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THE ASTROPHYSICAL OBSERVATORY OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

THE International Education Board, at its annual meeting in May, authorized its executive committee to provide for the construction of an astrophysical observatory, equipped with a 200-inch reflecting telescope and many auxiliary instruments, for the California Institute of Technology in Pasadena. A prime purpose of the gift was to secure for the new observatory the advantage, in its design, construction and operation, of the combined knowledge and experience of the strong group of investigators in the research laboratories of the institute and in the neighboring Mount Wilson Observatory of the Carnegie Institution of Washington. The assurance of such cooperation and of the willingness of the institute to assume full responsibility for the establishment of the observatory and its maintenance when completed were accordingly made conditions of the gift. These conditions were unanimously agreed to by the board of trustees of the institute, and the executive committee of the International Education Board has ratified the arrangement and provided for its execution.

The prompt action of the institute trustees was made possible by the fact that on May 13 President John C. Merriam, of the Carnegie Institution of Washington, with the unanimous approval of the executive committee of the institution and of Director Walter S. Adams and his associates of the Mount Wilson Observatory, cordially accepted a request for cooperation from the California Institute and assured the International Education Board of the willingness of the Carnegie Institution to join in the proposed undertaking. Formal approval has thus been given to the continuation and extension of the cooperation which has been in progress between the California Institute and the Mount Wilson Observatory for several years, especially in the study of the astronomical, physical and chemical aspects of the constitution of matter.

The purpose of the astrophysical observatory is thus to supplement and not to duplicate the Mount Wilson Observatory. The chief problems in view are those which naturally fit into the general scheme of research in which the two institutions are engaged. Thus the increased light-collecting power of the 200-inch telescope should permit further studies of the size and structure of the galactic system, the distance,

radiation and evolution of stars, the spectra of the brighter stars under very high dispersion, the distance and nature of spiral nebulae and many phenomena bearing directly on the constitution of matter. The possibility that a 40-foot Michelson stellar interferometer, designed to rotate in position angle, may be attached to the telescope is under consideration. The measurement of the separation of the components of any spectroscopic binary stars within the range of such an instrument would give very complete information regarding the nature of these systems and the masses of their components.

The new observatory will consist of two parts. One of these will comprise the 200-inch telescope, with its building, dome and auxiliary equipment, to be erected on the most favorable high-altitude site that can be found within effective working distance of the associated groups of investigators and their extensive scientific equipment. The other will be an astrophysical laboratory on the campus of the California Institute. This laboratory will serve as the headquarters in Pasadena of the observatory staff and the graduate school of astrophysics. Its equipment will include instruments and apparatus for the measurement of photographs, the reduction and discussion of observations and for such astrophysical investigations as can be made there to the best advantage. Its instruments for the interpretation of astrophysical phenomena will be designed to supplement those of the laboratories of the institute and the Pasadena laboratory of the Mount Wilson Observatory. It will also include an optical shop, but the astrophysical instrument shop will be housed in a separate building, to avoid the effects of the vibration of machine tools.

The value of a telescope depends as much upon the efficiency of the instruments and apparatus used to receive, record and interpret celestial images as upon its optical and mechanical perfection and its light-collecting power. In the present plan special emphasis is therefore laid upon the development of all forms of auxiliary apparatus, such as spectrographs and their optical parts; photographic plates of the various types required for astrophysical and spectroscopic research; radiometers, thermocouples and photoelectric cells; recording microphotometers and other forms of measuring machines; and laboratory apparatus for reproducing or interpreting celestial phenomena. The study of these auxiliaries will be pushed forward as rapidly as possible, in view of the fact that any results obtained will be immediately applicable in existing observatories and laboratories.

An observatory council, consisting of four members of the executive council of the California Institute, has been placed by the trustees in full charge of the design, construction and operation of the astrophysical observatory and laboratory. This council consists of Messrs. Robert A. Millikan, Arthur A. Noyes, Henry M. Robinson and George E. Hale (*chairman*). Through the courtesy of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed by the observatory council as its executive officer, in direct charge of design and construction. An advisory committee, including Dr. Walter S. Adams, director of the Mount Wilson Observatory; Professor Frederick H. Seares, assistant director; Dr. Charles G. Abbot, secretary of the Smithsonian Institution; Professor A. A. Michelson, of the University of Chicago; Professor Henry Norris Russell, of Princeton University, and Professors Richard C. Tolman, Paul S. Epstein and Ira S. Bowen, of the California Institute, will aid the observatory council and Dr. Anderson in determining matters of policy. Many other leading astronomers, physicists, chemists, meteorologists and engineers in these and other institutions will be called upon for advice and assistance. Dr. St. John and Dr. King, of the Mount Wilson Observatory, who attended the meeting of the International Astronomical Union in Leyden, were requested to look up many matters calling for early decision, and the reports they have presented embody much valuable information kindly given by leading authorities on the design and construction of instruments.

