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THE SMITHSONIAN INSTITUTION, ITS FUNCTION AND ITS FUTURE[1]

Origin and Principles of the Smithsonian

What is the Smithsonian Institution? What is its relation to the government? How was it founded and for what purpose? Above all, what does it do and what may be its significance to human welfare in the future? Is it capable of meeting the wholly different needs of science to-day with the same success which attended its earlier years? These are the questions which I propose to answer.

The institution is the interpretation of the broad interests of James Smithson, an English scientific man who, though he never saw this country, had such confidence in our then young republic that he made it the trustee of his entire fortune to be used for "the increase and diffusion of knowledge among men." His interests are most tangibly brought out by his published writings. Smithson's publications number twenty-seven and include contributions to a wide range of subjects, from the origin of the earth, the nature of the colors of vegetables and of insects, the analyses of minerals and of chemicals, to improved methods of constructing lamps and of making coffee.

Certain fundamental facts necessary to a proper understanding of the Smithsonian's past and its potentialities can be deduced from the strange story of its origin. In the first place the institution is not of national origin, as is frequently supposed, but was the establishment of an individual. In the second place it is privately endowed and privately financed. The government of the United States is merely the trustee to carry out the design of the testator, and to put this into effect has transferred the responsibilities to a board of regents or trustees. In the third place the organization has the maximum of flexibility; a minimum of individuals are permanently supported; at any time it may be so remodeled as to meet existing circumstances, permanent or temporary.

As to the institution's achievements, whatever it accomplishes must result from its adherence to the basic principles deduced from the will of its founder by its first secretary, Joseph Henry.

The first of these principles is to investigate problems of scientific promise irrespective of present eco-

[1] American Association for the Advancement of Science, General Session, Friday, January 1, 1926.

nomic value in directions which hold no immediate prospect of economic return; to undertake the investigation of field problems in this country and abroad, either by itself or in cooperation with other institutions; and to provide means of publication for worthy investigations which otherwise would have no certain prospect of reaching the scientific world, avoiding the publication of such matter as can be published through other agencies.

Since the will makes no restriction in favor of any particular kind of knowledge, a second principle permits the institution to give a share of its attention to all branches. As a result of this the Smithsonian's record includes achievements in fields so widely divergent as aviation, astrophysics and the animals of the deep sea.

Perhaps the principle that has permitted the institution to make its most effective contributions is that which forbids it to undertake any activity that is being carried on by any other organization. In other words, the policy of the institution is to insure the furthest possible advance of knowledge; to aid and encourage scientific research along lines not receiving adequate support from other sources, and not to interfere with work done under other auspices, private or governmental. The Smithsonian Institution collaborates with other scientific institutions, but strives to avoid competition with any.

ACHIEVEMENTS, PAST AND PRESENT

What has the institution done? By the frugal and efficient use of its slender resources it has demonstrated most conclusively the fundamental economic value of many lines of scientific work. Congress appropriated last year $5,618,549 for the support of bureaus, such as the Weather Bureau, the Bureau of Fisheries and the Geological Survey, which are a direct outgrowth of the early activities of the institution; which took their origin from small beginnings under its auspices. Congress now appropriates annually a sum equal to about five times the whole endowment of the institution for the running expenses of organizations either directly created by it or made possible through its researches and other activities.

Of this annual congressional appropriation $971,000 is for the support of various units still retained under the direction of the institution, which exercises supervision over them and guides their work in its broader aspects. This administrative work is merely a side issue of the Smithsonian's activities, and is carried on purely for the sake of functional efficiency.

The fact that Congress annually entrusts the supervision of the disbursement of such a sum of money to the Smithsonian is a striking testimonial of congressional confidence in the institution.

At the present time certain of these administrative children of the institution, especially the National Museum, have become so large that they have become confused with the parent organization. This has led to the very prevalent idea that the Smithsonian Institution and the National Museum are really the same thing, which is not at all the case. The National Museum is a government bureau, the Smithsonian is a private institution situated at the seat of the government under its immediate protection and, through the governmental representation on the board of regents, under its supervision, in such a way, however, as to be wholly free from the influence of politics.

If the Smithsonian has done no more than to lay the groundwork of these ten technical bureaus of the government it would have fully justified its existence.

These represent, however, only one phase of the institution's work. As typical of the wide range of concrete accomplishments I may mention Secretary Langley's work on aerodynamics, Michelson's determination of the standard meter in wave lengths, H. L. Clark's work on the apodous holothurians, Standley's exhaustive studies of the trees and shrubs of Mexico, which has already enabled one American industry to eliminate waste in the importation of raw gum from Central America, and the publication of Squier's and Davis's work on the ancient monuments of the Mississippi Valley, the first great monograph on American archeology published in this country.

NEEDS IN SCIENCE WHICH THE SMITHSONIAN PROPOSES TO MEET

Out of the Smithsonian's past and present looms its future. In the past few years the institution has been developing a broad program of fundamental research and publication on which it proposes now to enter.

