supplying to the water the oxygen necessary for the respiration of living protoplasm. Our object must be to estimate the rate of production and rate of destruction of all organic substances in the sea.

To attain to an approximate census and valuation of the sea—remote though it may seem—is a great aim, but it is not sufficient. We want not only to observe and to count natural objects, but also to understand them. We require to know not merely what an organism is—in the fullest detail of structure and development and affinities—where it occurs—again in full detail—and in what abundance in different circumstances, but also *how* it lives and what all its relations are to both its physical and its biological environment, and that is where the physiologist, and especially the biochemist, can help us. In the best interests of biological progress the day of the naturalist who merely collects, the day of the anatomist and histologist who merely describe, is over, and the future is with the observer and the experimenter animated by a divine curiosity to enter into the life of the organism and understand how it lives and moves and has its being. "Happy indeed is he who has been able to discover the causes of things."

Cardiff is a seaport, and a great seaport, and the Bristol Channel is a notable sea-fisheries centre of growing importance. The explorers and merchant venturers of the south-west of England are celebrated in history. What are you doing now in Cardiff to advance our knowledge of the ocean? You have here an important university centre and a great modern national museum, and either or both of these homes of research might do well to establish an oceanographical department, which would be an added glory to your city and of practical utility to the country. This is the obvious centre in Wales for a sea-fisheries institute for both research and education. Many important local movements have arisen from British Association meetings, and if such a notable scientific development were to result from the Cardiff meeting of 1920, all who value the advance of knowledge and the application of knowledge to industry would applaud your enlightened action.

In a wider sense, it is not to the people of Cardiff alone that I appeal, but to the whole population of these islands, a maritime people who owe everything to the sea. I urge them to become better informed in regard to our national sea-fisheries and to take a more enlightened interest in the basal principles that underlie a rational regulation and exploitation of these important industries. National efficiency depends to a very great extent upon the degree in which scientific results and methods are appreciated by the people and scientific investigation is promoted by the Government and other administrative authorities. The principles and discoveries of science apply to aquiculture no less than to agriculture. To increase the harvest of the sea the fisheries must be continuously investigated, and such cultivation as is possible must be applied, and all this is clearly a natural application of the biological and hydrographical work now united under the science of oceanography.

Summaries of Addresses of Presidents of Sections of the British Association.

Mathematical and Physical Science.

PROF. EDDINGTON's presidential address to Section A deals with the investigation of the internal conditions of the stars. Most of the naked-eye stars have densities so low that they may be treated as spheres of perfect gas (giant stars). In familiar hot bodies the energy existing in the æther (radiant heat) is extremely small compared with that associated with the matter (molecular motions); conditions might exist in which this disproportion was reversed; but the stars are of just such a mass that the two kinds of energy are roughly equal. It is thought that this balance cannot be a coincidence, but determines why the masses of the stars are always close to a particular value. From astronomical data as to the masses and radiation of the stars it is possible to determine the opacity of stellar material to the radiation traversing it. The opacity turns out to be very high and of the same order of magnitude as that found for X-rays in the laboratory. (At the high temperatures in the stars the radiation consists mainly of soft X-rays.) A rather surprising result is that the opacity varies very little with the temperature of the star or wave-length of the radiation. The discussion leads to many astronomical results which appear to be generally confirmed by observation; in particular, it fixes within fairly narrow limits the period of a mechanical pulsation of any star, and this agrees in all known Cepheid variables with the observed period of light-pulsation. The question of the source of a star's heat is raised in an acute form by these investigations. It appears that the energy of gravitational contraction is quite inadequate. The recent experimental results of Aston and Rutherford seem to throw some new light on the often-discussed question whether sub-atomic energy can be made available in the stars. The address concludes with some observations on the legitimate place of speculation in scientific research.

Chemistry.

