acre. Parenthetically, it must be noted that although fixed nitrogen is of such great importance in fertiliser practice, soil requirements of other elements have also to be provided. Examples of the influence on crop yield of systematic fertilisation might be multiplied. So also might examples of neglect to profit thereby. For example, a correspondent to the *Times* (British West Africa Supplement, October 1928), describing farming conditions in Sierra Leone, writes : "... The second problem is that of maintaining the fertility of permanently cleared land by suitable manuring. There are practically no horses and very few cattle.... In consequence there is no form of farmyard manure available, and the average native farmer sets more store on putting up some sort of 'ju-ju' to protect and encourage his crops than on considering the purchase of artificial manures." Ju-jus, let it be observed, are of divers kinds.

The growth of the fixed nitrogen industry has lowered the prices, in terms of goods, of all nitrogenous fertilisers, and of phosphates and potash also, but we still lack sufficient accurate and co-ordinated scientific knowledge of the extent of the benefits which may be ours ; of the factors determining soil fertility and climate ; of the state of combination, interactions, proportions, and variations in the elements concerned. At Rothamsted it has been realised that although an enormous mass of data was being accumulated, it was not being employed to the best advantage by older methods of examination, and in consequence modern statistical methods have been applied. These methods have opened up a new line of study —the study of the influence of nutrients on the reaction of the plant to environmental conditions, that is, the influence of soil and climatic conditions on the effectiveness of fertilisers. Those in the best position to judge have declared that, if the general character of a season could be predicted, appropriate manurial schemes could be recommended, or tables of expectancy of crop yield could be constructed for the guidance of insurance companies willing to insure farmers using recognised fertiliser mixtures against getting less than an agreed yield per acre.

Finally, we must not, in contemplation of a rosy future, lose sight of the realities of the present. Unless new knowledge is acquired, unless education in the modern use of nitrogenous fertilisers is advanced, the danger of overproduction may be great. Mr. F. C. O. Speyer, the general manager and a director of Nitram, Ltd., estimated that if announced programmes in various countries are carried out, there should be an extra production of about $2\frac{1}{4}$ million tons of nitrogen between June 1928 and June 1931. He calculates that, although 92 per cent of this could be absorbed by Europe alone if applied to main crops at the rate of 0·8 cwt. per acre, the additional world population in this period would not consume more than half of the extra food which would thus be available. On the other hand, Dr. Bueb, managing director of the Stickstoff Syndikat, has pointed out that the monetary return on the use of nitrogen has steadily risen, and the prices of foodstuffs have been kept down. The problem of production is subject to the economic laws, but co-operation between the forces concerned—those directed by the chemist, the engineer, the agriculturalist, and the plant breeder, is so full of economic possibilities that it would indeed be unwise to base our estimate of to-morrow's need solely on to-day's demand.

A. A. E.

Biology and Education.[1]

By Prof. F. A. E. CREW.

THE method of education is the stimulation of the cells of the brain by impressions from without : impressions provided by the casual and haphazard incidents of experience and by the deliberate and systematic agencies concerned with the imparting of facts and opinions. The aim of education is so to guide the development of the individual that he can hope to discover his powers, to recognise his limitations, and to determine the ways in which he may achieve the fullest degree of expression of his inherited mental and physical endowment in the circumstances, physical and social, in which he will find himself. Education, therefore, is concerned with the living individual and with the habitat in which this individual is to live and, living, achieve his destiny. So also is biology, the science which deals with the nature of living things and with the relation of these to their environment. It seeks to find answers to the questions as to whence came man, what is man, and whither goeth he. These are the very questions that occupy the popular mind to-day. Surely the tasks of the educationist must be those of equipping his experimental material with the ability to formulate these questions properly and of showing how and where their answers may be found.

The most conspicuous factor in the history of civilisation during the last two hundred years has been the exploitation of physical Nature by means of scientific knowledge. Science has provoked and made possible a complete metamorphosis of the western world since the middle of the eighteenth century, and during this time science has been nurtured by industry. The Europeanisation of the world had its origins in the developments of commerce, and the broadening of the mental outlook which distinguished the Renaissance was made possible by the increased wealth and the increased leisure this commercial prosperity gave to western peoples. The industrial revolution in England was but the inevitable sequel of the developments of trade during the period 1600–1750, and the present-

[1] From an address delivered before the Incorporated Association of Assistant Masters in Secondary Schools at Brighton on Jan. 1.

day appreciation of scientific knowledge in relation to the practical affairs of life is again the inevitable outcome of this industrial revolution.