A survey of the scientific field to-day shows an increasing number of lines of fundamental investigation which presumably will yield results of value, yet of which no one can confidently predict the economic outcome. Such lines of work can not well be carried on except by institutions with unusual facilities and the broadest contacts, and it is precisely these lines of investigation that the Smithsonian proposes to undertake.

STUDIES ON THE SUN

The work of the Astrophysical Observatory, begun many years ago by Secretary Langley, now gives promise of leading to results transcending in importance his achievements in the field of aeronautics, which laid the foundation for modern aviation.

Under C. G. Abbot, the observatory's measurements of solar radiation have come to be the standard for the world, as are the instruments originated and perfected by it. As a result of the work already under way, there is a possibility amounting almost to a probability that in the near future these investigations will furnish a sound basis for the accurate determination of at least the broader features of long-range weather forecasting. You can all appreciate what such a development would mean to the navigation of the air as well as of the sea, to agriculture, to industries, to all of you here present in your individual lives, no matter what your interests or occupation.

The chief object of the work of the Astrophysical Observatory at present is to secure the most exact measurements of the variations of the sun in order to provide proper data for studying the influence of solar changes on the weather conditions of the United States and the whole world. Daily telegrams reporting the solar radiation are received from the stations in Chile and in California which arrive in Washington within twenty-four hours of the observations in the field. For the past two years daily telegrams giving the solar values have been sent from the observatory to Mr. H. H. Clayton for use in connection with his experimental forecasts for the city of New York. These usually reached him before noon on the day after the observations were made in Chile and in California. Making up his New York forecasts for three, four and five days ahead, Mr. Clayton communicated these to the observatory by letter on the same afternoon. On Friday of each week he forecast the temperature departures for the ensuing week beginning on Sunday, and about the end of each month he forecast the temperature departures for the ensuing month. These forecasts were also mailed in advance to the observatory.

These forecasts were compared with the actual weather conditions, using mathematical processes of verification not susceptible of personal bias. A moderate degree of foreknowledge is certainly indicated, both for the specific forecasts of three, four and five days in advance, and for the more general average forecasts of weeks and months. These experimental forecasts were stopped at the close of 1925 because of the lack of further financial support.

In order to eliminate so far as possible all error in the measurement of the solar constant, the institution needs a fourth observatory, in addition to those in Chile and in California, and the one for which the National Geographic Society has just provided funds in Morocco or Baluchistan.

In order to hasten our knowledge of the complex relationship between the solar variation and the weather, it is essential that meteorological data for the past one hundred years be collected, digested and published for the purpose of furnishing a basis for the determination of new principles.

The expansion of the Smithsonian's astrophysical program will include investigation of the quantity and quality of the vital ultra-violet rays emitted by the sun; the intensity of sky radiation as well as of sun radiation; the effect of the earth's atmosphere on the quantity and quality of the ultra-violet rays, and the effect of the sun's rays on food plants. For these and similar studies plans are ready.

STUDIES ON THE SEA

The second phase of the Smithsonian's program concerns investigation of the sea. There is no line of investigation in which so many different forms of science play a part as in the study of the sea, and there is no line of work that promises to yield more results of value to us.

What is known as oceanography contemplates investigation of the waves and tides and currents and of all the physical and chemical properties of water, both pure and with various substances in solution or suspension. It includes the study of the plants and animals of the sea, of the relationships between them and of the relationships of both to the physical and chemical features, fixed or variable, of the medium in which they live. It also includes the study of the erosion of the shore lines and the change in bottom contours as well as of the piling up of sediments, organic and inorganic, on the ocean bottom, and of the resulting alteration in the isostatic balance. It further covers the investigation of the evaporation from the surface of the water, and of the circulation of the air above it. Oceanographic observations are of value only if we know the exact spot where they were taken. The localities are determined by recourse to applied astronomy and to various forms of mathematics.

From the sea each year we draw an enormous quantity of food, mostly in the form of fish, shellfish, crabs and lobsters. In order to conserve these food resources and further to develop them, we must know just how these creatures live, what they feed upon, their habits and the habits of their parasites and enemies, and their relation to salinity and temperature.

As an illustration let us take the cod. The cod is our most important fish. It can exist only in cold water, and there only where its food is plentiful. It feeds mostly on bottom living scavengers, chiefly crustaceans and echinoderms. What do these feed on? They consume mostly dead organic matter which in the cold waters frequented by the cod is preserved as in an ice box. This dead organic matter is from two main sources. Uncountable billions of small organisms in the upper layers of water are continually dying and falling to the bottom where the larger are discovered and devoured by the scavenging crustaceans, and the smaller, mixing with the bottom mud, are digested out of it by the mud-swallowing echinoderms. What feeds these billions of small organisms? The minute plants, diatoms, peridinians and others form the basic food upon which ocean life exists, with the help of sunlight forming organic out of inorganic substances. What supports these plants? Materials washed from the soil by rain and brought to the sea by rivers, gases taken from the air in cold rough weather, and the dead bodies of sensitive southern creatures brought up by the Gulf Stream and killed by cold. The other source of food for the crustaceans and echinoderms that serve as food for cod is the dead bodies, sometimes the living bodies, of the bottom living types, sea-pens and similar things among which they live. These are all fed, however, from above. Near the coast the detritus from the seaweeds on the shores, especially the eel-grass, where it occurs, is an important food, particularly for bivalve mollusks, and through them for crustaceans, echinoderms and the cod.

