pox, vaccinia, yellow fever, human influenza, swine influenza, measles, chickenpox, shingles, lymphogranuloma inguinale, pseudo-rabies, cattle plague, leucosis of fowls, Rous's sarcoma of chickens, peach yellows, curly top of beets, aster yellows and bacteriophagy. This partial list leaves no doubt in the mind of any one that the virus group of maladies is an extremely important factor in the physical and economic well-being of man.

In addition to the immediate importance of virus diseases, there is a more remote one of a philosophical trend which has to do with the nature and origin of their causative agents. A consideration of this phase of the problem eventually leads to a discussion of the nature and origin of life. As every one knows, this discussion was started many years ago. In 1872, it was already well under way in relation to bacteria which at that time were considered the smallest of living things or as Pouchet expressed it "the infinitely small in biology." Indeed, Cohn in an article of that year made the following statement: "Through these facts we surely have a right to hope that in the development of bacteria the key will be found to the origin of life in the world in general."

Scientists of seventy years ago were hoping to find in a study of bacteria an answer to questions about the origin and nature of life. After a time it was realized that these small entities are not simple but quite complex and that it would be unlikely to find in a study of them all the secrets of the origin and nature of life. When a group of infectious agents, the viruses, was found, members of which are smaller than ordinary bacteria, when it was realized that some of them are much smaller than ordinary bacteria even approaching in size that of certain protein molecules, and when a few of these infectious agents were shown to be crystalline proteins, the old discussions regarding the origin and nature of life and what constitutes "the infinitely small in biology" were resurrected and clothed in new garments. Dr. Stanley has played a leading rôle in these discussions and has said and done many things to arouse the curiosity of numerous investigators in many and diverse fields of science.

In these times when the world is greatly disturbed by wars and rumors of wars, it is nice to take a recess from anxiety about what is going to happen to us and our cherished institutions and pay tribute to a man who seeks to make life on this earth more profitable and pleasant. In this connection there comes to mind a statement made by Louis Pasteur in 1888:

> Two contrary laws seem to be wrestling with each other nowadays; the one, a law of blood and of death, ever imagining new means of destruction and forcing nations to be constantly ready for the battlefield—the other a law of peace, work, and health, ever evolving new means of delivering man from the scourges which beset him.
>
> The one seeks violent conquests, the other the relief of humanity. The latter places one human life above any victory; while the former would sacrifice hundreds and thousands of lives. . . .

Mr. President, I have the privilege of presenting to you for the high honor of the Gold Medal of the American Institute of the City of New York, a true pioneer in science, one investigating "the infinitely small in biology," a man respected and honored by his colleagues, my friend, Dr. Wendell M. Stanley.

SOME CHEMICAL, MEDICAL AND PHILOSOPHICAL ASPECTS OF VIRUSES[1]

By Dr. W. M. STANLEY

MEMBER OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, PRINCETON, N. J.

I DEEPLY appreciate the high honor which is conferred by this presentation of the Gold Medal of The American Institute of the City of New York for crystallizing the virus of tobacco mosaic. However, I should perhaps say that I greatly doubt that the crystallization of tobacco mosaic virus which I accomplished in 1935 was the first time that this material had been crystallized. It has been known for years that crystalline inclusions occur within the cells of certain mosaic-diseased plants. Within the past few years, evidence was obtained that this crystalline material consists almost exclusively of tobacco mosaic virus; hence, credit for first crystallizing this virus must go to nature. It might be expected that I should be able to claim to have been the first person to bring about the crystallization of this material. However, I believe that even this is denied me. In 1904 Iwanowski prepared stained sections of mosaic-diseased leaves and noted that the addition of an acid fixative caused the formation of a "striate material." I think, in view of present-day knowledge, that the striate material was crystalline tobacco mosaic virus which was induced to crystallize by the addition of the acid fixative. Therefore, to Iwanowski, who is already credited with the discovery of viruses in 1892, must also go the credit for the first crystallization of a virus. Now, in order to forestall the beginnings of wonderment in the minds of some of you as to why we should be gathered here

[1] Address accepting the 1941 Gold Medal of the American Institute of the City of New York.

to-night, let me hurry on to say that, judging from their writings, neither Iwanowski nor any of the persons who subsequently described the striate material envisioned the possibility that it might be in fact tobacco mosaic virus. It is obvious, therefore, that this medal is not being awarded for the simple feat of crystallizing this material, but rather because the isolation of the crystalline protein in 1935 was accompanied by the realization that it might be tobacco mosaic virus, because of the subsequent work which has demonstrated beyond a reasonable doubt that it is crystalline tobacco mosaic virus, and especially because of the impact which a full realization of the diverse implications of this fact is having and will have upon the thoughts and actions of scientists.

