(*d*)

No. 13.—Human and animal figures combined in a miniature totem pole, sculptured in partial relief, material black slate, shaped with metal tools. Northwest Coast Indians. Period recent. 178,064

(*d*)

No. 14.—Human figure, fully relieved, but falling short of the best Central American work. Material gray, porous lava. Probably shaped with stone tools. Precolumbian period. 61,814

lustrations covering the same ground and besides furnished additional steps up to the highest achievements of human genius in this art (20 numbers).

Four kinds of labels are required for the sculpture exhibits as follows:

(*a*) *Case label*, about 4 by 16 inches; framed and placed at the top of the case *A* (Fig. 8).

(*b*) *Group label* descriptive of the entire exhibit; size about 8 by 10 inches; framed and hung at a suitable height within the case (*B*, Fig. 8).

(*c*) *Series label*, to be placed at the beginning of each series. The example given pertains to Series 2 of the sculpture exhibit (*C*, Fig. 8).

(*d*) *Specimen label*, briefly describing the specimen, and placed with it in each instance. The examples given belong to specimens 13 and 14 of the American Series (*D*, Fig. 8) as installed in the National Museum.

The sculpture exhibit as installed in the National Museum occupies a space 5 feet high, 8 feet 6 inches long and 12 inches deep. It includes about 100 specimens and 60 labels.

The ends to be subserved by the exhibits of a general anthropological museum are mainly those of education, and the aim of the classification and arrangement here proposed is to so present the collections that the student as well as the ordinary museum visitor may secure the maximum benefit from them. As indicated at length in the preceding pages, the three great ideas capable of satisfactory presentation are: (1) the biology of the race—the origin, evolution and present characteristics of physical man; (2) the ethnology of the race—the various groups of people and their culture; (3) the history of culture—the evolution of arts and industries. To these three series a fourth is added, which consists of various special exhibits, each teaching its individual lesson. The anthropological collections are thus assembled in four grand divisions separately installed.

W. H. HOLMES.

U. S. NATIONAL MUSEUM.

*A BIOLOGICAL FARM FOR THE EXPERIMENTAL INVESTIGATION OF HEREDITY, VARIATION AND EVOLUTION, AND FOR THE STUDY OF LIFE-HISTORIES, HABITS, INSTINCTS AND INTELLIGENCE.**

THE biological laboratories of to-day, in design, equipment and staff, are almost exclusively limited to the study of *dead* material. Living organisms may find a place in small aquaria or vivaria, but they are reserved, as a rule, not for study, but for fresh supplies of dead material. It is no disparagement of the laboratory to point out a broad limitation in its ordinary functions and the pressing need of new facilities for observation and experiment on *living* organisms.

The fundamental problems of heredity, variation, adaptation and evolution cannot be wholly settled in the laboratory. They concern vital processes known only in living organisms—processes which are slow and

* Read to the Corporation of the Marine Biological Laboratory, at the annual meeting, August 12, 1902.

cumulative in effects, expressing themselves in development, growth, life-histories, species, habits, instincts, intelligence. These problems require, therefore, to be taken to the field, the pond, the sea, the island, where the forms selected for study can be kept under natural conditions, and where the work can be continued from year to year without interruption. Such a field, combining land and water, and stocked with animals and plants, and provided with a staff of naturalists, would have the essentials of a biological farm, now justly considered to be one of the greatest desiderata of biology.

This great need (pointed out in all our annual programs since 1892, and named as one of the three leading purposes of the Culver endowment) has been felt ever since Darwin's time, and has been strongly urged by such evolutionists as Romanes, Varigny, Galton, Weismann and Meldola. Thus far the project has not been realized, except on a small scale through individual effort.

The most notable move in this direction is that of Professor Cossar Ewart, of the University of Edinburgh. 'The Penycuik Experiments'—the first product of Professor Ewart's enterprise—form a brilliant illustration of the kind of fruit to be expected from a farm devoted to experimental research. Single-handed, Professor Ewart attacks the problems of heredity, and quickly shows how decisive are direct experiments in dealing with such subjects as telegony, prepotency, reversion, inbreeding, etc.

The plans proposed by Romanes and Varigny had as chief ends in view demonstrative tests of the theory of the origin of species by natural selection. But the contest between the old belief in the immutability of species and the new doctrine of descent has been decided, and the original idea of the farm has consequently ceased to have great influence.

The functions to be fulfilled by a farm are no longer prescribed by the exigencies of theories, but by the deeper and broader needs of pure research on *living* organisms. The problems of heredity and variability are fundamental, and naturally form the center of interest. Variability is the source of new species and the fountain of all progressive development in the organic world. In heredity lies the power of propagation and continuity of species. These are inexhaustible subjects, from the investigation of which must flow rich accessions to knowledge, which will redound to the advancement of human welfare.