The first decision of the observatory council and the advisory committee, supported by the unanimous opinion of every one consulted in this country and abroad, favored the use of fused silica for the 200-inch and other mirrors of the large telescope. President Gerard Swope and Dr. Elihu Thomson immediately promised the cordial cooperation of the General Electric Company, and work has been undertaken at West Lynn, Massachusetts, under the personal direction of Dr. Thomson. After coating with bubble-free silica the face of a 22-inch disk already in hand, a 60-inch disk will be undertaken, for use as one of the minor mirrors of the telescope. If this proves to be satisfactory, a still larger disk will be made before the casting of the 200-inch mirror disk is attempted.

A mathematical study of the optical design of the telescope, undertaken by Dr. Frank E. Ross, of the Yerkes Observatory, with the kind approval of Director Edwin B. Frost, has confirmed the selection of the ratio F: 3.3 for the 200-inch mirror. The field of sharp definition in the principal focus of such a mirror will be small, but the possibility of photographing extremely faint stars, especially in the spiral nebulae, makes such a powerful concentration of light

highly advantageous. Dr. Ross, who will devote himself to these optical problems during the coming year, also believes that a lens can be designed, for use in the converging beam, which will serve when desired to give a much larger field, also with a short equivalent focal length. It is planned to use a Cassegrainian combination with a ratio of F: 10, having a sharp field 30′ (17 inches) in diameter, for spectrographic and other work. A coudé arrangement similar to that of the 100-inch Hooker telescope, permitting the images of celestial objects to be formed in a constant temperature laboratory, for study with large fixed spectrographs, radiometers or other auxiliary instruments, is also projected.

Dr. Pease has devoted considerable time to a study of the telescope mounting, which has been facilitated by his previous work in designing large instruments. Much additional study will be necessary, however, before even a preliminary design can be adopted, because of recent advances accomplished by telescope builders in this country and abroad. It is our hope that an equatorial design of the fork type, of sufficient rigidity to carry a 40-foot interferometer and meet other severe requirements, will soon be worked out. In this task we have been promised the cooperation of many leading engineers, including Mr. Gano Dunn, Mr. Ambrose Swasey and his associates of the Warner and Swasey Company, and others of wide experience.

The extensive investigation of auxiliary instruments that forms a prime feature of the general scheme has been begun and will soon be developed in various directions. Mr. George Eastman and Dr. C. E. K. Mees have generously agreed to deal with many of the special photographic problems at the research laboratory of the Eastman Kodak Company. A Zeiss recording microphotometer has been ordered and will be used in a comparative study of various forms of this instrument. Dr. Sinclair Smith will attempt to develop and improve the radiometer recently used very successfully by Dr. Abbot with the Hooker telescope in measuring the distribution of energy in the spectra of stars of several types, and work on other auxiliary instruments will soon be commenced.

A comparative study of several possible high-altitude sites has been undertaken. Precise measures of the seeing, rather than estimates, are desirable. Dr. Anderson accordingly devised a simple means of measuring the atmospheric oscillations of star images under a power of 600 with a 4- or 5-inch telescope, and Mr. Ellerman has tested it satisfactorily on Mount Wilson in comparison with the estimates of experienced observers with the 60-inch and 100-inch telescopes. Preliminary observations with this method by Messrs. Ellerman and Humason have been made at Palomar Mountain and "Horse Flats" (north of Mount Wilson), and some tests made by Dr. Abbot and Mr. Moore at Table Mountain show that this site, like the others, deserves careful examination. Dr. Hubble, with the kind cooperation of the authorities of the Grand Canyon National Park, is engaged in the investigation of conditions near the Grand Canyon and at other points on the high plateau area of Central and Northern Arizona. In this work he is having the cordial assistance of Dr. Slipher and the members of the staff of the Lowell Observatory. All this work will be facilitated by the loan of three sets of recording meteorological instruments by Dr. Charles G. Marvin, chief of the U. S. Weather Bureau, who has also kindly supplied us with many meteorological data for various sites in California and Arizona.

The policy of the observatory council, in all phases of this undertaking, is to bring into cooperation the most competent authorities in their respective fields. In the operation of the telescope the same policy will be maintained which has been followed in the past at the California Institute and the Mount Wilson Observatory of inviting eminent authorities in astronomical and astrophysical research to use the instrument in connection with their investigations. It is hoped that in this way the astrophysical observatory will also become an international center for research. The willingness of so many leading men of science to lend their assistance and the fact that all decisions have been unanimous give promise of such results as the broad-minded attitude of the International Education Board most certainly deserves.

THE CHEMICAL CONSTITUTION OF RESPIRATION FERMENT[1]

I

FERMENTS are substances which effect chemical reaction in living matter. It is one of their properties that they occur in living matter in extremely small concentration. It has not been possible thus far to measure the amount of a ferment present anywhere. It is also one of their properties that they are unstable. In all attempts to isolate the ferments they are usually destroyed, and we have not yet succeeded in the preparation of a pure ferment. Because of this it is not known how the ferments are chemically constituted, and hence it is not understood how chemical reactions occur in living matter.

[1] Address before the Kaiser Wilhelm Gesellschaft on February 22, 1928. Published in *Die Naturwissenschaften*, Vol. 16, p. 345, May 18, 1928. Translated by Dr. W. A. Perlzweig, the Johns Hopkins Hospital.