Thus in order properly to understand the cod, we must be familiar with the contacts of all the other creatures in the seas in which it lives; with the effect upon them of different degrees of heat or cold and the concentration of salts, wave action and varying degrees of light or darkness; with the relative food values of the substances in the bottom muds; with the amount and kind of the food material delivered by the rivers, and with many other things quite apart from the life history, migrations and other facts about the cod itself.

Certain of our sea foods, like the northeastern lobster and the oyster, are so very popular that the demand threatens the supply, and measures must be taken to protect them. But such measures as are taken are devised by inference from what we assume to be the facts in their life history and environment, and have been developed by a series of experimental measures each meeting with more or less success, whereas obviously they should be based upon a complete or at least adequate knowledge of what they feed upon and how, their relation to the bottom and the physical and chemical conditions of the water and their life cycle. We do not have a complete picture of the interrelationships of any of our marine animals or plants. The oyster is practically the only creature in our seas of which we have even a reasonable knowledge. But even with the oyster new and important facts each year are brought to light.

As on the land, all animal life at sea must depend on plant life for its existence, since only plants can form organic from inorganic compounds. Plants can do this only with the aid of sunlight. Therefore all ocean life depends wholly on conditions within the thin illuminated surface layer, nowhere more than 600 feet in depth, beneath which it is too dark for plants to grow. We know practically nothing of the conditions of illumination necessary for the growth of sea plants, or of the depth in different places or at different seasons of the illuminated upper layer of water in which alone the plants can grow.

The sea plants are of two main types, each with important subdivisions. There are the large attached algae and flowering plants, commonly known as seaweeds, along the shores, and the minute plants of microscopic size which live suspended freely in the water like suspended particles of mud or silt. We know practically nothing about the relative abundance of the different kinds of plants, their relative value as food for animals, their wastage or their fluctuations in response to varying conditions, all of which is of basic importance in understanding the potentialities of the sea as a source of animal foods.

Most people visualize the sea as more or less equally productive everywhere. This is not so. In the first place, though animal life extends downward into the abysses for at least three and three quarters miles, plant life can not exist below at most 600 feet, all the sea animals no matter how deep they live being fed by plants growing in this thin surface layer. In most places in the sea animals are most numerous and varied in the so-called twilight zone where the light is dim and not harmful to them and yet where there is enough light to support some plants. A mapping of this zone and its inhabitants along our shores would produce results of the greatest interest. Below this zone, which is the great zone of mystery wherein presumably the giant squid, huge crabs and large and grotesque fishes find their home, animal life becomes rapidly less abundant, and the animals decrease in numbers, kinds and size. In the second place, in passing from the shores out into the open sea animal life becomes less common and toward the middle of the oceans disappears. Why? Because the animals of the sea depend upon the plants which in turn depend largely, though how largely we do not know, on foodstuffs washed into the sea by rain and streams and by the action of the currents held for the most part near the shores. Of the details of this we know practically nothing.

Each year the rivers of the world carry to the sea millions of tons of mud taken from the surface of the land, and millions of tons of salts in solution in their waters. By this continuous process an enormous total weight of soil and salts is being constantly removed from the land areas. The soil, in the form of mud and sand, is dumped upon the ocean bottom, while the dissolved salts increase the weight of ocean water both by their own added weight and by gradually diminishing the amount of evaporation from its surface, thus adding to the ocean's bulk. Much of the dissolved material brought to the sea by rivers goes to form the shells of billions of small creatures which when they die fall upon the ocean floor, covering millions of square miles of bottom.

The continuous subtraction of vast masses of material from the land and their addition to the weight of the ocean basins in which they are very unequally distributed necessitates constant or intermittent readjustments to maintain an equilibrium or condition of isostasy between the land and sea.

So far we have not attempted to appraise the effect upon us of the transference of material from our land area to the ocean basins, nor do we know the percentage of the loss in soil fertility of our farm lands which is recoverable in the bodies of the fish and other creatures caught along our shores.

As an example of an interesting bit of work along this line I might suggest the following. The Mississippi River delivers every year to the Gulf of Mexico 370 million metric tons of silt, in addition to millions of tons of salt dissolved in its water. Most of the silt, which is derived from the whole area of the Mississippi Valley and also from the mountains on each side, is dumped upon a relatively small area of sea bottom. There is a possibility that this disturbance of the equilibrium has some relation to the volcanic activity and the earthquakes which are so frequent from Mexico to Costa Rica. Similarly it is conceivable that the deposition on the sea bottom of the mud from the Orinoco and the Amazon may have some relation to the disturbances in the Antillean chain from St. Vincent to St. Kitts. In this area the study of the building up of the ocean bottom by silt from rivers and by the accumulation of the shells of animals dying in the upper layers of water can be carried on to the best advantage, for from time to time at well-known dates there have occurred terrific eruptions on the island of St. Vincent scattering dust over almost the whole area of the Caribbean Sea, which, going to the bottom, provides us with date lines in the bottom sediments.