Before entering upon a discussion of these implications, I should like to digress for just a few moments and tell you something of the events which preceded the isolation and crystallization of tobacco mosaic virus. The Board of Directors of The Rockefeller Institute decided to establish a Laboratory of Plant Pathology at Princeton in 1931 in conjunction with the then existing Department of Animal Pathology, so that comparative studies of diseases of plants, animals and man could be carried out within a single organization. The director, Dr. Flexner, and the newly selected leader of this group, Dr. Kunkel, invited me to go to Princeton to do chemical work on viruses. Although I hardly knew the correct definition of a virus, I was in a receptive mood for this invitation, for my interest in the application of chemistry to medical problems had been awakened during my years as a graduate student in organic chemistry with Roger Adams at the University of Illinois and nurtured by a year's study on sterols with Wieland in Munich and by a year with Dr. Osterhout at the Institute in New York. It seemed to me that the biological activity represented by a given virus must belong to some tangible entity and, whether it be an organism, molecule, "molechism" or "organule," it should be possible by chemical methods to purify, concentrate and eventually isolate this entity and learn something of its general nature. I knew that Dr. Kunkel was firmly convinced, like most people, as Dr. Rivers has already pointed out, that viruses were merely still smaller living organisms, but I also knew that Dr. Kunkel, unlike many others, was nevertheless firmly convinced of the advisability of conducting chemical investigations on viruses. Furthermore, at that time the work of Allard and others, especially that of Dr. Vinson, who was associated with Dr. Kunkel at the Boyce Thompson Institute, had demonstrated that one virus, namely, tobacco mosaic virus, could be manipulated successfully by ordinary chemical methods. This pioneer work of Vinson and others was very important because it indicated that, regardless of its nature, tobacco mosaic virus was susceptible to chemical attack.

Another event which had just occurred and which was to have a great influence on the chemical work was the demonstration by Dr. Holmes that tobacco mosaic virus would cause local lesions or spots on the leaves of certain plants and that the number of these spots could be used as an index of the virus concentration in the inoculum. In earlier work it had been very difficult, following separation of a given virus preparation into two or more fractions, to determine which fraction contained most of the virus. The local lesion method did not receive immediately the attention which it merited. It was, however, used extensively throughout the course of the chemical work at Princeton and the importance of the fact that by means of this technique differences of 10 to 20 per cent. in virus concentration could be determined readily can not be overestimated. Another happy circumstance was the location of the Laboratory of Plant Pathology only about 100 yards from Dr. Northrop's laboratory, where it had just been demonstrated that certain enzymatic activities were the specific properties of certain protein molecules. The latter fact and a close and cordial association with Dr. Northrop and his coworkers had a profound influence on the course of the chemical work on the plant viruses. Also of great importance was the fact that by virtue of the location of the chemistry laboratory in a Department of Animal and Plant Pathology, it was possible to consult animal or plant pathologists at a moment's notice and through them to gain access to a tremendous store of knowledge of viruses. As a matter of fact, in retrospect, it is difficult to see how the combination of the factors which I have just described could have resulted otherwise than in the isolation and crystallization of tobacco mosaic virus. In many different ways the time was most opportune. It is obvious, therefore, that the event which is being celebrated tonight came about as the result of the interplay of many factors, each of which was of such importance in its own right that its omission might have delayed for years the result that has been achieved. Thus, the Gold Medal Award honors the many individuals associated with these factors and stands as a symbol of the importance of the culmination of these factors in the isolation and crystallization of tobacco mosaic virus and of the influence which this has had and may be expected to have in many different fields of scientific endeavor.