These subjects are in some aspects and details amenable to laboratory research; but for the most part they can only be effectively dealt with under conditions represented in the farm. This holds, for example, in that most promising branch of experimental biology—*hybridisation*. Botanical gardens and zoological parks have been utilized to some extent in this work, but they are adapted to show-purposes, and are of little value for research of this kind. The far-reaching importance of this subject, for both science and practical breeding purposes, is well attested in Mr. Ewart's experiments, in those of Hugo de Vries, as recorded in his monographs on the origin of species in the plant world, and again in Mr. Bateson's 'Experimental Studies in the Physiology of Heredity.'

The functions of a biological farm are not all summed up in experimentation. That old and true method of natural history—*observation*—must ever have a large share in the study of living things. Observation, experiment and reflection are three in one. Together they are omnipotent; disjoined they become impotent fetiches. The biology of to-day, as we are beginning to realize, has not too much laboratory, but too little of living nature. The farm will certainly do much to mend this great deficiency. The farm would enable us to work out life-histories, bring us face to face with instinct, put it under control so that we could handle it, photograph it, analyze it, read its history, and extort from it an answer to the question, Whence and how came intelligence?

It would enable us to extend the study of development beyond the stages represented in the egg and the embryo to those leading up to mature age, and thus bring within reach vast series of most important data for the study of evolution.

In such data we might expect to see to what extent individual development recapitulates race development, and to get important clues to the meaning of this so-called biogenetic law. The whole meaning of development and heredity is involved in these phenomena of 'recapitulation.' That the first step in recapitulation is the germ-cell, we know. The fertilized germ, or egg, passes through a series of form-stages, leading through the morula, blastula, gastrula, embryo, larva, etc. Whether these stages epitomize the ancestral series is a question very difficult to decide, and opinion is much divided. This obscure but fundamental problem of development can probably never be solved by embryological data alone. Paleontology throws much light on the general question, but deals entirely with non-living remains. If there be recapitulation, it should certainly be discoverable in post-embryonic stages, where characteristic features are slowly elaborated and brought to a completion in detail quite beyond the possibilities in earlier life. Strange to say, these later stages have been but little studied in living forms, museum morgues having been the chief reliance. It is in these stages that recapitulation may be actually seen as a life-process, successive steps in evolution repeating themselves with sufficient fullness to satisfy the most skeptical. Such sequences are often manifest in the development of instinctive behavior, and even in voice-changes and food-instincts at certain life-epochs corresponding seemingly to evolution epochs. Remembering that the distant ancestors of land animals were undoubtedly aquatic, the history of individual development in amphibious forms of to-day becomes intelligible as an abbreviated and variously modified record of race development. Making all allowance for secondary adaptive changes, it is nevertheless safe to say that race evolution is sketched in the development of the individual—sketched not only in fundamental features of structure, but also in the accompanying physiological and psychological changes.

Reminiscences of aquatic life are seen not only in land animals that return to the water to deposit their eggs, but also in all the higher animals, since they begin life in the unicellular stage and require for their first development to be bathed in fluid.

Sequence in color-patterns, so characteristic of young animals of almost all species, and especially so of birds, furnishes innumerable illustrations of the biogenetic law, and in many cases, where only two extremes of the sequence are present, it is possible by simple experiment to bridge the gap, and thus to show that the two extremes are really two stages of a continuous development. For example, in some wild species of pigeons we find that the color-pattern of the first plumage succeeding the down is so different from that of the second (adult) plumage, as to appear to have no direct developmental relation to it. By plucking one or more feathers from the first plumage at different times before the first molt, intermediate stages can be obtained, showing precisely how the first pattern can be progressively converted into the second. Such experiments enable us to force from nature more complete records of her past and present doings.

Work on living organisms, dealing with such subjects as heredity, variation, adaptation, correlation, development, recapitulation, hybridisation, origin of species, nature of specific characters, life-histories, habits, instincts, intelligence, etc., requiring uninterrupted continuance from year to year for long periods, under conditions that secure most favorable control for experimentation and study, calls for facilities which have yet to be provided.

There is no quite satisfactory name for the new plant required for such work, and no one has suggested a practical method of developing it. Biological Farm, broadly defined, is perhaps the best we can do for a name, as the work would be, so far as possible, upon plants and animals under cultivation. A considerable tract of land, of varied surface, including woods, fresh-water ponds, some brackish water, and a stretch of sea-shore that could be utilized in the cultivation and study of marine animals, would represent the essentials of the farm headquarters.

The best location for the farm would be in the immediate vicinity of a laboratory holding the position of a national center of biological research. The Marine Biological Laboratory has a good prospect of becoming such a center, if it is not one already, and its proximity to the United States Fish Commission Station only insures additional advantages, of great importance to the farm. The farm, the laboratory, and the station would be reciprocally helpful and stimulating, and in many problems the three could work hand in hand, each supplementing the work of the others. These three establishments would form a most comprehensive biological center, such as has never been equaled.