From the surface of the oceans water vapor constantly is rising which passes to the air above. This water vapor by the winds is carried inland where, condensing in the form of rain, it makes possible the growth of plants and through them of animals. In other words, our agricultural and associated industries depend for their existence upon conditions in the seas surrounding us. The rain which nourishes the farmer's wheat and the water which he gives his cows are merely wandering bits of ocean, from which they came and to which they will return after they have served their purpose.

Evaporation from the surface of the sea depends on temperature. On a warm day in summer the hot attic of a house is very dry, but the cool cellar damp, for air when cool can not hold nearly so much moisture as it can when warm. It also depends on the salinity or the amount of salts contained, for the greater the amount of salts dissolved the less will be the vapor pressure or the amount of water vapor given off.

Regarding the temperatures and salinities of the seas about our coasts, we have but little information sufficiently exact for present-day requirements, nor do we understand the details of the seasonal and daily changes.

The climate of our coastal regions is to a very large extent dependent upon conditions in the seas adjacent, upon the great warm currents like the Gulf Stream and Kuro Siwo, or upon cold currents coming from the polar regions or welling upward from the ocean's depths. These all require much more extended study, with much more accurate instruments than have been available heretofore, and with more regard to the details of the contours of the bottoms over which they flow, which are as yet inadequately known.

There are various other features connected with the sea which are of prime importance to the dwellers on the land. But I have said enough to show that the details of the oceanography of the seas surrounding us provide a most inviting field for fundamental research, and also that whatever aspect of the problem may be studied our people as a whole will benefit.

We can not leave the subject of marine investigations without expressing our admiration for the excellent work along the most modern lines now being carried on by the Bureau of Fisheries in cooperation with Harvard University, under the direction of Dr. Henry B. Bigelow; by the Scripps Institution of Oceanography under Dr. T. Wayland Vaughan; by the Coast and Geodetic Survey under Commander N. H. Heck and others, and by the Coast Guard in connection with the International Ice Patrol. This work, and more or less similar work abroad, particularly in England, is recasting the whole subject of oceanography; it is pioneering work of a most fundamental nature. Infinitely more detailed and more accurate than any previous work, it shows us that we must begin the study of our seas anew. The Bureau of Standards and the Navy are developing new types of instruments of far greater accuracy and speed of operation than any we have had before, most of which have not yet been put to use. Truly here is a wonderful opportunity, acting in close cooperation with these men, to perform a most essential service. This the Smithsonian proposes to do along the lines which I have just outlined to you.

Why is the Smithsonian especially well fitted to undertake extensive oceanographic work? In the seventies and eighties when the Fish Commission was a part of the Smithsonian oceanographic work formed an important part of its activities. In recent years the Bureau of Fisheries has been able to do less and less extensive work in the non-economic phases of oceanography. The Smithsonian has in its custody all the collections made by oceanographic expeditions under government auspices, and, in addition, there are available to it the records and the data bearing on the subject in all the government departments. What, then, is more logical than that the Smithsonian, with the great collections in its charge, with a staff qualified to handle them and with its broad contacts, should undertake anew work along the lines in which it achieved so much distinction in the past?

With the cooperation of existing agencies, the Smithsonian now proposes a comprehensive program. To perfect methods the work will begin in a limited area where oceanographic investigations are readily made and will gradually extend to wider fields. It is proposed to determine the basic plant foods of the sea, on which all sea life depends, and to determine the food value to sea creatures of the bottom muds. From these biological beginnings, the work will expand to a survey of physical and chemical conditions, and of the interrelation of the various forms to one another and to the sea environment.

Studies on Insects

In its third phase the Smithsonian's program contemplates a study of the insects. We live in a world replete with other forms of life competing with us for our food supply and even striving to consume the very substance of our bodies. Our chief competitors are the insects, of which more than six hundred thousand kinds are known and vastly more remain to be made known. In growing the crops and stock by which we live, our farmers spend their lives in constant costly warfare with the insects. The number of people who could be fed by the wheat or corn or other grain destroyed by insects, or clothed by the cotton or wool lost every year through insect depredations, represent the casualties on this battle line. We discount these casualties as "losses to the farmer," but take these figures and read them as losses to our army and see what that would mean. The two are quite alike in being both losses to our man power and all that that implies.

The weapons of the fighting armies always represent the highest attainable perfection of the moment. We know that this is necessary. We also know the habits and the customs of our fellow men. The hordes which the farmer is called upon to meet are mostly merely "bugs" to him, while his weapons seldom represent perfection. Each separate kind of "bug," however, is as distinctive in its way as is the human race itself, and must be thoroughly understood in order to be vanquished. Some of our more adaptable native "bugs" may unexpectedly change their habits, or at least seem to do so, especially on being brought into a new locality, and so become transformed from a harmless sort into a serious menace, while hordes of alien "bugs" exist in other lands, of which the gypsy-moth, the boll-worms, the Japanese beetle and the European corn-borer are but samples, waiting to cross the sea to us.