Mr. C. T. Heycock deals in his presidential address to Section B with the manner in which our present rather detailed knowledge of metallic alloys has been acquired, starting from the sparse information which was available thirty or forty years ago, and sketches briefly the present position of the subject. He considers chiefly the non-ferrous alloys, not because any essential difference in type exists between these and ferrous alloys, but because the whole field presented by the chemistry of the metals and their alloys is too vast to be covered in an address of reasonable length. Though Réaumur in 1722 employed the microscope to examine the fractured surfaces of white and grey cast-iron and steel, and Widmanstatten in 1808 polished and etched sections from meteorites, the founder of modern metallography is undoubtedly H. C. Sorby, whose methods of polishing and etching alloys and of vertical illumination are used to-day by all who work at this subject. The first important clue to what occurs on cooling a fused mixture of metals was given by Guthrie's experiments on cryohydrates, and these researches, with those of Sorby, undertaken as they were for the sake of investigating natural phenomena, are remarkable examples of how purely scientific experiment can lead to most important practical results. Raoult's work on the depression of the freezing point of solvents due to the addition of dissolved substances led to the establishment by van't Hoff of a general theory applicable to all solutions. Later experiments established the similarity between the behaviour of metallic solutions or alloys and that of aqueous and other solutions of organic compounds in organic solvents; and in 1897 Neville and Heycock determined the complete freezing-point curve of the copper-tin alloys, confirming and extending the work of Roberts-Austen, Stansfield, and Le Chatelier. These were probably the first of the binary alloys on

which an attempt was made to determine the changes which take place in passing from one pure constituent to the other; and without a working theory of solution the interpretation of the results would have been impossible. Many difficulties are encountered in the examination of binary alloys, but they are enormously increased in the investigation of ternary alloys, and with quaternary alloys they seem almost insurmountable; in the case of steels containing always six, and usually more, constituents, information can be obtained at present by purely empirical methods only.

Geology.

In discussing the relations of palæontology to other branches of biology in his presidential address to Section C, Dr. F. A. Bather emphasises the influence of the time-concept, which gives palæontology a fourth dimension and necessitates a new method of classification. The known facts of succession, while upsetting some rash speculations, do not, unaided, prove descent. Recapitulation, however, does furnish the desired proof. The "line-upon-line" method of research is the only sure one, and this has brought out a continuous transition in development, and definite directions leading to a seriation of forms. But this appearance of seriation, though it may be sometimes due to determinate variation, in no way implies determination; and still less do the facts warrant the belief in predetermination so generally held by palæontologists. After rebutting the various arguments for predestination, counter-adaptive degeneration, and momentum in evolution, Dr. Bather shows how light is thrown on the supposed instances by the study of adaptive form and of habitat. The varying rate of evolution, the recurrent cycles of structure, and the birth and death of races, all are dependent on the secular changes of environment. To correlate the succession of living forms with those changes is the task of the palæontologist. When completed, our geological systems will express truly the rhythm of evolution. But if there is no inevitable law of progress for any living creature, neither is there a law of decadence; and man, by controlling his environment and adapting his race through conscious selection, has but to aim at a high mark in order to prolong and hasten his ascent.

Zoology.

Prof. Stanley Gardiner in his presidential address to Section D asks the consideration of the public to the claims of zoology to support, and of the professional students of the science to the comparative sterility of much of their teaching and research. The chief claim of zoology lies in its broad applicability to human life. Harvey's researches on circulation and embryology apply directly to medicine and human growth. Malaria, typhus, dysentery, trench fever, and now, perhaps, cancer, are understandable only by the studies of the pure zoologist on insects and on the physiology of unicellular organisms. Mendel's work gives hopes of the understanding of the laws governing human heredity and of establishing immunity to many diseases. Economic entomology is founded on the seventeenth-century study of insect life-histories, and now we struggle for knowledge of the enemies or parasites of insects wherewith to destroy them by natural means. Curiosity as to the possibilities of life in the deep sea led to the opening up of great banks, without which our fishing industry would still be a small thing. River-eels migrate thousands of miles to breed, and mackerel migrations are correlated with sunlight; the Swedish herring fisheries depend on cycles of sun-spots and longer cycles of lunar changes.

Great as are such results, they approach the limit of what can be attained from the old zoological studies of anatomy, distribution and development. The future lies in the study of the living protoplasm, its universal association with water, the effects of acidity or alkalinity on reproduction and growth, the possibilities of dissolved food substances and perhaps of vitamines in water, and, finally, reproduction without the help of the male. Yet zoology is in danger, for its results are seldom immediately applicable to industry, and economic specialists are trying to make their students study their specialities without having a sufficiently broad scientific education to be able to consider what life really is. The old naturalists were largely cataloguers, but what they sought was the understanding of life. Then came in succession the anatomists, the embryologists, and the evolutionists, the last clearly seen to-day in that the subject as taught in many schools is merely history. Zoology must emancipate itself from its dry bones, and recognise that its museums and institutions are means only for the study of life itself.

