Astrophysics and the 200-inch Telescope.

DURING the past few years, NATURE has published from time to time supplements containing the views of some of our leading astronomers and physicists on problems of the structure and history of the physical universe. These supplements have aroused widespread interest, and the progress which has lately been made, and is still going on, in physical astronomy is probably the most significant aspect of the scientific developments of our time. We may perhaps be pardoned for a feeling of pride that in Great Britain we possess some of the most brilliant workers in this field, whose labours have largely determined the direction of inquiry and inspired the forward march. It is a matter of intense satisfaction that we are second to none in the quality and extent of contributions to knowledge of the universe and its laws, and there is every prospect that the position which British astrophysicists have won will be well maintained in the years to come.

Of all inquiries, however, the study of the universe is the one in which an insistence on national boundaries is least appropriate. If British theoretical workers were asked to what they chiefly attribute the present progress they would undoubtedly reply: to the results achieved by the 100-inch telescope at Mount Wilson. Since that famous instrument was installed, not more than ten years ago, the new facts, of the utmost importance, which it has been the means of revealing, can scarcely be appreciated in their entirety and full significance. There is scarcely an advance in theoretical knowledge during that time that does not owe something, directly or indirectly, to the unrivalled light-grasping power and resolving power of this chief among telescopes. Every advance in knowledge depends in the last resort on an inprovement in means of observation, and behind every legitimate theory of the universe is a collection of photographs of fields of stars.

The proposal of the California Institute of Technology to erect a 200-inch telescope, to which we directed attention in NATURE of Nov. 3, is therefore a project of which it is scarcely possible to exaggerate the importance. We have received further particulars of this great undertaking from which it appears that the construction of the telescope itself is but one item in a scheme of wider scope. It is proposed to establish a new observatory consisting 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 favourable 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 promoters of this far-reaching scheme approach the problem in a broad-minded manner which augurs well for its success. "In the operation of the telescope," the statement continues, "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 centre for research."

It is impossible to foresee what further knowledge may come to light if the proposal becomes an accomplished fact: the most important revelations are probably beyond our present powers of anticipation. No one could have foretold that Lord Rosse's great reflector would have revealed the spiral character of the extra-galactic nebulæ, or that the 100-inch telescope would have given us their distances and fine structure. A fairly well defined preliminary programme of research has nevertheless been drawn up. "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 nebulæ, 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 chief difficulty in the matter is of course the construction of the large mirror, and it remains to be seen whether the confidence of the promoters will be justified. A 22-inch disc of fused silica is already being experimented on. It is proposed to coat it with a layer of bubble-free silica, and afterwards to repeat the experiment with a 60-inch disc, which would be used as one of the minor mirrors of the telescope. If this proves to be satisfactory, a still larger disc will be made before the casting of the 200-inch disc is attempted. It is intended to employ the exceptionally small focal ratio of 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 nebulæ, 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."

The device of overcoming the difficulties of casting so large a disc by making only the surface layer of homogeneous material recalls a somewhat similar idea put forward by Sir Norman Lockyer so long ago as the year 1884. He proposed the construction of an 8-foot reflector, of which the body of the mirror was to be of porcelain and the surface of glass. At that time astronomical photography was in its infancy, and Lockyer's ideas of the work which could be done with such an instrument, revolutionary as they then were, have a very modest appearance beside the schemes now contemplated.

In the matter of mounting the telescope, much additional study will be required before even a preliminary design can be adopted. It is hoped 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 selecting a site for the instrument, precise measures of the 'seeing' rather than estimates have been aimed at. Dr. Anderson has 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 co-operation 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."

The thoroughness which is evident in this part of the plan is characteristic of the whole. Not only the installation of the great telescope itself, but also the arrangements for all the auxiliary instruments and apparatus used to receive, record, and interpret the celestial images, are being subjected to a searching inquiry by an army of the greatest experts in the United States. If determination, skill, and energy can bring the plan to a triumphant issue, it is assured of success. We trust that the practical difficulties of so enormous an undertaking will not prove insurmountable.

The Transport of Carbohydrates in the Plant.

VERY little is certain as to the movements of carbohydrates in the plant. It is generally agreed that the green plant can build them up for its own needs in leaves exposed to the light, and that these supplies are then utilised in growth throughout the plant, so that considerable movements of sugars must take place from the leaves to the roots and fruits and various storage organs. There is no agreement, however, as to the tissue through which this movement takes place. Only two tissues, regularly present in this plant axis, are so extended in the longitudinal direction as to be very likely to convey such substances for long distances through the axis; these are the wood or xylem, and the phloem or bast. Usually, the sieve-tubes of the phloem have been regarded as the channels of sugar transport, as micro-chemical observations, such as those of Prof. Mangham, seemed to show considerable quantities of sugar in these tissues. The phloem in many trees is confined to a narrow layer near the periphery, so that it is possible to cut this channel completely by removing a narrow strip of tissue from the outside of the stem, and there is evidence that such ringing experiments always interfere with carbohydrate transport. Prof. H. H. Dixon pointed out, however (NATURE, vol. 110, 547-551 : 1922), that the xylem sap usually contains appreciable quantities of sugar, and that in the ringing experiment it is very difficult to remove the phloem without doing some damage to the wood. As a result, the wood may be partially blocked, so that the interruption of the carbohydrate movement, attributed to the ringing of the phloem, may be really due to the partial choking of the xylem channels.

In much of the experimental work done to elucidate this problem, the transfer of carbohydrates through the region of the axis experimented upon is gauged by the amount of growth afterwards made as the result of supplies assumed to come from sources on the other side of the ring. Thus Prof. Otis F. Curtis has published a series of observations upon ringed shoots which were defoliated above the ring, and as a result made little growth, presumably through the failure of supplies to cross the ring. In such experiments the plants have obviously to be left for some time following the original ringing operation, and though Prof. Curtis has on many occasions followed up his observation of growth by quantitative analyses of his plants for carbohydrates, nitrogen, etc., it is difficult to know how much the redistribution observed has been determined by metabolic activities connected with growth, and how much it has been directly the