The vast improvement in the means of transportation, especially by automobiles, has in recent years greatly increased our danger from the insects through providing them with an easy means of traveling from one place to another quite unnoticed, hidden in produce or in merchandise. Besides this, our common practice of planting large areas with a single kind of crop year after year greatly assists the insects in their efforts to destroy it. They now find an immense supply of just the right kind of food provided for them and are enabled to increase accordingly. And with the growing extension of our commerce into other lands, we are beginning to feel the local influence of their insect pests.

By far the worst enemies of any insect are other insects of predaceous or parasitic types. As a striking illustration of what parasites can do, I may mention the extirpation of our native cabbage butterfly over most of its range in the United States by the European cabbage butterfly introduced into Quebec in 1858, from which locality it soon spread over most of eastern North America. These two pretty little butterflies are in no way hostile to each other and they live primarily on different food plants, the European preferring cabbage and the native various related native plants. The abundance of cabbages growing in our gardens soon led to an enormous increase in the numbers of the invader, while the native white grew scarcer. Now the native white has completely disappeared from nearly all the region it formerly inhabited in the United States. What is the explanation of this curious phenomenon? The caterpillars of these two related butterflies seem to be attacked by the same parasites. That of the European kind bores into cabbage heads and thus in a large measure escapes attack; that of the native always lives exposed, and therefore is always subject to attack. So the introduction of the European cabbage butterfly has killed off our native one through greatly increasing the numbers of the parasites that attack them both, but from which the European, through the boring habits of the caterpillars, are to a large degree protected.

To indicate the extreme complexity of the insects' war upon each other I shall merely point out that the parasites that destroy the caterpillars are themselves preyed upon within the bodies of the caterpillars by other parasites which by destroying them serve to perpetuate the harmful insects.

The study of entomology is a vast web of interwoven facts full of incongruities and apparent contradictions, almost too vast for human comprehension. I do not need to labor this point, but I shall give one more example, that of those pretty and delicate little butterflies which as caterpillars feed wholly upon large and ferocious ants, especially the dreaded green "tree-driver." Ants are perhaps the most inveterate destroyers of the eggs and very young of nearly all the butterflies; yet no ant will ever hurt the eggs of any of the kinds of butterflies that feed on them.

We are fortunate in this country in having perfected to an extent found in no other land methods for the control of insect pests. But what we have done in this direction has already outstripped the facts upon which must be based really effective work. Our methods have been advanced beyond the detailed knowledge of the results achieved. In our methods of control we do not always know what it is we do.

It is the duty of the Bureau of Entomology to protect us from the ravages of insect pests. But work in economic entomology requires as a starting point an accurate identification of the insect to be studied. This provides the key by means of which we trace the facts concerning it through the literature.

The accurate identification of an insect is by no means a simple matter. In the first place, there are more than six hundred thousand different kinds of insects known, and at least three million more unknown. Of these, new kinds are being described at the rate of about six thousand every year. At this rate we shall still be describing new kinds of insects five hundred years from now. In the second place, in many types of insects the published information is so very widely scattered through such a vast number of different publications in various languages that, unless one happens to be an expert in the particular group concerned, it is almost hopeless to attempt to trace it out. In the third place, many insects, sometimes of widely different habits, are so very similar that it is practically impossible to distinguish them without an actual comparison by an expert with specimens in a reference collection. For instance, in the flesh-flies some kinds live as maggots in decaying meat, other kinds in living turtles, others in snails, and still others on the dead insects in the leaves of pitcher plants. But when these maggots, each with its distinctive habits, grow into adults, none but an expert can distinguish them.

We can see from all this that economic entomology must have the services of a staff of competent men trained to note the differences between the various kinds of insects. The Smithsonian proposes to aid in maintaining such a staff of workers in pure research. As a natural corollary to this work, the Smithsonian will publish monographs in which the widely scattered information will be presented as the basis for efficient advance.

So much for work in systematic entomology. Among the comparatively unexplored fields the physiology of insects offers the greatest promise. Our acquaintance with the insects is largely limited to their obvious relations to us. To deal successfully with them, we must know everything that they do and why they do it; we must understand the food elements necessary for the various types in all their stages and how they use them; their oxygen requirements and various other features. On this depends our knowledge of their tropisms and behavior, what is commonly called psychology in insects, and further our knowledge of the general ecology of insects, their relations with their food and other plants, with each other, with their parasites and enemies in general, and with those humbler forms of life causing disease among them. Here also the Smithsonian's research program contemplates investigation.

The subject of entomology is so very vast and the opportunities for fundamental and most useful work along lines essential to but not intruding on the economic field and not duplicating the efforts of any present student of the subject are so very great that the possibilities for real service, in close cooperation with the Bureau of Entomology and other organizations, and with interested individuals, here seems unlimited.

Under Smithsonian administration there is assembled one of the finest collections of insects in the world, which is constantly receiving additions from the Bureau of Entomology, from the Bureau of Animal Industry, and from other sources, both governmental and private. No other institution in the country offers such facilities for the carrying out of that extensive systematic work on which economic work ultimately depends.