Geography.

In his presidential address to Section E Mr. J. McFarlane discusses the principles upon which the territorial rearrangement of Europe has been based. He considers that the promise of stability is greatest in those cases where geographical and ethnical conditions are most in harmony, and least where undue weight has been given to considerations which are neither geographical nor ethnical. The transfer of Alsace-Lorraine to France must be defended, if at all, on the ground that its inhabitants are more attached to France than to Germany. The loss of territory which Germany has sustained both in the east and in the west is aggravated by the fact that from the regions lost she has in the past obtained much of her coal and iron-ore. Serious as her position is, however, her economic stability is not necessarily threatened. The position of Poland is geographically weak, partly because the surface features are such that the land has no well-marked individuality, and partly because there are no natural boundaries to prevent invasion or to restrain the Poles from wandering beyond the ethnic limits of their State. On the other hand, the population is sufficiently large and the Polish element within it sufficiently strong to justify its independence on ethnical grounds.

Czecho-Slovakia, in various ways the most interesting country in the reconstructed Europe, is alike geographically and ethnically marked by some features of great strength and by others of great weakness. Bohemia possesses geographical individuality, and Slovakia is at least strategically strong, but Czecho-Slovakia as a whole does not possess geographical unity, and is, in a sense, strategically weak, since Moravia, which unites Bohemia and Slovakia, lies across the great route from the Adriatic to the plains of Northern Europe. Rumania has sacrificed unity of political outlook and ethnic homogeneity by the annexation of Transylvania, while her position on the Hungarian plain is likely sooner or later to involve her in further trouble with the Magyars. Indeed, the treatment of the Hungarian plain is the most unsatisfactory part of the whole Peace settlement. In that great natural region the Magyar element is the strongest, and to divide it as has been done is to induce a position of unstable equilibrium which is likely to lead to trouble in the future.

The troubles of Austria are due to the fact that she has failed to realise that an empire such as hers can be permanently retained only on a basis of common

political and economic interest. At present she has no place in the reconstructed Europe, and a complete political re-orientation will be necessary if she is to emerge successfully from her present trials.

The pre-war frontier of Italy in the east is unsatisfactory, because it assigns to Austria the essentially Italian region of the Lower Isonzo. But beyond that region and a position on the neighbouring highlands for strategic purposes, Italy has no claim except what she can establish on ethnic grounds. The so-called "Wilson line" meets her requirements fairly well.

Economic Science and Statistics.

Dr. J. H. Clapham's presidential address to Section F contains a comparison and contrast between the economic condition of Western Europe after the Napoleonic wars and its economic condition to-day. Figures for the total losses of France and for the debt accumulated by Great Britain during the former period go to prove that if warfare in those days lacked intensity, it made up in duration. As in 1918, France was short of men, and her means of communication had suffered; her rapid recovery illustrates the essential difference between the two periods: a hundred years ago few men were demobilised in either France or Germany, and these were readily absorbed in an agricultural community. In 1816 the harvest was bad, and Western Europe approached starvation; the situation was saved only by the excellent harvest of the following year. Economic organisation was primitive, but elastic. A modern parallel is Serbia, which has improved wonderfully since the bountiful harvest of 1919. Germany suffered rather longer owing to the lack of a strong central Government; the States which have risen from the wreckage of the Austro-Hungarian Empire are now in a similar plight. Great Britain was partly industrial, and recovery was delayed by mismanagement of supplies, taxation, and demobilisation. Stocks of Colonial goods had accumulated with which home markets were flooded, and a commercial and industrial crisis followed. A similar situation exists now in the United States; she is a creditor nation with a big export trade, but she will not permit indiscriminate exchange. Modern financial methods are staving off such a crisis as followed the Napoleonic wars. The central problem is: When will the inability of war-damaged countries to pay for the material they require to restart their industries be felt by the nations supplying them? If trade balances are adjusted, the post-war slump will become a slow decline; otherwise, a crisis must occur when international obligations cannot be met. Another feature of the situation in the early part of the nineteenth century was the rapid growth in population observed everywhere. Official figures indicate the possibility of a repetition of this phenomenon.

Engineering.