Dr. Rivers has told you that viruses as disease-producing agents have been recognized for only about 42 years but that during most of this time the general consensus of opinion has been that these agents are very small organisms. However, the material which was isolated and crystallized in 1935 and which carried all the virus activity of the starting material proved to be a nucleoprotein which was larger than any protein heretofore known. The immediate task which presented itself was to prove that the virus activity either was or was not a specific property of this unusually large nucleoprotein. This was, or at least appeared to be, a rather simple chemical problem. It was found that this same material having constant chemical and biological properties could be obtained not only from mosaic-diseased Turkish tobacco plants but also from many other species of mosaic-diseased plants. The amount isolable was found to vary greatly and to depend upon the nature of the host. The material could be taken into solution and recrystallized, subjected to different types of chemical manipulation, passed through fine collodion membranes, and mixed with other biologically active as well as inactive proteins and reisolated without causing a loss of the virus activity. Many attempts based on diverse techniques were made to separate the virus activity from the nucleoprotein, but none was successful. Of special significance is the fact that by one type of chemical treatment it was possible to cause structural changes in the large nucleoprotein and loss of virus activity, but by reversing the structural changes the virus activity was regained. This result and the other experiments which I have described briefly are all compatible with the idea that the virus activity is a specific property of the nucleoprotein.

However, if the nucleoprotein is tobacco mosaic virus, then it should occur solely in mosaic-diseased plants and should not occur in plants diseased only with other viruses. It was soon found that plants diseased with certain other viruses contained different amounts of high molecular weight nucleoproteins, but that in each case the amount and the properties of the nucleoprotein which was isolated were different and characteristic of the virus. A more severe test was provided by the examination of the same type of host plant diseased with different strains of tobacco mosaic virus. This resulted in the isolation of quite similar nucleoproteins which, however, occurred in different amounts and possessed slightly different properties that have in each case proved to be characteristic of the given strain. These results demonstrated that in every case the nucleoprotein isolated was always characteristic of the infecting agent regardless of the host, the virus or the strain of the virus. On the basis of the experiments which I have described and many more which can not be discussed because of lack of time, it was concluded that the large nucleoprotein was in fact tobacco mosaic virus. This conclusion did not receive universal acceptance, and I well remember the many arguments which ensued. Fortunately, the trend of the opposing argument was usually the same and was to the effect that viruses were living organisms; hence the crystalline nucleoprotein could not possibly be the virus, for obviously it was not an organism. It was always assumed that the virus activity accompanying the nucleoprotein was due to contaminating organisms. When asked to describe the properties of these organisms, it was usually stated that they had the same properties as those of the nucleoprotein, which of course must be the case if the organisms were to remain undetected by the searching chemical, physical and serological examination to which the preparations had been subjected. I suppose that such a possibility must always be granted, but from a practical standpoint it is obvious that it is absolutely unnecessary to postulate the existence of two entities when one is sufficient to satisfy the data.

Because no opposing argument more serious than the one I just mentioned has been advanced, but more especially because during the ensuing years there has issued from laboratories all over the world a great mass of experimental data which indicated that the virus activity is a specific property of the nucleoprotein, there has come to be an almost universal acceptance of the idea that the nucleoprotein is tobacco mosaic virus. This idea is accepted so completely in my laboratory that we work with and think of tobacco mosaic virus much as we would with simple organic molecules. I have already indicated that we have inactivated and reactivated the virus by bringing about and then reversing certain structural changes. Recently Dr. Anson and Dr. Miller were able to cause different kinds of structural changes without inactivating the virus. It is significant that these changes in structure not only did not inactivate the virus but were not perpetuated in subsequent generations. Still other relatively minor changes in structure have been found to cause inactivation. It is obvious that by focusing the chemical attack on different points of the architecture of the molecule, it should be possible to determine whether virus activity results from some force emanating from essentially the whole structure or from an unusual field of force localized at some definite position or positions. This is thrilling work, for, because of the peculiar nature of virus activity, a change in structure may result in a loss of activity or result in the retention of activity either with or without the perpetuation of the structural change in subsequent generations. The second possibility is important because it would correspond to the mutation of a virus induced by known structural changes with the formation of a new active structure which presumably would cause a new disease. Each of the three possibilities has deep-seated medical implications which I shall discuss in a few moments.