Studies on Fossils

What are the steps in life's progress from the age of trilobites to that of man? Do new forms of life appear suddenly, and, if so, what may we fear or expect of the future? The answers to these questions lie imprisoned in the rocks—the fossils of animals that have lived in the past. But these extinct forms of life are more than historians. They are proving to be an important aid in the economic development of our country. They identify the rock strata and so serve as guides to indicate the presence of our oil, coal and other mineral resources.

A good example of this is furnished by the work of Dr. J. A. Cushman. For many years he devoted his attention to a most detailed and careful study of the recent and fossil Foraminifera, which form a very extensive group of small to minute creatures of, so far as was then known, not the least importance. But the small size of these objects renders them relatively little liable to breakage, either through the action of the waves along the shores, the changes due to the process of fossilization, or the fragmentation of the strata caused by boring operations. As a result of Dr. Cushman's studies, he discovered that these little animals are of enormous economic value in indicating, by the careful and exact determination of the various kinds represented in a sample, the presence of oil-bearing strata. It is not unlikely that other minute fossils will be found to be of corresponding economic interest and value.

During the past thirty years, large collections of fossils, invertebrates, vertebrates and plants have been accumulating under the administration of the Smithsonian Institution. Some of these collections represent fossil faunas that are new to science; others are from areas of which little is now known, and the further study of many others will greatly increase existing knowledge.

The Smithsonian desires to meet the obligation which rests upon it to investigate these, to translate and to interpret the great encyclopedia of facts represented by the fossils in the rocks, of which a large amount of unstudied material is now available and more is constantly coming in, chiefly from the Geological Survey.

As an example of what the Smithsonian has already done along these lines, I may mention the fundamental work of the present secretary, Dr. Charles D. Walcott, on the earliest known life, and especially on the fauna of the Cambrian.

Studies in Anthropology and Archeology

For the study of aboriginal man and the beginnings of culture, the Americas with their numerous Indian tribes provide an ideal field. But the fate of the Indian in North America is sealed. Many tribes have disappeared; others are constantly being drawn into the tide of higher civilization and their story and identity lost forever. The plough is burying traces of their past. Before it is too late, the Smithsonian proposes to continue its studies of the remains left by such peoples as the Basketmakers, the Pueblo Indians and cliff dwellers, the Mississippi mound builders, the Choctaw and Natchez; to discover who constructed the shellheaps which line our coasts and rivers, and to survey the supposed routes through Alaska by which the first human immigrants came to America.

Smithsonian anthropologists propose further to expand the work of thirty years past on the rise of man by investigation of sites in Africa and Java where important discoveries of primitive man have come to light.

In the custody of the Smithsonian there is the most extensive collection of American anthropological material to be found in this country, and in addition the most extensive collection of material bearing on the subject of physical anthropology, as well as the subject of early man. All this material is in charge of a staff of competent curators, working in collaboration with the staff of the Bureau of American Ethnology. With this background the Smithsonian is in a position singularly favorable for the prosecution of research in anthropology and ethnology.

Research on Animal Diseases

It is well known that there is often a distinct relationship between the diseases of man and those of the lower animals. Sometimes they are identical, sometimes very similar, and sometimes a disease of man is dependent upon one of the lower animals as an intermediate host. For instance, it has recently been shown that a peculiar disease called tularemia may be transmitted to man from wild rabbits through the bite of a fly.

The National Zoological Park, under the administration of the Smithsonian Institution, contains one of the finest and most complete collections of wild animals in the country. These are drawn from every land, from the Arctic, from the temperate zones, both north and south, and from every region of the Tropics.

It is proposed to establish in the park a laboratory adequately equipped for the study of the diseases of the animals—mammals, birds and reptiles—in the expectation, indeed the certainty, that much information will be gained which will assist in the solution of many problems connected with the diseases that afflict mankind.

At present the National Zoological Park cooperates so far as possible with the Bureau of Animal Industry in the Department of Agriculture and with the research department of the Johns Hopkins Medical School, both of which find in the park a rich field for their studies. The establishment of a laboratory in the park will greatly assist cooperation with these institutions in addition to furnishing facilities for research work.

Studies on Plants

To a scientific audience, it is not necessary to stress the fundamental importance of the exact determination of the material in any branch of natural science. An exact knowledge of the kind of plants with which one deals is an essential for the botanist. But the correct determination of the plants is by no means an easy matter. In the first place, there are some two hundred and twenty thousand different kinds of flowering plants alone, many differing only very slightly from others of quite different attributes. In the second place, in various groups we have as yet no very clear idea as to what characters separate the various kinds; much revisionary work of a fundamental nature remains yet to be done.

With the National Herbarium under its administration, the Smithsonian Institution is in a position singularly favorable for the prosecution of detailed, extensive and continuous work in systematic botany, working in cooperation with other institutions. Such work would very greatly aid and supplement the work of the Department of Agriculture and of numerous state and private agencies without in any way competing with them. Further, we must extend our information concerning the plants of regions as yet but little known.

