sciences that the peace and prosperity of the world will largely depend. Until recently there have been far too few careers open to young biologists outside the field of the medical sciences. There has been nothing corresponding to the Colonial Service, which has offered to young administrators a life of adventure nicely seasoned with economic security. All members of the British Association will therefore welcome the intention of the Government to inaugurate a Colonial Scientific Service, and will hope that the conditions of service will be such as to attract young men of the highest quality.

Challenge of the Times

We live, indeed, in difficult times. But they are very interesting times; and difficulties are bracing to a nation which has not lost the resilience of youth. We must not get into the way of thinking of our great country as an elderly man who is told by his doctor that if he is very careful of his diet, and avoids all exertion and worry, he may look forward to some years of placid life before he dies. This is a time for adventure; for taking risks. Calculated risks, of course; but not so nicely or so lengthily calculated that they are taken too late. My contacts with universities and with industry are not now so frequent or so close as I should like them to be; but they are enough to convince me that the spirit of adventure in science is as lively as it ever was. It is that spirit which will largely determine the future. Many years hence, when a president of the British Association reviews the progress of the nation from the depths of bankruptcy to new and unsurpassed heights of prosperity and influence, he may well have occasion to refer, as I did at the beginning of this address, to the great influence of the work of a few young men who are now unknown to the public; and he may justly claim that the chief cause of the change was that we had found the right way to combine originality in science with enterprise and speed in its application.

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

RECENT ADVANCES IN THE STUDY OF THE CRYSTALLINE STATE

IN his presidential address to Section A (Mathematics and Physics), Sir Lawrence Bragg points out that X-ray analysis of crystals may be said to have attained its majority this year. Its importance has been recognized by the formation of an International Union of Crystallography, and it takes its place with the other branches of science which have unions of their own. Laue discovered the diffraction of X-rays by crystals in 1911; now most universities have an active centre devoted to the investigation of the arrangement of atoms in matter by means of X-ray diffraction. Sir Lawrence has worked in this field from the beginning, and takes the opportunity which this address affords to review what has been accomplished in little more than a generation. X-ray analysis is a typical border-line subject. Its successes are interesting to the chemist, mineralogist, metallurgist and biologist as well as to the physicist, and this is perhaps its most attractive feature.

In X-ray analysis in general, we are seeking to interpret the manner in which a substance diffracts X-rays owing to the spatial arrangement of its atoms. Two main lines of work may be distinguished. On one hand, there is the analysis of the pattern of the perfect crystal, where the atoms have taken up positions of equilibrium under the influence of the interatomic forces; from the conformation of the structure we can gain a deep insight into the nature of these forces. This study is principally of interest to the chemist, because it presents him with a scale plan of the chemical molecule and of the way molecules or ions are held together by the intermolecular forces to form a solid structure. The results of X-ray analysis have had a profound influence on chemistry and mineralogy and solved many problems. A steady advance has been made in tackling more and more complex molecules, and a stage has already been reached where such compounds as the sugars, strychnine, sterols and penicillin can be analysed, to take a few examples. We would like to pass on to the study of such high complexes as the molecules which form part of living matter—nucleic acids, proteins and others.

The other side of X-ray analysis is concerned with what we might call the 'geography' of atomic arrangement in matter. The perfect crystal is an ideal which is rarely attained. Even if the substance is pure it is composed of a mass of crystals, and we are interested in the size and shape of the crystallites and their growth, in allotropic change, and in their preferred orientation and state of strain after mechanical treatment; if complex, we are interested in the fitting together of the crystallites of different kinds. Metastable structures often exist in which there is partial separation into regions of different composition, while a continuous crystal lattice is preserved though in a distorted form, as in the permanent magnet alloys, in martensite, or in age-hardening alloys. We can study the distortion of the lattice by the thermal waves at high temperatures. Amorphous and semi-crystalline matter can be examined. All these aspects of structure are of prime interest to the physicist and metallurgist. They are vitally interesting to the technologist, because the geography of the structure has a profound influence upon its mechanical, electrical and magnetic properties.

In this address, Sir Lawrence reviews the active centres carrying out X-ray investigations in Great Britain; examples are given of recent work, presenting a picture of what has already been achieved, and indicating the lines of exploration which are now being pursued.

SPECIALIZATION AND CULTURE IN CHEMISTRY

PROF. JOHN READ, president of Section B (Chemistry), deals with some of the problems of increasing specialization in chemistry. The growing burden of new knowledge in chemistry, as in science generally, has created many new problems for the student, teacher and research worker. These problems are largely bound up with the growth of

specialization. A fundamental problem confronting the chemist is that of acquiring a proper education leading to a cultured outlook and fitting him to take his place in the world of men and affairs. What steps can be taken to combat the narrowing outlook which threatens to affect science students at all levels, and to provide for their social, cultural and spiritual needs?

