influences de milieu se ramènent en somme à des différences de nutrition."

Nutrition therefore becomes a factor of primary importance for morphology as well as for physiology. The form and structure of all living organisms are clearly dependent in large measure upon the quantity and quality of their nutriment. The effects of inanition of various types apparently account for many of the variations observed among living organisms, under both normal and abnormal conditions. A knowledge of these effects gives a deeper insight into the process of morphogenesis and a means whereby it may be experimentally controlled to a degree hitherto generally unrealized. Furthermore, even though it be contrary to the generally accepted biological doctrine, there is another possibility which must be considered. Not only the somatoplasm, but under certain circumstances even the germ plasm may perhaps likewise be modified by nutritional conditions, a possibility of fundamental significance for heredity and evolution.

CLARENCE M. JACKSON

A RESEARCH CAREER IN ASTRONOMY

WIDELY different types of investigation are now included in astronomy, and only the most general remarks would apply to all of them. For the student who is considering a professional career in astronomical research it may be useful to outline the various branches from the standpoint of the personal aptitudes of the investigator.

THEORETICAL ASTRONOMY

For the mathematically inclined there is the great field of theoretical astronomy. The theoretical astronomer is a mathematician who uses the principles of mechanics, for example, together with calculus, infinite series, etc., to achieve his purposes, as a carpenter uses hammer and nails. If the tools and materials are not properly handled the structure either never rises at all, or collapses the first time its strength is tested. Hence a thorough apprenticeship is essential. Typical problems with which the theoretical astronomer deals are the computation of orbits of comets, planets, satellites, meteors and double stars; the more general problems of celestial mechanics, such as the formation of stars and stellar systems, or the stability of rotating bodies; statistical inquiries concerning the structure of the universe; and, of growing importance, the application of theoretical physics and chemistry to celestial bodies.

The theoretical astronomer can get along without a telescope, but he needs a library and the assistance of computers. His usual position, therefore, is that of professor of astronomy at a college or university. He will ordinarily be expected to conduct classes, but at many institutions some research will be possible if he is sufficiently eager and persistent. The American student who is looking forward to work of this character should prepare to teach, as there are few theoretical astronomers in the United States who do not have duties of instruction.

OBSERVATIONAL ASTRONOMY

Astrophysics—For one whose interest is along the lines of physics and chemistry there is the expanding realm of astrophysics. This science is concerned with deriving all possible information from a study of the quality and intensity of the light received from the heavenly bodies. The observational goal of astrophysics is a complete knowledge of the spectral energy curves (including state of polarization) of the light radiated from every celestial source. The heart of the matter lies in the interpretation of these curves and here astronomy and physics blend. The three main divisions are spectroscopy, photometry, and radiometry.

Spectroscopy is the study of spectral details, *i.e.*, lines and bands, without special reference to the absolute intensities. This line of work has undergone a remarkably extensive development since the pioneer days of Secchi and Huggins. The chief subjects of research are chemical identifications, physical conditions, radial velocities, and intrinsic stellar luminosities (which when combined with apparent luminosities give distances). There are, of course, many special problems of great importance, in particular, those referring to the disk of the sun. It would take too much space even to outline the contents and value of the branches of astronomical spectroscopy, but nearly every school library contains a few books describing them. Miss Clerke's "Problems in astrophysics" and "The

system of the stars," Hale's "Stellar evolution" and Campbell's "Stellar motions" may be mentioned.

Photometry has to do with the brightness and color of the stars, and is of value not only for the vast number of separate facts which have been gathered and which serve as essential aids to many investigations, but also for the general conclusions which may be drawn from its data. The science of star colors still remains in a rather crude form, however, and it is only a matter of time until the present methods will be largely superseded—at least for the brighter stars—by more complete and detailed methods of spectro-photometry. A most promising problem is the practical development and application of such methods.

Stellar radiometry, or the measurement of the radiation of the stars by the thermocouple or bolometer is in its infancy and has thus far consisted chiefly in observing the total, undispersed radiation. A few successful attempts have already been made, however, to adapt these instruments to stellar spectro-photometry, and it is certain that there is a fine future for this line of work.

The new science of stellar interferometry occupies an intermediate position between astrophysics and the astronomy of the measurement of position. Students who have a thorough acquaintance with the principles of optics and with laboratory interferometry are needed to develop this attractive field.