Less is known of the plant life of northern South America than of almost any other section of the Western Hemisphere. Before plants yielding drugs, gums, fruits, fibres, dyes and oils can efficiently be made available to the world, they must be discovered, named and described. In an expansion of work already begun, the Smithsonian in cooperation with four other institutions plans as part of its botanical program to study the plants of Colombia, Ecuador and Venezuela.

Research Assistants

The first essential for any effective work is men. All the equipment, material and tools in the world are of little value without capable men to handle them. We all admit that not every one can be an artist, though it is not so commonly realized that not every one can be developed into a first class scientific man. In so far as research in pure science means the discovery of new facts and their interpretation, the number of men who can achieve success in this field is limited. Really first-class research men must be developed from a basis of superior natural abilities, and during their development they must be prepared to undergo a long and grueling apprenticeship.

What do we find the situation of pure research to be with regard to the men engaged in it? In the first place, the men are far too few in numbers. The superior and more immediate rewards in applied science are thinning the ranks of those seeking new facts without regard to their economic application. Mr. Hoover recently calculated the number of workers in pure science to be three thousand as against thirty thousand in applied science. And yet these thirty thousand are comparatively helpless without the basic work of the three thousand.

This is a serious situation. That part of the Smithsonian program which contemplates the securing and training in research of superior men is therefore of prime importance.

In what way does the Smithsonian propose to train these men?

The National Museum, under the direction of the Smithsonian Institution, is the legal repository of all collections made by the various governmental agencies and of the data accompanying them. Thus, for instance, the plants, vertebrates, animal parasites and insects gathered by the Department of Agriculture, the marine life and the bottom samples gathered by the Bureau of Fisheries, the Coast Guard, the Navy and other agencies, and the fossils and minerals gathered by the Geological Survey are all deposited in the National Museum.

All these collections are under the immediate care of a staff of curators and their assistants who are responsible for their upkeep, and who are expected to devote such time as may be spared from their strictly curatorial duties to increasing the value of the collections in their care by a detailed study of them leading to the discovery of new facts. The first responsibility of the curators is the care of the collections. These are so large and are increasing so rapidly that their available time for original work upon them is limited.

Here the Smithsonian offers a unique opportunity for giving experience in pure research along certain lines, for preparing selected men and women for fundamental research out of which eventually is bound to come the highest type of constructive economic work. How does the institution propose to do this? The Smithsonian has more freedom of action in pure science than any of the governmental agencies and is exceptionally well placed to undertake investigations in pure science, not only in restricted subjects, but also along lines involving several different branches of science. With increased resources the institution plans to take on each year a certain number of promising young men and women in the capacity of research assistants. These research assistants will get their training under the guidance of men of established reputation, and will be privileged to work upon collections which certainly are not surpassed in interest and in extent anywhere in this country. They will see science as a whole and thus will get a larger perspective than if they were working in an isolated field or in an isolated place; and furthermore constant contact with men in other lines of scientific activity will stimulate interest and understanding.

In this way the Smithsonian Institution confidently expects not only to build up its own staff, but also to increase the number of trained men available for pure research in the country, and in doing both greatly to increase the value of the collections under its administration.

EXPLORATIONS

From its inception the Smithsonian has been interested in exploration. Heretofore exploring expeditions have been largely in the nature of collecting trips which as they went along gathered up material of every sort from the regions that they traversed. So much has now been done that such general expeditions no longer yield results commensurate with the expense involved. We have a pretty good idea of the general features of the world, so that general expeditions increasingly result in duplicating work already done with the resultant waste of effort.

We have now reached the time when fruitful and efficient exploration can be undertaken only after adequate study and preparation, with very definite aims in view and with as many different lines of scientific work as possible served in each endeavor. Intensive rather than extensive exploration is the need to-day, equally in zoology and in botany.

The Smithsonian Institution plans from time to time, as occasions may arise or as opportunities may offer, to send out expeditions to those regions as yet but little known, especially in Central and in South America, expeditions thoroughly equipped and with a personnel competent to carry on at the same time many different though correlated lines of work. As in the past it is expected that these expeditions will often be undertaken in cooperation with other institutions.

PUBLICATIONS

In any country progress in science is dependent on the appreciation of an interested public. The theory that it is the hobby of the rich and leisure classes and that effective advance can be made in it thanks to the restricted patronage of a Louis XIV will not hold water. Isolated steps may be taken in such a way, but a great sound body of science can no more be built without the interest and backing and yes even participation of a large part of the population than the Cathedral of Chartres could have been built by the nobles of Beauce alone. The best science, like the finest art, belongs to the people and must express their interests.

I suppose that no one will deny that England with her Newtons, her Faradays, her Darwins, her Lubbocks, leaders in every branch of science, holds first place in the discovery of basic scientific principles. It is equally undeniable that interest in science among the common people is greater in England than in any other country. There exist in that country any quantity of scientific societies made up largely of working men and tradesmen. The relationship between these two sets of facts is beyond question.

So much to indicate the dependence of scientific advance upon popular support. What of America? We are to-day witnessing a flowering of interest in science in this country which is without precedent. A number of startling achievements such as the automobile, the aeroplane, the radio, the X-ray—all products of pure research—have forcibly impressed upon every man the concrete significance of science to himself. Science owes it to itself to meet this new-born interest and to nourish it. And the medium through which it must work to these ends is primarily the press—newspapers, magazines, books. We have got to devote an increasing share of our attention to publication.