Formerly a chemistry student was trained to become an all-round practitioner of his art; but latterly the vision of the student and research worker has narrowed. We have entered into an age of team-work. Chemical science has been aided nobly by such work; but the individual worker is liable to sacrifice a great deal in the process.

The mental effect of an unrelieved absorption in a specialized field of science has been vividly described by Charles Darwin, and the growth of such specialization in later times has led to many criticisms of its effect upon the human subject.

It is in the schools that we view the education of the incipient scientific worker in its broadest aspect; and it is here, helped in the ideal case by home influences, that the foundations of the necessary wider interests must be firmly laid. There ought to be no sense of antagonism between arts and science, and any form of modern education should be made up of a proper blend of each. A lively interest in literature, history, art, music or the drama, gained in early life and nurtured thereafter, would do much to solve some of the problems of specialization in science. Highly specialized teaching in science ought to be avoided in the schools.

In the universities, the way of teaching chemistry is of the first importance. Although his chemical studies must deepen rather than broaden as the student passes onwards towards research, he should always be encouraged to realize that there are a chemical geography and a chemical history, and that these offer him avenues leading to a wider horizon. Chemistry itself may become a cultural and humanistic instrument of high value. Historical chemistry is linked in turn with philosophy, literature, art, and even with music. During the student's undergraduate days a great deal could be done to arm him against the dangers of specialization, and more importance should be attached to the technique of teaching from this point of view.

During postgraduate research work the student should be encouraged to undertake a certain amount of teaching work in the junior laboratories. He should also use opportunities to migrate to new research centres either at home or abroad. A research theme of a suitable kind ought to help the student to become resourceful and to develop originality of thought, besides stimulating his imaginative and critical powers; unfortunately, research themes often fail to fulfil these requirements. Finally, the proper education and training of the young scientific worker, with the application of the various influences that have been mentioned, including personal contact with his teachers, call for the provision of adequate staff and accommodation.

GEOLOGY TO-DAY AND TO-MORROW

THE theme of Dr. A. E. Trueman's presidential address to Section C (Geology) is the future of geology. At the present time, he points out, geology is passing through a period of very active growth. It is doubtful if at any time since the 'heroic age' of the science, a hundred and fifty years ago, there has been so rapid an increase in our knowledge of earth history. More geologists are professionally employed in all parts of the world; many more fields of human activity are dependent on the success of their operations than ever before. They search for ores, coal, oil and water. If in the future we are to depend on atomic energy for some of our power, it will need geologists to locate the new materials. Inevitably, we shall be driven to exploit mineral resources occurring at greater depths, or of poorer quality; while we continue to use materials from the earth's crust the geologist will have an increasing part to play in their discovery. In the course of these explorations much new information is being gathered, but many major problems still await solution.

Although geology is in this phase of active development, its results and methods are probably less familiar to the educated public in Britain than those of any of the other fundamental sciences. This widespread unawareness of geology, which is not found in most other countries, is in marked contrast with the position of fifty to a hundred years ago and calls for serious attention, for it cannot be held that any science is in a healthy condition if its work is insufficiently understood by laymen. The absence of almost any geology teaching in schools and the scarcity of teachers with any acquaintance with the subject are partly responsible for present conditions. It is claimed that geology should form part of a wide cultural education; it can serve as a link between science and more humane studies or as a basis for a new type of synthesis.

Fortunately, the comparative lack of public interest in geology has not in recent years limited the recognition of its value by Government. Much has happened to stimulate the demand for geological advice for a variety of economic purposes, both in Britain and overseas. In the limited area of Great Britain, the Geological Survey, founded more than a hundred years ago, not only meets new demands for more detailed maps but also is required to undertake great new responsibilities. The record of its work in war years, recently published, exemplifies the wide range of activities in which geological information is necessary; in view of the growing importance of the work of the Survey, the need for an expansion of its numbers has been recognized. The Colonial surveys, even more in need of increased support, are accepted as having a vital part in the economic development of the Colonial territories. The present Secretary of State for the Colonies has himself on several occasions appealed to young men to take up the work of geologists in these areas. The small surveys of the past have been sparsely staffed, one geologist being responsible for thirty times the area for which a member of the home survey was responsible. In the past, several Colonial geological surveys have paid for their own cost many times over by discoveries of diamonds and ores, but future results must not be judged only in terms of exportable minerals; more bulky materials, such as limestones, clays, road materials and especially water, may contribute even more to the development of the territories. Alongside these developments of geological survey activity throughout the Commonwealth, the promotion of researches by unofficial geologists is equally essential.

In the immediate future we must expect an increasing tendency to specialization in limited fields and particularly on the fringes of the subject, as on