At this time I should like to tell you about some rather interesting special properties of tobacco mosaic virus. Solutions of this virus exhibit what is known as double refraction of flow. When examined by means of polarized light, the flowing stream is found to be doubly refracting, whereas when quiescent the same material is not doubly refracting. This property may prove of importance in apparently unrelated fields for, because of it, solutions of tobacco mosaic virus could be used to study the flow currents in apparatus such as pumps and hydraulic rams or the nature of the flow when boats or projectiles move through the liquid. If the solution of virus is sufficiently concentrated, it may gradually separate out into two layers, the lower of which is spontaneously doubly refracting and the upper of which shows double refraction only when caused to flow. Because of this behavior, it has been inferred that the particles of the virus are not spherical but markedly anisometrical in shape. By means of indirect methods, Dr. Lauffer estimated that the virus molecules were about 400 mμ in length and about 12 mμ in width and had a molecular weight of about 40 millions. From x-ray data, Bernal and Fankuchen inferred that the virus molecules had a diameter of 15 mμ and a length of some value greater than 150 mμ. They also suggested that the needle-like virus crystals described in 1935 consisted of these molecules arranged laterally in two-dimensional hexagonal close packing and that this form of the virus should be referred to as para-crystalline but that the individual molecules had such a regular internal structure that each molecule was in effect a single crystal.

It has been stated that the asymmetry and molecular weight values obtained for tobacco mosaic virus by certain indirect methods are wholly ambiguous, but it has always been my opinion that these values were reasonably valid. However, it is obvious that, because of the relatively small size of the virus particles, a means for their direct mensuration has been lacking. Fortunately, a new approach to this general problem was provided recently by the development of electron microscopes having resolving powers extending down to about 5 mμ. Since the limit of resolution for visual light is about 250 mμ and most viruses are known to range in size from about 250 mμ down to about 10 mμ, this new apparatus offered for the first time the possibility of securing pictures of the individual particles of such viruses and thus of establishing their sizes and shapes with some precision. The Radio Corporation of America, through Dr. Zworykin, has generously made an electron microscope available to us and by means of this instrument Dr. Anderson has secured many micrographs not only of tobacco mosaic virus but of other viruses. In the case of tobacco mosaic virus, the micrographs showed a preponderance of particles having a length of about 280 mμ and a width of about 18 mμ and served to prove beyond a reasonable doubt that this virus is rod-like in shape. Earlier micrographs obtained by Kausche and Ruska had also shown a rod-like shape for this virus. The size and distinctive shape of tobacco mosaic virus make it an admirable subject for study under the electron microscope. The reaction between this virus and a gold sol having spherical particles about 40 mμ in diameter has been studied by Kausche and Ruska and recently Dr. Anderson and I were able to follow the interaction of molecules of tobacco mosaic virus with certain smaller molecules. The electron microscope has also made it possible to confirm earlier indirect evidence that two or more molecules of virus may combine end-to-end to form long aggregates. The nature of the forces which are responsible for this peculiar type of aggregation is unknown. Langmuir and also Levine recently showed that there are good theoretical grounds for the existence of interparticle forces effective over large distances, and Bernal has made use of these in a theory of the duplication of chromosomes. It is obvious that the electron microscope has opened up new fields of research and has provided a new method of attack on older problems.

The medical aspects of viruses are perhaps the most important and intriguing not only from a scientific standpoint but also from a personal standpoint, since most of us have at some time suffered from one or more attacks of a virus. In the absence of living cells, these agents appear as harmless and as lifeless as pebbles on a beach, yet even after years of inactivity some viruses may spring into action and cause disease and death when introduced by chance or by design into certain living cells. It is at this point that we are being forced to the greatest revision of our ideas, for the virus structures, some of which have the chemical and physical properties usually ascribed to molecules, appear to be able to enter into the metabolic chain of events within cells and so alter normal metabolic activity that replicas of the virus structure are produced. All viruses so far purified have been found to contain or to consist of nucleoprotein, and this fact may be of special significance, for the bearers of heredity which we all carry within all the cells of our bodies and which may be regarded as virus-like because of their reproductive ability have also been found to be nucleoproteins. Some workers consider it possible that viruses may be derived from genes or nuclear material. Other workers entertain the idea that the alteration of some normal intracellular constituent either by the fortuitous contact with a normal material having a structure similar to that of the sex hormones or through the action of other carcinogenic agents may result in the freeing of a virus-like entity which then dominates intracellular activity. I should perhaps mention at this point that there may be a direct relationship between viruses and cancer, for it is conceivable that such a sequence of events might result in the inauguration of a cancerous growth. This idea can not be dismissed as being preposterous, for in 1911 Rous demonstrated that a chicken tumor was caused by a virus, and during the past few years he has shown that a close relationship exists between the Shope papilloma virus and the cancers which usually develop from the virus-induced papillomas in domestic rabbits.