Astronomy, as a part of general physics, is capable of making important contributions to our knowledge of the properties of matter, of light and ether, and perhaps of the "nature of space." This prospect should attract the student whose ambitions are such as to lead him to devote himself to the type of work underlying the progress of science, even though his investigations may not find practical application in a month or a decade. There is a romantic appeal in the idea of studying the structure of the atom by observing objects invisible to the naked eye and so distant that light, which could encircle the earth seven times in a second, is hundreds of years in making the journey which ends on a human retina or on a photographic plate at the end of a telescope. With the aid of the mysterious but powerful "quantum" theory, knowledge of atoms and electrons and their relationships to light waves is progressing by leaps and bounds, and spectroscopic facts of all kinds are assuming an importance which was but dimly foreseen a few years ago. Properties of matter not yet exhibited in the laboratory can be studied in the stars by means of the spectroscope, but only a beginning has been made. It is doubtful whether space has any properties except those which are postulated into it, but perhaps the best way to talk about certain geometrical and physical relationships is to assume that space does possess objective properties. Our ideas of the relationship between space and ether are, at the present time, in an unsatisfactory state of profound confusion, the saving feature of which is that the foundations of physics are being scrutinized as never before. Much careful thought is required concerning these matters, and the investigator should be an astronomer, a physicist, and a mathematician combined in one.

Direct visual observation—To one who has keen eyesight and a fondness for making precise observations astronomy has much to offer. Double stars are discovered and measured visually. The determination of time and of the fundamental positions of reference stars depend on visual observations with meridian circles. Observation of the surface details of the moon and planets makes a strong appeal to some persons.

Photography—The taking of direct photographs of celestial objects, especially of comets and nebulae, is a never ending source of delight. Much interesting and profitable work of this kind can be done with telescopes having apertures from one to one hundred inches. Photography also serves for accurate position observations as in parallax and proper motion work and in star charting, and in recording solar and stellar spectra. In fact, photography is extensively used in so many types of work that the prospective observational astronomer should cultivate a thorough acquaintance with photographic operations and materials.

Nearly every type of work mentioned in this article, except stellar radiometry, can be successfully carried on with telescopes of moderate size, although in many instances the in-

creased power of large telescopes is a great advantage. Worth-while investigations and fine work of a miscellaneous character can be done with apertures of twelve inches and less. The small and medium-sized telescopes in the United States are capable of being used for research to a far greater extent than is the case at present.

Observational astronomy is carried on at special research observatories and by departments of astronomy in academic institutions. Excellent graduate instruction in astronomy may be obtained in any one of ten or twelve colleges in the United States. The two largest research observatories in which there are regular arrangements for the admission of students are the Lick Observatory at Mount Hamilton, California, and the Yerkes Observatory at Williams Bay, Wisconsin. In several places there are graduate fellowships or assistantships which pay the living expenses of the holder while he is working for a doctor's degree.

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As a basis for a worth-while research career in astronomy, the student should have an insatiable curiosity concerning the secrets of the stars, and unbounded enthusiasm for personal investigation. Without these he would surely find an astronomical career unenjoyable, and it would probably prove unprofitable as well; but possessing these qualifications and fortified by sound technical preparation, astronomy may be the only life work which he could carry through without vain longings and regrets arising from a sense of stifled aspiration.

PAUL W. MERRILL
MOUNT WILSON OBSERVATORY

SCIENTIFIC EVENTS

EPIDEMIC DISEASE IN EUROPE

THE sixth number of the *Epidemiological Intelligence Bulletin* has just been issued by the health section of the League of Nations Secretariat. According to the summary in the London *Times*, it deals with epidemic diseases in Eastern and Central Europe from May to December, 1922, and treats in some detail typhus and relapsing fever, Asiatic cholera, dysentery, smallpox, plague, epidemic diseases of the central nervous system, malaria and enteric fever. The statements are based on the number of cases notified. Actual comparisons between countries are generally impossible. Briefly summarized, the comparison between 1921 and 1922, in so far as the reports have been received, is as follows:

The incidence of typhus and relapsing fever was fully twice as great in 1922 as in 1921 in Russia, another extremely high epidemic wave having occurred in 1921-22. This wave was quite double the 1920-21 wave, but was less than half as great as the second wave of 1919-20, judging from the number of cases reported. In Poland no improvement in 1922 over 1921 was noted for typhus and the prevalence of relapsing fever has greatly increased. In Latvia there was apparently an increase of typhus, but a decrease of relapsing fever.

With the exception of the Ukraine and the Russian Black Sea littoral, the cholera situation improved considerably in 1922. In Russia, exclusive of the Ukraine, the number of cases reported in 1922 was about one fourth of those reported for 1921 since the great epidemic in South Russia of 1921 had come to an end. In the Ukraine, however, a serious epidemic occurred in 1922; the number of cases in July (the highest month), 1922, was four times as large as in July, 1921. No serious epidemics were noted elsewhere.

Notifications of dysentery probably mean nothing more than certain intestinal infections with similar clinical symptoms, but the prevalence of the disease in 1922 was apparently considerably less than in 1921 in all the countries concerned. Even in Russia, for which the reports are extremely incomplete, there is no evidence of unusual prevalence.

Smallpox declined in 1922 in all countries where it was markedly prevalent during the preceding year, although its incidence was still high in Russia.

Malaria assumed more alarming proportions in Russia during 1922 and the situation was rendered even more serious by the appearance of the tropical type in Eastern Russia. The million and more cases actually reported for Russia represent a small proportion of the cases which must have actually occurred.

The incidence of enteric fever was less during 1922 than during the preceding year in nearly all European countries.