So far as newspapers and magazines are concerned, the interest exists. We do not have to create it. Our responsibility and opportunity consist in providing accurate material and plenty of it. Where we must stimulate publication is in the presentation of the results of research in pure science, and that is commonly presented in technical treatises and monographs.

Our facilities in this respect as a result of the increased cost of printing and as a result of the growing demand for popular enlightenment have fallen far behind what they were two decades ago. Yet the necessity for such publication has increased enormously, while far more first-class material is produced than can possibly be taken care of. Each of you here either has manuscripts of your own or knows of others containing the results of work to which years have been devoted hidden away with no immediate prospect of publication. This is particularly true in regard to comprehensive monographic works, invaluable summaries of the life studies of able men, in which all previous information on the subject treated is included.

Monographs are the stepping stones to more efficient work through summarizing all that has been done before. The value of the time saved to students by each such comprehensive work may safely be measured in thousands of dollars.

It is safe to say that without adequate facilities for publication research work is largely futile. No scientific man any longer works alone. All future advances must be based on what other men have done, and the further the advance the more this is true. Perhaps the greatest scientific need to-day is for vastly increased facilities for the publication of results of research in pure science. The recognition of this fact is no new thing on the part of the Smithsonian Institution. In the founder's single statement of purpose —"for the increase and diffusion of knowledge among men"—publication is given a place in importance equal to research. As Secretary Henry said in his plan of organization drawn up in 1846, "Knowledge can be most successfully diffused among men by means of the press."

In obedience to the expressed will of James Smithson and to the interpretation thereof by Joseph Henry, the Smithsonian has for eighty years maintained a definite program of publication with such success that these publications have come to be among the best-known books of the scientific libraries of the world. Who among you does not know of the "Contributions to Knowledge" series, of the "Miscellaneous Collections," of the "Smithsonian Physical Tables"? These various series include the results of pure research in widely different lines of science, many of which would never have been published had not the Smithsonian undertaken the work.

Not only has the Smithsonian faithfully striven to publish the results of as much fundamental research work as possible, but it has made sure that these publications would do the greatest amount of good by the free distribution of them among scientific bodies and libraries in all parts of the world. It is no uncommon thing for a traveler in Siam, for instance, in Borneo, in Nairobi, in Uruguay, in Queensland to come upon local scientific groups, the libraries of which give a place of honor to the torch of the Smithsonian publications.

In recent years the greatly increased cost of printing has forced the Smithsonian to suspend the "Contributions to Knowledge" series altogether, and to reduce the "Miscellaneous Collections" to a third of the number published annually before the war. While I have no desire to overdraw the picture, I can not forbear calling this a tragedy. The Smithsonian Institution earnestly desires not only to resume publication on the former scale, but to increase it to an extent more nearly commensurate with modern needs.

In this ambition we know that we can count upon the support of every man of science in America.

THE FUTURE

At the present time the enormous extension of applied science and its superior rewards are attracting to this line of work much of the best material from among the graduates and from the faculties and staffs of our educational and other institutions. Consequently the sources to which we must look for the elaboration of new ideas and theories are gradually drying up. The application of facts already known is outrunning the discovery of new facts. And yet application is dependent upon discovery; it can not come before. Our first duty, therefore, is to support agencies for the discovery of new facts.

Quite apart from the ultimate materialism of this point of view, such mining for new truths is the nearest approach that man can make to the intriguing realm of the unknowable. Such mining will assist man's spiritual growth, while at the same time adding to his material prosperity. Let us not turn aside from this opportunity.

The Smithsonian Institution is consecrated to a definite program of research in pure science and the publication of the results thereof. So it has been for eighty years. So it is now that we are on the threshold of new endeavors. You know what the institution has done. I have told you what it proposes to do. In carrying out its program for research, publication and the training of promising men and women, the Smithsonian will perform a fundamental service to the American people and to the American government. Only by the performance of such service will it continue worthy of the traditions of achievement which have made it "The Smithsonian Institution."

AUSTIN H. CLARK

SMITHSONIAN INSTITUTION

EDWARD SYLVESTER MORSE

PROFESSOR MORSE, son of Jonathan K. and Jane Seymour (Beckett) Morse was born in Portland, Maine, June 18, 1838, and died at Salem, Mass., Dec. 20, 1925. Like most naturalists he early showed an interest in natural history, amassing a notable collection of shells at the age of thirteen, and what is less common, he developed unusual artistic ability. He made for Dr. William Stimpson numerous admirable drawings of living mollusks of the Maine coast. In 1859 he became one of Louis Agassiz's special students at the Museum of Comparative Zoology, where he pursued his studies until 1862 when he published his first paper on brachiopods, a subject to which he later made notable contributions. His first paper to attract particular attention was devoted to some very minute landshells of Maine, illustrated by his own drawings and proposing new generic names for several of them based on anatomical characters. This paper, published in 1864, was the precursor of a long series of studies by Bland, W. G. Binney and