It is possible that there exists within our cells masked or latent forms of viruses which may at some time be stirred into action by mutation or by some other provocative influence. Several cases of the harboring of viruses by presumably normal cells have already been discovered. For example, practically all of the potato plants grown in the United States are known to carry a virus. The plants might be regarded as normal, for the presence of this infectious agent, known as the latent mosaic of potato virus, can not be demonstrated readily so long as one works only with potato plants. Its presence can be demonstrated easily, however, by applying extracts of such plants to certain other plants, such as Turkish tobacco, which respond to the virus with obvious disease symptoms.

The roads traversed by viruses appear to be many and devious and not always apparent. Shope has recently shown that swine influenza virus may be harbored within lung worm larvae carried in turn within earthworms for many months, and that the ingestion of these earthworms by swine may result at some later date, following a provocative stimulus, in an attack of swine influenza. Although the virus can not be demonstrated directly when in the lung worm larvae within the earthworm, the results show it to be present at the start of the sequence of events and it is demonstrable at the end. The situation may be likened to that of a train going through a tunnel—you may see the train as it enters and as it leaves the tunnel, but it is not apparent while in the tunnel. This brilliant work in which a virus has been traced from a diseased host through a long and circuitous path involving two intermediate hosts back to a normal host and other work on intermediate virus hosts such as insects make one pause and wonder whether similar situations may not obtain in the cases of other virus diseases. It is already known among other things that the actual amount of virus present in a host may vary as much as 100-fold at different stages of the disease. Another point of considerable importance is the fact that some diseases result from the combined action of two infectious agents. Thus in 1926 Vanderpool showed that tomato streak was due to tobacco mosaic and potato mosaic viruses and Shope discovered that swine influenza results from the combined action of a virus and a bacterium.

Let us consider briefly some of the measures which have been taken to control the activities of viruses. Plant virus diseases represent a special case because of the nature of the plant circulatory system and the fact that plants do not appear to develop antibodies. Consequently, control measures consist largely of special methods for preventing infection and the use of resistant varieties of plants, although, as Kunkel has shown, heat treatment may be used to cure certain virus-diseased plants. There are, as you may know, three general methods which are employed in the protection of man and animals against virus diseases. In the first method, active virus is used in conjunction with immune serum. The second method, which involves the use of active virus of a strain which will cause an innocuous disease, is employed extensively and successfully against smallpox, yellow fever and certain other viruses. The strains of virus used for immunization may be secured by passing the virus through other hosts. For example, in the protection against smallpox a strain of this virus obtained by passage through calves may be used and for yellow fever a strain originally obtained by passing this virus through mouse brains is used. The change in environment during the production of virus in the second host apparently results in the formation or selection of a strain of virus which is much less virulent in the first host. We know from our work with tobacco mosaic virus that its strains consist of closely related nucleoproteins which nevertheless have slightly different properties. Recently Dr. Knight secured information concerning the nature of the chemical differences between strains of this virus. It seems likely, therefore, that passage of a virus through another host may yield a virus strain having a different chemical structure. Although at present we know little about the nature of the change or why it occurs, the work with the plant viruses indicates that eventually these problems will be elucidated. Furthermore, the production of new and useful strains of viruses by means of structural changes brought about *in vitro* by definite chemical reactions offers even greater possibilities in connection with this general method of protection.

The third general method involves the use of inactivated virus and has been used in the past with claims for success for many viruses such as rinderpest, hog cholera, dog distemper, influenza and others. The method is now being widely used in the case of equine encephalomyelitis virus. The success of this method appears to depend upon securing by chemical or physical treatment structural changes of sufficient magnitude to cause loss of virus activity but insufficient to cause much change in the antigenic properties.

