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MARINE BIOLOGY AND THE MARINE LABORATORY AT SAN PEDRO.

By William Emerson Ritter.

A marine biological laboratory has been maintained at San Pedro by the Department of Zoölogy of the University during the last two summers. What this laboratory has been doing does not matter much. It has not accomplished momentous things, and the University community would not be much interested in the details of the tentative work that has been going on. What, in broad terms, it wants to do, what it intends to do, if it does anything further, is the point. This would amount to something and the University community ought to be interested in it.

Why are biologists so fond of marine laboratories? Why do they so much like to study things that live in the sea?

Perhaps laymen do not realize that biologists have any special preference for such studies. But glance over the roster of the names of those illustrious in the biological domain and note who have won their distinction wholly or in part by researches in marine life: Darwin, Huxley, both Agassizs, Haeckel, Kovalevski, Balfour, Loeb, Mechnekoff, Weismann, Brooks, Milne-Edwards, Hertwig, Dohrn, Wilson, Driesch, Lankester, and many more were it worth while to extend the list. For most of these it was no mere matter of circumstance, such as might be expected in the course of any active scientific career, that attention should

sooner or later be directed to this realm. In the main these men have appealed to sea creatures for light that could not be got elsewhere on large problems of biology. Glance now at some of the focal points in the science itself—at the points around which, as in all sciences, the efforts of its foremost cultivators always chiefly center.

It is hardly going too far to say that almost all the exact knowledge we possess of the mechanism of heredity, of the structure of reproductive cells and of the wonderful processes gone through by them during the initial stages of development, has come in the first instance from sea animals—from the humble sea urchin more than from any other.

The new and very important department of developmental science known as "Developmental Mechanics" (interpreted by one of its foremost exponents as "the doctrine of the causes of the origin and maintenance of organic forms") has been built up almost wholly, but for the one notable exception of the all-pervading frog, around animals that live in the sea.

Strangely enough it seems at first, our deepest insight into the fundamental difference between plants and animals, and likewise into the fundamental dependence of the latter upon the former, is coming from the infinite millions of minute one or few celled beings (you may call them plants or animals as may suit your whim, and not be wrong) that float on the surface of the sea.

Jelly fishes and polyps have taught us more than all other animals combined about how the nervous system got a start. And from other sea animals, particularly worms, molluscs, and fishes, has come most of what we know about the beginnings of eyes and ears. Barnacles and sea squirts have given us our most impressive lessons in down-hill evolution. Creatures that dwell in the abysmal depths of the ocean have instructed us as no other organisms have on the ability of animals to flourish happily in regions where, *a priori*, it was believed they could not exist at all.

In other words, from these we have gained our most important lessons on the range of conditions to which living things are able to accommodate themselves.

And why are sea creatures thus preëminently important for philosophical biology? There are several reasons. One is precisely the reason why savages with their tribes and clans are so important for the philosophical study of human beings and human society. The most primitive of all animals dwell in the sea. The incipient stages of family and colonial aggregation among animals are nearly all found among sea creatures. Another reason is that by far the greatest diversity of animal forms, so far as fundamental types are concerned, is found in the sea. Of course this is of prime importance for the investigation of great problems of biology. The more doorways there are to a problem, the more chances there are of getting into it. Another reason is the greater simplicity of organization of sea creatures, and especially of their ways of development. Embryological processes are difficult enough to follow and to understand at their simplest. In their maximum of complexity they well-nigh defy the efforts of the student; so it is of the greatest moment to get them first in their least involved and least complex states. A final reason to be noted is the greater ease with which marine animals, and particularly their eggs and embryos, can be got at for study, and hence the readiness and ease with which they lend themselves to experimental investigation.