Prof. C. F. Jenkin in his presidential address to Section G suggests that the time has come for an extensive revision of the theory of the strength of materials as used by engineers. The mathematical theory needs to be extended to cover anisotropic materials, such as timber, and to enable concentrations of stress such as occur at all changes of section to be calculated. Our knowledge of the physical properties of materials requires to be extended so that their suitability for all engineering purposes may be known. The need for the wider theory and for more research into the properties of materials is illustrated by examples of the problems which occurred in aeroplane construction during the war. The first material dealt with by the Air Service was timber. How was the strength of such material to be calculated? It was shown that the components of the tensile stress in three principal directions must not exceed the tensile strengths in those directions. Curves limiting the stress at any angle to the grain have been drawn for spruce, ash, walnut, and mahogany. For plywood, "split-off" veneers were recommended in place of "cut-off" wood. The method used for the determination of Young's modulus for wood neglects the effect of shear, and is therefore inaccurate. As an example of an isotropic substance steel is discussed. Fatigue limit is suggested as a measure of strength; in samples examined it was found to be slightly less than half the ultimate strength. Research is necessary to determine the effects of the speed of testing, rest and heat treatment, and previous testing. For this improved methods are required; Stromeyer's method would be useful if modified for commercial use. Present methods of testing in torsion are unsatisfactory, and knowledge of the internal mechanism of fatigue failure is required. For members of structures subjected to steady loads a proof-load specification which limits the permanent set to $\frac{1}{2}$ per cent. or $\frac{1}{4}$ per cent. is suggested. If fatigue limit is the basis for engine-strength calculation, the distribution of stresses in irregularly shaped parts of the machine must be investigated. Prof. Coker's optical method has been applied to this end, but A. A. Griffith's calculations on the effects of grooves and polishing have not been tested. Wood and steel are the only materials about which trustworthy data have been collected.

Anthropology.

Prof. Karl Pearson in his presidential address to Section H urges the importance of anthropology, "the true study of mankind." Science should be studied, not for itself, but for the sake of man. For this reason there is no use for the collection of measurements of height, span, size of head, etc. The important characteristics are the psycho-physical and psycho-physiological factors, reaction-time, mental age, and pulse-tracing. Body measurement has no connection with "vigorimetry" and psychometry, for no pure "line" in man has been traced. Moreover, present methods are entirely qualitative; they must be made quantitative. Three things are urged as essential to the recognition of anthropology as a useful science. First, folk-psychology as well as individual psychology should be studied as a means to determine race efficiency. For this purpose, the ancestry of man must be investigated in order that we may know which is likely to have the greater influence on his future, Nature or nurture. Secondly, institutes for the study of anthropology ought to be established in at least three of our universities. There the workers would be in touch with allied sciences, they would have a wide field open for measurements, and would be able to teach as well as to research on the subject. In this way men could be fitted for important "extra-State" work as diplomatic agents, traders, etc., in foreign lands. Another section of the work should be devoted to a study of the population at large; the schools, the factories, and the prisons must all be investigated, so that the present wasteful organisation of society may be remedied. When its value to the State has been proved, anthropology can ask for adequate support as its right. The third point urged is the adoption of a new technique. Logical accuracy and mathematical exactness must be introduced; training should start with anthropometry in its broadest sense, advancing later to ethnology, sociology, prehistory, and the evolution of man. Only by devotion to problems of real use can anthropology achieve her true position as "Queen of the Sciences."

Physiology.

Mr. Joseph Barcroft in his presidential address to Section I deals particularly with anoxæmia—by derivation a deficient quantity of oxygen in the blood—which is used to cover a larger field embracing all those conditions in which the supply of oxygen to the tissues is inadequate. The statement has been made that anoxæmia not only stops, but also wrecks, the machine. An inquiry into this statement cannot be made without first specifying whether the anoxæmia is sudden and profound, as in drowning, poisoning with mine-gas, etc., or is of long duration but trivial in degree. In the former case the stoppage of the machine may be almost complete, as in the case of persons rendered unconscious by carbon monoxide, by stoppage of the cerebral circulation, or by attaining an altitude in the air at which the oxygen pressure is too low. In such cases the permanent damage to the machinery is very slight. On the other hand, mild anoxæmia continued over weeks and months, as in sufferers from gas-poisoning, shallow respiration, and deficient ventilation of portions of the lung, is stated by Haldane, Meakins, and Priestley to produce far-reaching effects on the central nervous system. Anoxæmia may be classified as consisting of three categories. They are tabulated as follows, with examples:

ANOXÆMIA.