It is because man has gained so spectacular a control over his physical environment that science exercises such a dominant influence in Western culture to-day; and it is because commerce has encouraged the development of the physical sciences for its own ends that physics and chemistry and allied sciences have grown so amazingly. But it is not because these sciences are so much more complete than are the biological that they find a place in the school curriculum. It has yet to be shown that physics and chemistry are keener tools wherewith to fashion mind than is biology. I submit that they are now taught simply because they have been taught, and because they are not only useful educational instruments but also profitable when the pupil is translated to secondary school, technical college, and university. Industry is demanding men trained in the physical sciences, and a knowledge of these subjects, while it may be helpful in a cultivation of the art of living, is most certainly useful in the business of earning a living. If men were bought and sold to-day, as they used to be, doubtless human biology would possess an equal importance.

No part of one's general education should be coloured, however, by any consideration of what one will do in order to live: general education is concerned solely with the development of an art of living, of teaching the developing individual how to think and how to feel and how to seek and gain opportunities for exercising these faculties. Manifestly, during this period the individual must receive an introduction to science, since it is of the utmost importance that youth should acquire the scientific point of view. Science has done more than merely give to man a marvellous power over material things: it has revolutionised human thought. It is this spiritual aspect of modern science that is its most significant virtue. The revolution is still spreading, and it is in a world dominated more and more by this scientific habit of mind that our pupils are to live.

Science has completely changed the concept of authority. Credulity is no longer accepted as a virtue and doubt as a sin. The final authority in spiritual as well as in temporal matters is no longer Scriptural phraseology and the traditional teachings of the sages of antiquity. The Old Testament is no longer accepted as a trustworthy text-book of human biology. Belief must now rest upon evidence that is open to examination, and critical judgment has usurped the place of authoritative statement. To-day, mankind demands the right to seek the truth and to extend it without restriction: facts, verifiable facts, are the only justification for authoritative statement. This concept has to be presented to and accepted by the youth of to-day.

It was this revolution in human thought that led to the replacement in education of the asceticism and scholasticism of the Middle Ages by the humanism of the Renaissance and later to the replacement of this in turn by science. To escape from the scholasticism that was becoming obnoxious it was necessary to turn to the literature of Rome and Greece. Latin, the language of the learned, became the vehicle of the new humanistic philosophy, and, because the new ideal found its counterpart in the thought of ancient Greece, Greek became the pathway to this older source of European culture. For these reasons, Latin and Greek assumed positions of great importance in education. Times have changed, yet even now the position of these classical languages in educational schemes is robustly defended, though the original need for their teaching has disappeared. The authority of tradition, enunciated in the pronouncements of classical scholars, no longer convinces. The average man can, and should be encouraged to, capture the spirit of this humanism in adequate translations and interpretations; if these do not exist, then the classical scholar is blameworthy: no one can afford to disregard the attitude of mind which requires that there shall be a spiritual joy in living and a confidence in the future, but the languages themselves are now the delicate hobbies of such as find more joy in the contemplation of the affairs of yesterday than in the adventures of living to-morrow. Every man does not require a knowledge of Greek, but he will require each day and every day a knowledge of the physico-chemical mechanism that is himself.

The acid test of scientific method is now applied in education, and the classics have been eroded. The day of passive acceptance of that which is, because it has been, is passed. It will be agreed that we are incredibly ignorant of what constitutes scientific procedure in education. It will be agreed, further, that because certain time-honoured standards have been overthrown the new ones are not necessarily final. The value of science in the school curriculum is that it can replace adequately the humanistic philosophy of life in combating and vanquishing fear of the unknown. This it is that physics and chemistry do, and that biology could do even better. The time has already arrived when physics and chemistry, sciences that deal with the phenomena of man's environment, should make room for biology, for it is biology more than anything else that is modifying human thought. To-day, the philosopher recognises the biological foundations of philosophy, the theologian the biological development of theology, the historian the biological framework of historical events. But more important than all this is the fact that the average citizen is intensely interested in the biological nature of his own existence. Biology occupies a pivotal position in human understanding, for mankind, having conquered its environment, is now seeking the control of itself and its destiny. The life of every man is affected in all its aspects by the two great generalisations of biological science—the theory of the cell and the theory of organic evolution. An introduction to these theories should therefore be given to all as part of their general education.

In the specialised scientific education that follows upon the general, biology is a necessity; it is as indispensable for the embryonic chemist and physicist as are physics and chemistry for the biologist. Biology is no longer fragmented into the watertight compartments of zoology, botany, and physiology. Comparative morphology is no longer over-emphasised, and through the developments in genetics, ecology, and experimental morphology the barriers between zoologist, botanist, and physiologist have been broken down. The necessity for studying the physico-chemical processes of living organisms requires that the biologist shall be physicist and chemist as well, and the physicist and chemist with a knowledge of biology can find ideal material for the exercise of their techniques—the day of the biochemist and biophysicist has already dawned.