Now if the questions be asked, why the greater primitiveness of sea creatures? why their greater diversity of fundamental types? why their greater simplicity? the answer is ready at hand, and is twofold. First, they are as a whole vastly older racially—phylogenetically in the stilted terms of the biological cult—than the animals of the land and the air. It is now known positively that not only was the sea the original home of all animal life, but that this life remained in its original home for countless ages before it began its migrations to the land. Second, the condi-

tions of life in the sea have ever been and still are much more constant, and in general easier, than upon the land; consequently evolution has been much slower in the sea; much less change has been wrought there than on the land upon the fundamental types of organization. There has been less covering up and obscuration through modification of foundation plans. Exegesis of the evolutionary record of sea creatures is accordingly much easier than that of land creatures. This is enough, perhaps, to establish the point that facilities for prosecuting researches at the seaside are of supreme importance for biological science.

This being so, the question, Ought California biologists to have such laboratories? would not be in order. To be given great opportunities by nature and to make no effort to use them is always an unpardonable offense against the powers of light and progress. The only questions are: What sort of laboratory should we have? What should be its special aims?

Researches in the life of the sea have been prosecuted widely and with great energy in recent years. We have learned much, very much, from them. Perhaps the most important thing we have learned, however, is what to do next. Now it is exactly the thing that should be done next that we here in California are, by the grace of a beneficent Providence, specially commissioned to do. Detailed, comprehensive, continuous and long-continued *observation* and *experiment*—these are the two golden keys that will let us farthest into the mighty *arcana* of the life of the sea.

Who that is accustomed to the sea can fail to recognize that an ocean like that off Southern California, where icy tempests never rage, and where torrid heat never enervates, must be exactly the sort of an ocean where observations and experiments of the kind specified could best be carried on.

First of all, future marine biological research must rest on thorough knowledge of the sea itself. This is the *milieu* of marine animals; and the veriest tyro in evolution well knows that an animal without an envir-

onment is as little to be conceived as are oranges without orange trees. The depth of the water; the currents flowing through it—their direction, their strength, and their variableness; the material and conformation of the ocean floor—all these must be studied. The chemistry of the water, its organic and inorganic constituents, solid and gaseous, must be accurately known, as also the temperature of the water—and the variations of all these for different localities, and in the same localities for different depths, different seasons of the year, and different times of the day. The depth of penetration of sunlight into the water, and the effect of it and its absence, direct and indirect, on organisms must be investigated.

So the future marine station, particularly the California station—must be planned for chemical, physical, and hydrographic as well as for strictly biological research. It must have boats fitted with a great variety of apparatus. For the all-important experimental researches it must have aquaria that will reproduce in miniature and in a form easy to control the conditions of nature as far as possible. And over all, of course, there must be men. The work must go on every hour of the day, and every day of the year.

It would be wholly useless to attempt to particularize here the biological problems that should at once engage the efforts at our station. One group of problems is, however, of such peculiar importance and appropriateness for us that I allude to it. It is that of the relation of organisms that inhabit the shallow waters along shore, and the surface layers of the open sea—organisms, consequently, subject to the direct influence of the atmosphere and solar heat and light,—to the animals that dwell in the profound depths, wholly shut off from the influences above mentioned. Why have these animals left their ancient surroundings, so normal and benign to their natures, and sought regions so abnormal, so seemingly hostile, that we should have pronounced—and indeed science actually did pronounce—them *a priori* incapable of supporting animal

life? The great pressure, the absolute and eternal darkness, the supposed absence of available oxygen, and of food supply, seemed sufficient grounds until the facts actually proved the contrary for denying that life of any sort could exist in the abysmal depths.

What exactly have been the steps in these migrations, what their causes? Shall we accept as a sufficient explanation the idea of pressure from the "struggle for existence?" No, this is too general, too vague to satisfy. Physical and chemical actions and physiological reactions of a wonderful nature have been going on here. Upon these processes the struggle for existence hypothesis throws no light.