Types	I. Anoxic	II. Anæmic	III. Stagnant
Characteristics	Too little oxygen pressure and too much reduced hæmoglobin in arterial blood, which is too dark in colour	Too little oxyhæmoglobin, but normal oxygen pressure in arterial blood, which is bright unless discoloured by some abnormal pigment	Arterial blood normal in oxygenation, but blood-flow too slow
Examples	Mountain sickness, pneumonia, etc.	Anæmia CO poisoning Methæmoglobin poisoning	Shock Back pressure

For a given deficiency of oxygen carried to the tissue in unit time the first type is the most serious, and the last least so. The anoxic type is measured by the percentage saturation of the arterial blood; the anæmic by the quantity of oxyhæmoglobin in it; and the stagnant by the "minute volume."

Botany.

Miss E. R. Saunders in her presidential address to Section K deals with the subject of Heredity. In the brief historical introduction attention is directed to the fundamental opposition between the earlier statistical methods of representing the hereditary process and the Mendelian conception which has its foundation in the act of sexual reproduction. Various complex relations which have proved capable of elucidation through the application of Mendelian principles are illustrated, and evidence is adduced in proof of the applicability of these principles to the case of specific hybrids. Certain cases are described where the unit for which the Mendelian factor stands appears to be a particular state of physiological equilibrium, and where lack of conformity of phenotypic appearance to genotypic constitution can be readily induced by a change in environmental conditions. The assumptions and difficulties involved in the explanations offered by the reduplication theory and the chromosome view respectively are discussed, together with the bearing of the evidence to date upon the question whether the same end-result, viz. segregation, may not be effected by a different mechanism, or at a different phase of the life-cycle, in different types. As a practical outcome greater co-operation is pleaded for between cytologists, physiologists, chemists, and breeders in attacking genetical problems.

Educational Science.

Sir Robert Blair in his presidential address to Section L directs attention to two of the wider aspects of present educational activities. The first part of the address is devoted to a general statement of the lines of advance and the success obtained in the application of psychology to the problems of education. The president, however, desires that education should become something more than applied psychology. The science of education "must be built up, not out of the speculations of theorists or from the deductions of psychologists, but by direct, definite, *ad hoc* inquiries concentrated upon the problems of the class-room by teachers themselves. When by their own researches teachers have demonstrated that their art is, in fact, a science, then, and not till then, will the public allow them the moral, social, and economic status which it accords to other professions." The second part of the address consists of an appeal to all voluntary effort to associate itself directly with the work of the local education authority. Sir Robert Blair thinks that our system of education will become national only when such national institutions as the public schools, the endowed grammar schools, and the universities have joined forces with the local education authorities and take a direct share in the solution of their problems. He seeks a form of association which will retain all the advantages of the older traditions.

Agriculture.

Prof. F. W. Keeble's presidential address to Section M is devoted to the subject of intensive cultivation. Commencing with a review of the work done by horticulturists during the war, it passes on to consider the prospects of success of any large development of intensive cultivation which may be undertaken. It insists on the great need for organisation in research, education, and administration, and describes the organisation which the author established during his tenure of the office of Controller of Horticulture in the Ministry of Agriculture. In this connection the important question of the relation of the "expert" and the "administrator" is considered, and the conclusion reached that "if the work of a Government office is to be and remain purely administrative, no creative capacity is required, and it may be left to the sure and safe and able hands of the trained administrator; but if the work is to be creative it must be under the direction of minds turned, as only research can turn them, in the direction of creativeness." The consideration of our imports, of the reduced acreage under fruit, and of the continuous rise in the standard of living throughout the world suggests that the acreage under fruit might be increased by a good many thousand acres without fear of over-production. After illustrating by a series of striking examples the effect which the practice of intensive cultivation has on bringing about the colonisation of the countryside, the address reaches the conclusion that it is the duty of the State to help the intensive cultivator to hold his own against world-competition by perfecting the organisation of horticulture, and, above all, by providing a thorough and practical system of horticultural education. The measure of success which intensive cultivation will achieve will depend ultimately on the quality and kind of education which the cultivators are able to obtain.