In other words, the virus must be inactivated but the resulting structure must on injection be able to induce the formation of antibodies which will neutralize the active virus. This result was achieved in work with certain of the plant viruses and anti-plant-virus rabbit sera some years ago, but it was obvious from the results that each virus would have to be studied individually in order to arrive at the best method for inactivation. The problems involved are chiefly chemical in nature and they are receiving considerable attention at present. Some of you may be wondering why, with all of the information which now appears to be available, we are not protecting our general population against such virus diseases as influenza and poliomyelitis. It so happens that, although we know much about certain viruses, we know relatively little about other viruses. This is due to such factors as availability, stability, ease of titration and existence of a good experimental host, which cause one virus to be an especially favorable experimental subject and another virus to be a very poor experimental subject. For example, work with poliomyelitis virus has been especially difficult because it has been necessary to use a certain kind of monkey as the experimental host and only a very small portion of the animal contains a good concentration of virus. Therefore, the amount of diseased tissue available as starting material for experimentation is definitely limited and the titration of the virus is extremely difficult and very expensive. Factors such as these represent the bottlenecks in virus research, and as they are eliminated a burst of progress usually results. Thus, Theiler's discovery of the mouse as an experimental host for yellow fever virus and TenBroeck's discovery of the existence of a tremendously high concentration of equine encephalomyelitis virus in diseased chick embryos not only made possible new and diverse studies but led directly to methods of protection against the ravages of these two viruses. Therefore, the emphasis of the research work must in some cases be placed on ways and means for securing larger amounts of virus, in others on studies of titration methods, and in still others in a search for a good experimental host. However, it should be recognized that advances made in connection with any one virus aid greatly in the work with other viruses and that, although the fight should be pushed forward vigorously on all fronts, complete advantage should be taken of those viruses which, like tobacco mosaic virus, have already proved to be unusually favorable experimental material.

In closing I should like to discuss briefly some of the philosophical aspects of viruses. Dr. Rivers has already indicated that a consideration of the nature and origin of viruses eventually leads to a discussion of the nature and origin of life. It is possible that viruses have always been produced only by the action of viruses or of virus-like entities within cells, or that they have not always existed but arose from bacteria by a process of retrograde evolution under parasitism with loss of function and associated substance. These are examples of biogenesis, and opposed to this theory to-day as in Pasteur's day is heterogenesis or spontaneous generation, the outstanding advocate of which is Oparin, who has described in detail a possible mode of evolution of matter. Since one of the outstanding properties of viruses to-day is their dependence upon living cells for reproduction, it has been reasoned that they are the supreme representatives of obligate parasitism and hence followed cells in the process of evolution. However, other persons argue that it is but a step from synthesis *in vivo* to synthesis *in vitro* and prefer to use the viruses as proof that a molecule may duplicate itself *in vitro*. It must be admitted that the theory of heterogenesis is most challenging and would serve to explain the origin of viruses.

However, I think that there is another approach to the general problem which merits consideration. In order to have spontaneous generation, there must be a difference between living things and inanimate things and, despite the general acceptance that a difference does exist and the building on the one side of two schools of thought, vitalism and mechanism, a few feeble although penetrating voices have cried out on the other side. Over 2,000 years ago Aristotle is supposed to have said that nature makes so gradual a transition from the animate to the inanimate that the boundary line between the two is doubtful and perhaps non-existent. Spinoza expressed the concept that all matter possesses different degrees of life depending upon the organization. I believe that the virus data now available enable us to visualize this general idea with a new understanding. It is difficult, if not impossible, to place a sharp line separating living from non-living things when one considers a series of structures of gradually increasing complexity such as would be represented by hydrogen, water, benzene, ergosterol, egg albumin, insulin, pepsin, tobacco mosaic virus, papilloma virus, vaccine virus, pleuropneumonia organism, bacteria, a mammal like a dog and intervening entities. The problem is similar to that encountered when an attempt is made to determine the exact point at which one color blends into another in a color spectrum or when one attempts to establish just where acid becomes alkaline. It is possible, of course, to set up arbitrarily a point of division as has been done for acid and alkali, but this can not detract from the fact that the difference is not of a fundamental nature but merely one of degree. It has been said that living things differ from non-living things in that for the former the total is always equal to more than the sum of the parts. Yet the same is true for even simple molecules, for, knowing only the two gases oxygen and hydrogen, who could have predicted the properties of the water molecules formed by a certain combination of these gases? It is obvious that as new structures are formed new properties characteristic of these structures are evolved. I believe that the work on viruses has provided us with new reasons for considering that life as we know it owes its existence to a specific state of matter and that the principle of the vital phenomenon does not come into existence suddenly but is inherent in all matter.