Two circumstances make an attack upon this particular group of problems here on the California coast especially promising of results. They are, first, the uniquely favoring climatic conditions, above referred to, that will render possible the essential *continuous observation* and *experiment*. The second is the fact that our coast at so many points drops off abruptly to the profound oceanic depths. Six miles off San Pedro, for example, we plunge down to a depth of 500 fathoms; and 45 miles off, to a depth of 2,000 fathoms. At most places on our Atlantic coast 50 miles are required to reach the first depth and 100 miles to reach the second, while nowhere about the British islands can 500 fathoms be reached short of from 100 to 200 miles from shore. The whole North Sea and English channel are comparatively shallow, nowhere more than 200 fathoms in depth.

What the Lick Observatory is doing in astronomy, and what, too, the College of Mines is doing in its domain, are not wholly due to the men, excellent as these undoubtedly are, to whose hands the conduct and work of these departments are entrusted. With both, the unique advantages of position are being made to count.

The endowment in money by James Lick and the Regents and friends of the University, coupled with the endowment by nature of a matchless atmosphere and climate, are

together the factors that are enabling the Observatory to achieve splendid results for science and win renown for the University. California's natural advantages for Biology, particulary for marine Biology, are, I fully believe, even more exceptional than those for Astronomy.

These advantages we must turn to account. The San Pedro Station has no ambition merely to do again what has been and is being well done elsewhere. It would be unworthy of our State and unworthy of our University for the station to rest its ambitions at anything less than the doing of that which by nature it is peculiarly fitted to do. There are diversities of gifts; to one prophecy; to another divers tongues; to another interpretation of tongues; but the same spirit. Each according to the measure and kind of its own endowment to the one great end, the increase of man's knowledge of himself and the world, that is the watchword with marine biological stations as with men.

What has been done at the station during the past two years has been ordered as far as possible with the little funds available, as though it were the beginning of what ought to be done.

In the collecting carried on a year ago every spot at which the dredge or trawl was cast was accurately located on our charts. All the specimens captured were either preserved, and are now in the University collections, or were recorded, so that we have the data for full and accurate information as to what creatures were at hand at these particular stations at this particular time. We also learned as much as we could, with our rather crude instruments, about the condition of the water at each station.

We shall now be able to return at any future time, when we have the means for doing so, to these identical spots for the purpose of seeing what the conditions may then be there, and how much change may have taken place in the animal population.

Then, of course, we have not neglected to carry on various investigations of the sorts usually prosecuted at such

laboratories. Diverse creatures new to science have been discovered and described. Additional information about imperfectly known animals has been obtained. Systematic observations on the habits of different animals have been made. Experimental studies in regeneration of animals have been carried on. Experimental studies also, on the action of the heart of certain humble creatures have been prosecuted. Various points in the embryology of several animals have been investigated; and so on. Furthermore, formal instruction has been given to a number of beginners in biology. And a number of teachers in colleges and high schools have increased their knowledge, experience, and enthusiasm at the laboratory.

And now as to the future. Have our ambitions as herein outlined reckoned in any way with the prosaic question of their possible realization? To carry on the investigations we have outlined will require $25,000 for building and equipping the laboratory and experimental aquaria; $10,000 for a 50-ton gasoline launch and its equipment; $5,000 a year for running the laboratory and small vessel. This does not contemplate any exploration of the profound depths of the ocean. For this an outfit not here contemplated would have to be sought. The University cannot, I suppose, be counted on to contribute anything to the undertaking from its own resources. Pity it is that the admission must be made. But it is so. This is the unfortunate position in which the University finds itself: While fully recognizing that the only way it can become a university in the highest sense and can obtain a place in the foremost rank of universities, is through research, it has nothing to devote primarily to this end. It must therefore for the present accept the humble role of being little else than a good dispenser of knowledge. So the funds must come, if they come at all, from outside sources.

Interested friends at Los Angeles, foremost among whom are Mr. H. W. O'Melveny, of the class of 1879,

Mr. J. A. Graves, Mr. Jacob Baruch, and Mr. A. C. Balch, are making heroic efforts to secure in that community the money necessary for the laboratory and its equipment. For the rest, like Elijah of old, we "stand before the Lord," hungry but full of trust, and therefore expecting the ravens laden with bread and meat to appear at any moment.