In dealing with the problems of heredity and variation, it is of the highest importance to know the *history of the material* to be investigated. It is this prime essential that is so conspicuously missing in most of the work hitherto done in these lines. Curves and formulæ may be all right mathematically and yet all wrong biologically. Even Galton, the father of the statistical school, warns us that 'no pursuit runs between so many pitfalls and unseen traps as that of statistics.' ('Biometrika,' I., p. 8.)

The farm will furnish material with *exact records,* and will thus render a most important service to laboratory workers. A single illustration will suffice. It has been discovered that the paternal and maternal chromosomes in the cross-fertilized egg remain distinct, at least in the earlier stages of development. This seems to account for the fact that hybrids of the first generation between distinct species are generally 'intermediates.' When these hybrids breed *inter se* or with the parent species, we often get so-called 'reversions.' Hitherto we have not found any explanation for these 'reversions.' The solution of this most interesting problem in heredity only waits for the right material with precisely defined origin, and for this the laboratory could look to the farm. But the farm would do more than supply the needed material; its records and experiments would suggest the theory and give the physiological test, while the laboratory work would find the morphological test. The cooperation between laboratory and farm would thus be intimate and of inestimable value in a multitude of ways.

It must be remembered, moreover, that Wood's Holl has great natural advantages as a location for the farm. Ever since Baird's time it has been generally known that this is the best place on the Atlantic coast for the study of marine biology. Indeed, Wood's Holl has become a strong biological center by virtue of the exceptional opportunities for work here offered in a varied and extensive shore fauna and flora, in numerous accessible islands rich in forms of peculiar interest, and in many perfectly isolated fresh-water ponds, brackish ponds, and salt-water ponds of easy control. These attractive features, together with a climate suited to both winter and summer work, certainly comprise the essentials of a good location.

A further consideration in favor of this location is the fact that here for the first time in this country the farm project was definitely formulated; and, what is more to the point, it is here that the first step in the development of a farm has been taken, and the work carried forward for some six years by individual endeavor. The birthplace of an enterprise is not likely to be a pure accident. In the present case it was certainly determined by the various causes which have conspired to make Wood's Holl a biological center. This center has at least fifteen years of growth, and every year makes it stronger and increases its importance as a location for the headquarters of a biological farm.

The argument for location has already suggested that the farm is not necessarily limited to a single tract of land. It is designed to supplement, and cooperate with, a laboratory, and hence must have its headquarters conveniently near. There is no reason, however, for limiting its territory to the ground selected for this purpose. If, to take a familiar example, a study of the terns were to be undertaken, we should undoubtedly resort to Penikese, taking advantage of the headquarters selected by the birds. If we were to take up some groups of migratory birds, we might find it desirable to migrate with them, changing our location to suit their summer and winter predilections. For forms settled in tropical regions, longer excursions might be necessary, and this might lead to the development of a new farm. These possibilities do not in the least conflict with the plan proposed for Wood's Holl. No matter where a farm be located, it must have headquarters, and occasionally extend its field of work to more or less distant points of interest.

The headquarters must be in close touch with a laboratory, and both should be in a place where the natural advantages and the organization are such as to draw a large number of investigators—most emphatically not in a place that invites a large number of spectators, as in the public parks of cities. In this latter respect Wood's Holl is most perfectly adapted to the purpose, and the prospect is good that we shall never be troubled with throngs of summer visitors. This is an ideal feature in the situation that it would be hard to duplicate.

The practical question arises as to how to proceed with the development of a farm. Our limited experience strongly confirms the opinion with which we set out, namely, that the best method is to develop the farm slowly, section by section. Each section should be a group of related species, selected with a view to combining a wide range of problems. It should be developed and directed by an investigator prepared to make it his life-work. This investigator or director should have the support of a number of assistants competent to deal with special problems, one or two artists, a photographer, a keeper and a business superintendent.

Developed in this way, the cost of maintenance would not be heavy at first. Ten thousand dollars a year would support a large and thriving section. The multiplication of sections and the gradual growth of the work would call for a larger income. A farm of ten large sections would require an endowment of a million, and it is easy to see room for many millions.

If the scheme here outlined approaches the ideal which science is waiting to see realized, it will be seen that the farm does not find its chief purpose in demonstrations of the truth of evolution or in testing the theory of natural selection. It is not a project designed simply to turn out curves and formulæ for the delectation of the knight-errants of statistical lore, nor is it the particular pet of any school or fad. Moreover, the prevailing idea that it has something in common with a zoological or botanical park rests on a total misapprehension. The organization, management and all the conditions obtaining in the public park are incongruous with those required for a research farm. Heterogeneous collections of animals, exhibited for the amusement of people, are wholly unsuited to the purposes of investigation in time, place and character. For the kind of work contemplated, the investigator must have forms of his own selection, collected, arranged and kept for his special purposes. He must have complete and permanent control of his quarters and the forms he is to study, and above all, *complete isolation from the public.* Only under such conditions could he have the unbroken quiet required in delicate observation, or expect natural behavior from the forms occupying his attention.