Biology in its origin was closely associated with medicine and with agriculture. The more scientific medicine and agriculture become the greater will be their demands upon biological science. As biology becomes more exact in its conclusions it will claim an even greater value in the social sciences, in which fields its main contribution as yet is the point of view which it imparts. But the significance of zoological and particularly of medical knowledge is becoming evident to the social worker, whose eagerness for the facts of heredity and hygiene is remarkable and will persist. When once there has developed a biology of the group, a scientific interpretation of human behaviour, then biology will indeed exert a most profound effect upon the social activities of humanity. The problems of evolution are no longer solved through the exercise of pure dialectic; biology has progressed towards the method of experimental analysis, and because its conclusions rest increasingly upon experimentation they are held in higher esteem. The voice of the biologist is now eagerly heard, because he speaks of facts that cannot be denied, of facts that concern the welfare of mankind.

Biology is not commonly included in a school curriculum, for the reason that the headmasters of yesterday had no knowledge of the biology of to-day. It cannot be expected that most teachers of physics and chemistry should themselves agitate for the appointment of a biological colleague, for the reason that it is quite obvious that the total amount of time allotted to science in the school curriculum cannot be advantageously increased, so that if biology enters the school it must necessarily reduce the time now given to physics and to chemistry. It is but to be expected, however, that I, a professional biologist in spite of my school education, should seek to advance the interests of my own subject. Science advances through the general acceptance of its teachings as much as by additions to knowledge. The teacher who pursues the implications of science and induces others to follow his example is no less important to scientific progress than he who contributes to the establishment of some technical generalisation.

In a university curriculum there is no time to present biological facts in a romantic fashion, and in any case the student's capacity for recognising the wonders of the living organism that is himself is spoiled somewhat by the economic necessity of equipping himself vocationally in the shortest possible time. He may become a biologist in later years, but at the university he is far too much occupied in his painful metamorphosis into a doctor, an agriculturalist, a veterinarian, an entomologist, or what not. Only those matters that seem to possess an importance to him in his professional capacity are of any real interest to him during this phase. Seldom does he capture the spirit of science; scarcely ever does he exhibit the scientific attitude of mind. Soon we shall see biology alongside chemistry and physics as a pre-registration subject: it would be that even now if the mechanism for teaching it existed in the schools. I, for one, look forward to the time when biology will be taught in the schools by carefully trained men, for school is the place where one should receive one's introduction to biology. That is the time and the place to give to the temperamentally suitable the spirit of the naturalist. This should be the endowment the school should give to youth.

At the present time the schools are providing the universities with a more than adequate supply of botanically attracted maidens, whereas what we need is an increased supply of young men who know that they are destined to be biologists. It is not because chemistry and physics are ultimately more profitable than biology that so many university students attend these courses; it is because so few have had biology at school, and because the majority of youths are urban-bred. At the present time there is a demand for men with a biological equipment that cannot be supplied. Imperial schemes for the advancement of agriculture are even now being embarrassed in their development because there are no young biologists to accept the posts that have been created. In the Dominions and Colonies, agriculture is the all-important industry, and in agriculture a knowledge of biology is of greater usefulness than is a knowledge of physics. Commonly, I am asked for advice concerning the prospects for a trained biologist. I answer that a well-trained man of suitable personality can readily start on a career which offers him a salary advancing from about £300 to £1000. To those who argue that this is not so good as a career in medicine, law, or commerce, I reply that I, for one, get from life rewards that cannot be found outside biology.

What is more important to humanity than the manufacture of helminthologists, entomologists, and the like is, however, the further extension and democratisation of the evolutionary concept. It was this that overthrew the medieval theology and completed the enlarging of the mental horizon of humanity. Man's notion of himself has changed from that of a being recently created and awaiting a day of reckoning in a not too distant future to that of a being originating as part of organic Nature and set in a universe without beginning and without end. This intellectual revolution has emancipated countless men from the bondage of authority. It must free all. The evolutionary concept has been applied to religion and to philosophy. Its influence is seen in sociology in the incessant questioning of the necessity for existing conditions—it has shaken the whole edifice of social tradition. Disease and crime are no longer regarded as inevitable consequences of the organisation of society to be treated by curative measures. They are being attacked with all the scientific knowledge that we now have, and it is intended that they shall be eliminated by the evolution of a type of man and a form of society in which they will not exist. Man is no longer content to allow natural forces to work their will upon him; he has challenged Nature, bending it to his will, and hereafter will direct his own evolution.