SCIENTIFIC EVENTS

EXPEDITIONS SENT OUT BY THE U. S. NATIONAL MUSEUM

Twelve scientific expeditions were conducted by members of the staff of the U. S. National Museum during the past fiscal year. They were for a variety of purposes such as collecting animals of many kinds, fossils and geological specimens and archeological materials, many of which will serve as reference types for American scientists. These expeditions are described in the report of Dr. Alexander Wetmore, assistant secretary of the Smithsonian Institution, who is in charge of the museum.

One was an anthropological survey in Russia and Siberia by Dr. Aleš Hrdlička, curator of physical anthropology, to study remains of peoples who may have been closely related to the ancestors of the American Indians. The red men are generally believed to have been neolithic Asiatic peoples who entered North America by way of Alaska.

The eastward extension of Pueblo Indian influences into Kansas was studied by Dr. Waldo R. Wedel, of the museum staff. The builders of the great "apartment houses" of the Southwest are popularly supposed to have been confined to that part of the continent. Actually small buildings on the Pueblo model are found extending into the Great Plains area although the exact relationships between their builders and the southwesterners still remain to be found.

Dr. W. F. Foshag, curator of physical and chemical geology, collected specimens of rare minerals in Mexican mines. Dr. G. A. Cooper, with Dr. Josiah Bridge, of the U. S. Geological Survey, journeyed from Nevada to north-central Indiana in search of invertebrate fossils of the Devonian and Ordovician periods in the history of the earth. They collected many types of fossils new to the collections, including some new to science.

Dr. C. W. Gilmore, curator of vertebrate paleontology, assisted in a survey of the Big Bend region of Texas, which has been proposed for a national park. The area, he found, gives considerable promise of yielding dinosaur remains.

Dr. Leonard P. Schultz, curator of fishes, brought back a collection of about 14,000 fishes, together with mollusks, echinoderms, worms, other marine invertebrates, reptiles, birds, mammals and plants from the Phoenix and Samoan Islands. He served as naturalist on a U. S. naval expedition.

As in past years, Captain Robert A. Bartlett, who has long served as a collaborator of the museum, brought valuable specimens from Greenland waters. Among these this year was a collection of Arctic plants.

There were 2,505,171 visitors to the various buildings during the year. This is an increase of more than a quarter of a million over the year before.

THE NEW SCHOOL OF PUBLIC HEALTH OF THE UNIVERSITY OF MICHIGAN

According to the *Michigan University Record*, the reorganization of the work in hygiene, public health and preventive medicine has been for some time under discussion. As early as August, 1939, on recommendation of the Division of Health Sciences, the regents authorized, when it should become possible, the establishment of an independent unit of the university to carry on this type of activity. It may now be announced that the W. K. Kellogg Foundation, of Battle Creek, and the Rockefeller Foundation, of New York, have each agreed to provide $500,000 for the establishment of the new school, not more than one half of the total sum of $1,000,000 to be available for site, building and equipment, and the remainder to be used over a ten-year period for its initial expenses of operation. The regents in December accepted the proffer of these sums, subject to the conditions attached, which involve both the method of applying the funds, as outlined above, and the formulation of a plan of organization satisfactory to the two foundations and the university. While progress has been made upon the scheme of organization, it has not yet reached the stage at which a detailed statement can be made public.

The long-continued interest of the Rockefeller Foundation in public health is well known. The trustees of the W. K. Kellogg Foundation are led to participate in the enterprise because of their conviction that public health education is important and a strong school of public health is essential to the success of the Michigan Community Health Project. The university is expected to use its present resources for graduate training in public health and to make certain further provisions for this work in the future.