The farm project, let me say in conclusion, is one we cannot afford to see drawn away from Wood's Holl. It is an undertaking born and nurtured here, on a small scale to be sure, but still sufficient to give results and make clear the direct path to a large and most important development.

SUMMARY STATEMENT.

Laboratories.—The biological laboratories of to-day are almost exclusively devoted to the study of 'pickled' animals and plants. They have very few and inadequate facilities for the study of *living* organisms. This is a limitation for which no remedy has thus far been provided.

Field-work.—For the study of development, growth, life-histories, species, habits, instincts, intelligence, heredity, variation, adaptation, hybridisation, etc., we can depend neither upon the laboratory nor upon the field-work of naturalists. A world-wide field in which there can be no *control* of the forms to be studied, and no possibility of *continuity* in observation or opportunity for experiment, obviously does not meet the requirements of science.

Biological Farm.—The laboratory is too narrow, and the world too wide for the continuous study of living organisms, under conditions that can be definitely known and controlled. For such study, selected groups of organisms and a limited territory, with favorable conditions of land, water and food, are needed. Territory, living organisms and scientific staff would constitute a new plant, which might be called a *Biological Farm.*

Grounds.—The grounds of a biological farm would vary in extent with the growth of the work, from ten to a hundred or more acres. Land, woods, fresh-water ponds, sea-shore and islands would make a good combination.

Location.—The location of headquarters should be at a biological center, near laboratories drawing a large number of investigators, but at a safe distance from any large city or summer resort. These prime advantages of situation superadded to the exceptional natural advantages of available grounds are represented at Wood's Holl.

Natural Conditions.—A biological farm should include the largest possible diversity of natural conditions to insure wide freedom of development and opportunity for experimentation. *Water* is the first essential, and three forms of this element are needed, namely, sea-water, brackish water, and fresh water. All three forms abound at Wood's Holl, and vicinity. The fresh-water ponds are numerous, and many of them, both on the mainland and on the neighboring islands, are *completely isolated* and stocked with forms in-bred for centuries. Brackish water in almost every degree, pure sea-water and tide-currents are right at hand.

Land is the next essential, and here we have hill, plain, marsh, swamp, shore and islands, and some of these islands are inimitable biological farms of nature's own make.

A seasonable range of temperature is essential to the existence of a majority of the forms best suited to cultivation and study; and in this are supplied very important conditions for experimental work. The surrounding sea protects Wood's Holl from extremes of heat and cold.

Isolation.—The most favorable combination of conditions may be utterly worthless, unless the farm can be made secure in its isolation from the public. Its work must go on in a *quiet environment*, where all the conditions are under control, and the investigator is free from the danger of intrusion.

Mode of Development.—The work should be developed slowly, section by section, each section consisting of a group of related species, or a single species, offering a wide range of problems.

Each section should be in charge of a director, prepared to continue the work during life, and supported by assistants and help for all routine and mechanical service. The staff would consist of directors, assistant investigators, artists, photographer, clerical help, keepers and a business manager.

Outlay and Maintenance.—The original outlay for land, stock, buildings, equipment, inclosures of land and water for isolation purposes, would vary according to the forms selected for study. From $50,000 to $100,000 would suffice for this. The maintenance of the first section, including salaries, accessions to stock, library, etc., may be estimated at $10,000 a year. The cost of additional sections would be about $5,000 each.

Ideal Center.—The association of three such institutions as the Marine Biological Laboratory, the U. S. Fish Commission Station, and a Biological Farm would form an ideal biological center. Each would help and be helped by the other two.

Cooperation.—There should undoubtedly be several biological farms in the country. The larger universities might well have their own farms, and thus very extensive and effective cooperative work be carried on.

Use to Science.—The farm would enable us to approach all the fundamental problems of life from the two sides of observation and experiment on living organisms. It would furnish material for study with precise records, and make it possible to keep up continuity in the experimental study of heredity and variation.

Practical Utility.—The utility of such work is seen when we reflect on the practical results already realized in the multiplication and improvement of domestic species of animals and plants through cross-breeding, hybridisation and selection. We have very meager and uncertain knowledge of the laws of heredity and variation—laws which underlie all progress of the race.

C. O. WHITMAN.

SCIENTIFIC LITERATURE.

Manual of Astronomy, a text-book. By CHARLES A. YOUNG, Ph.D., LL.D. New York, Green & Company.

The preface to this volume informs us that it has been prepared in response to a rather pressing demand for a text-book intermediate