in California and recruited Kofoid to help. Ritter focused on San Diego as an appropriate location.

Scripps Institution for Biological Research. Along with the American newspaper businessman E. W. Scripps (1854–1926) and his half-sister, the American journalist and philanthropist Ellen Browning Scripps (1836–1932), Ritter founded the Marine Biological Association of San Diego in 1903 to develop support for a western marine station. In 1905 they acquired land in La Jolla, a 170-acre plot on which the first laboratory was built in 1907 and continued to grow and develop to become the Scripps Institution for Biological Research as part of the University of California (UC) in 1912 and then was renamed the Scripps Institution of Oceanography in 1925. The laboratory has evolved from a focus on study of marine life, has embraced Scripps's emphasis on public

education and communication, and has moved on to large oceanographic explorations. Becoming part of UC San Diego has expanded the educational mission and brought a wider diversity of research enterprises to the lab. This affiliation has also provided financial stability and opportunities to small independent laboratories.

Hopkins Marine Station. Also on the West Coast was the Hopkins Marine Station. Technically, this station affiliated with Stanford University started in 1892, though it had a troubled early history at Point Aulon (Lover's Point) on Monterey Bay. Mrs. Mark Hopkins paid for the first building and named it after her adopted son. The facility provided space for summer courses. According to the laboratory's official history, Timothy Hopkins requested that the name be changed to the Marine Biological Laboratory of the Leland Stanford Junior University in 1906. In 1917 the lab relocated to a more appropriate site on the bay and was renamed the Hopkins Marine Station of Stanford University.

With Stanford's support, the facility has grown dramatically, acquiring more land and new buildings including housing for researchers and students. The mission includes educational programs, graduate training, and research focused on oceanography as well as marine biology. To those who once argued that the United States did not need more than one West Coast marine station, the success and complementary programs at Scripps and the Hopkins Station have proven them wrong. In each case, alliance with a major research university has made possible the laboratory's sustained success.

Friday Harbor Laboratory. Friday Harbor provides another example, this time on the northern West Coast. Founded in 1903, the Friday Harbor Laboratory was affiliated with the University of Washington from the beginning, when the American zoologist Trevor Kincaid (1872–1970) looked for a suitable place to carry out research in Puget Sound. At first, the lab involved primarily summer studies, with students sleeping in tents, collecting specimens during the day and studying them in a simple laboratory setting. In 1910 a new building was erected on the additional land recently acquired. Since that time the facility has expanded in space, buildings, library, collecting equipment, and the scope of research. At first a summer teaching facility, the laboratory now includes year-round research in this area rich in biodiversity.

THE IMPORTANCE OF MARINE LABORATORIES

The laboratories mentioned here remain in some form, which provides testimony to the importance of marine laboratories for biology. The labs have evolved along with biology, and most of the successful ones have allied with major universities or other strong organizations to ensure their sustainability. Many have developed educational programs, and some have developed strong public outreach functions as well. It is instructive to read Kofoid's report from his 1908 and 1909 visits to European labs and to see his emphasis on their practical importance and impact. Marine laboratories help us learn biology and to discover the diversity of living organisms. They provide opportunities for people to come together and learn together. In addition, the laboratories play important practical roles in helping us understand the marine life that we consider resources for human value. This, he noted, was one reason that European laboratories were funded largely by state and local governments. The United States and other countries have taken a different approach, causing the labs either to find their own funding or to ally with universities.

SEE ALSO *Genes Recognized as Basis of Life; Gulf Stream; Ocean Circulation; Seafloor Hydrothermal Vent Organisms; Voyage of HMS Challenger.*

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