The biological discovery of man's place in Nature has created the need for a biological training for priests and law-makers, for further developments of civilisation will be made possible only through the growth of biological knowledge. The nineteenth century saw revolutionary advance in the physico-chemical field; the twentieth will see equal advance in the domain of biology. In the past, man's control has been over inanimate things: now the conquest of living Nature has begun.

Antarctic Discoveries.

IN his nine hours' flight of 1200 miles over Graham Land on Dec. 19, Sir Hubert Wilkins made discoveries of great value. This was the first flight ever made in Antarctic regions and shows the value of air transport for the explorer in a part of the world where pioneer work has yet to be done. In a few hours, travelling at a speed of 120 miles an hour, Sir Hubert reached farther south than any ship has ever been able to penetrate on the eastern side of Graham Land, where Captain Larsen in 1893 had managed to reach lat. 68° S. Previous knowledge of the coasts of Graham Land ended, with any detail, on the eastern side in about lat. 66° S., and on the western side in about lat. 69° S. Beyond these latitudes, and even to the north of them in many places, knowledge was very sketchy.

The main features of Sir Hubert Wilkins' discoveries can be gathered from his dispatches to the *Times*. From Deception Island he and Lieut. Eielson flew south over the high peaks of Trinity Peninsula and the King Oscar coast, and almost exactly on the Antarctic Circle found an ice-filled twisting channel joining the Weddell and Bellingshausen Seas. The eastern end seems to open between the Weather (Wetter) Island of Larsen and another large island lying about 50 miles farther south. From the description, this island would appear to belong to the zone of basaltic rocks that lies to the east of the folded zone of Graham Land.

The eastern end of this strait was missed by Larsen and Nordenskjöld. Larsen was too far east owing to the wide ice-shelf on that coast preventing his ship approaching, and Nordenskjöld's farthest south on his sledge journey in 1902 was about lat. 66° S. Yet at that point he had a vague suspicion of the existence of a very long inlet if not a strait. At its western end the strait discovered by Sir Hubert Wilkins no doubt opens into the great Auvert Bay which Dr. Charcot placed north of his Loubet Land. Auvert Bay has not been explored and its eastern end is left blank on the charts. The *Times* reports that this new strait has been named Crane Channel.

Farther south Sir Hubert Wilkins reports that the rugged ranges of South Graham Land decrease in height but rise again towards lat. 70° S. In that latitude there exists a second strait, named Stefansson Strait, forty to fifty miles wide joining the Weddell and Bellingshausen Seas. Beyond this the ice cliff which borders the Weddell Sea from Coats Land westward seems to continue. Very possibly it continues through the strait, borders the Pacific Ocean, and reaches King Edward Land. About here Sir Hubert was forced by lack of fuel to turn, but he writes of the ice-covered surface sloping upwards to the south, which suggests the high plateau of Antarctica. This part of Antarctica receives the name of Hearst Land. The mainland of the southern continent is probably entirely of the same plateau structure with conspicuous fault ranges in the Ross Sea area. The theory that any part of the mainland is a region of Andean folding must now apparently be abandoned.

These details will of course be amplified in the course of time and the photographic record of the flight will help to make the picture complete. At present the news suggests that the folded ranges of Graham Land are lost by depression in about lat. 70° S. They probably skirt the ice-covered plateau of Antarctica, appearing as emerged land in such areas as Alexander Island, Charcot Land, the volcanic Peter Island, and perhaps King Edward Land. So little, however, is known of King Edward Land that its participation in the Andean folds cannot be stated with certainty. The existence of many large tabular bergs off Alexander Island, which appears to lie near the western end of the large strait, suggested to Dr. Charcot many years ago that shelf or barrier ice could not be far distant from that coast.

Sir Hubert Wilkins' discoveries thus throw light on one of the chief problems of Antarctica, namely, the relation of the folded Andean structure of Graham Land and the plateau structure of Victoria and adjacent lands and probably of Coats Land. The more striking discovery of the straits across Graham Land is actually of less importance. It has been known since the days of the *Belgica* expedition towards the end of last century that Graham Land was a heavily submerged area. Its continuity with the folds of South America has been lost by submergence. Belgian and French expeditions on the west, and Swedish and other expeditions on the east, have shown the extent of submergence in outlying archipelagoes and deep inlets. Channels crossing from coast to coast are not surprising in such a land. In South America such channels occur in the far south. These newly