(heavy and early hormone treatment), and even the latter has some degree of genetic determination.

The canalization of an environmentally induced character is accounted for if it is an advantage for the adult animal to have some optimum degree of development of the character irrespective of the exact extent of stimulus which it has met in its early life ; if, for example, it is an advantage to the young ostrich going out into the hard world to have adequate callosities even if it were reared in a particularly soft and cosy nest. Now in so far as the development of the character becomes canalized, the action of the external stimulus is reduced to that of a switch mechanism, simply in order that the optimum response shall be regularly produced. But switch mechanisms may notoriously be set off by any of a number of factors. The choice between the alternative developmental pathways open to gastrula ectoderm, for example, may be made by the normal evocator or by a number of other things (the mode of action of which may be through the release of the normal evocator (cf. Waddington[14]), but which remain different to the normal evocator nevertheless). Again, we know many instances in which several different genes, by switching development into the same path, produce similar effects ; and attention has already been directed to the 'phenocopying' of a gene by a suitable environmental stimulus. Thus once a developmental response to an environmental stimulus has become canalized, it should not be too difficult to switch development into that track by mechanisms other than the original external stimulus, for example, by the internal mechanism of a genetic factor ; and, as the canalization will only have been built up by natural selection if there is an advantage in the regular production of the optimum response, there will be a selective value in such a supersession of the environment by the even more regularly acting gene. Such a gene must always act before the normal time at which the environmental stimulus was applied, otherwise its work would already be done for it, and it could have no appreciable selective advantage.

Summarizing, then, we may say that the occurrence of an adaptive response to an environmental stimulus depends on the selection of a suitable genetically controlled reactivity in the organism. If it is an advantage, as it usually seems to be for developmental mechanisms, that the response should attain an optimum value more or less independently of the intensity of stimulus received by a particular animal, then the reactivity will become canalized, again under the influence of natural selection. Once the developmental path has been canalized, it is to be expected that many different agents, including a number of mutations available in the germplasm of the species, will be able to switch development into it ; and the same considerations which render the canalization advantageous will favour the supersession of the environmental stimulus by a genetic one. By such a series of steps, then, it is possible that an adaptive response can be fixed without waiting for the occurrence of a mutation which, in the original genetic background, mimics the response well enough to enjoy a selective advantage.

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WORLD MINERAL RESOURCES : A SUGGESTED SURVEY*

By PROF. P. G. H. BOSWELL, F.R.S.

IN order that the Fourth Article of the Atlantic Charter (". . . endeavour with due respect for their existing obligations, to further enjoyment by all States . . . of access on equal terms to the trade and to the raw materials of the world which are necessary for their economic prosperity") may be implemented, what preparatory work can usefully be undertaken ? The terms of the clause are none too explicit, perhaps inevitably so. It is trite to say that the problems that arise in the international politico-economic field bristle with difficulties. But there are certain geological questions which, if the discussion of mineral resources is not to be entirely academic, should be borne in mind if we are to be prepared in any way for action when the time comes.

First, in the matter of assessing the world's resources of essential minerals. All will agree that knowledge of location and quantities is a pre-requisite of action. Our information dates from pre-war days. The very character of the present world war, however, has necessitated the exploitation of mineral deposits on a huge scale and may well prove to have permanently changed the relative importance of certain resources and the location of industries ; and under post-war reconstruction the process will be continued. Re-assessment is thus necessary, but it can only be effectively undertaken after the War, when conditions once more allow of access and exploration.

Nevertheless, available knowledge forms a foundation on which we can build. Our sources of information include (*a*) publications of the Imperial Institute, Mineral Resources Bureau (mainly statistical and relating to production, imports and exports of various countries), (*b*) world conspectuses of individual minerals (such as gold, iron, copper, coal), prepared by the International Geological Congress, (*c*) publications of various official Geological Surveys, such as the mineral reviews of the U.S.A., and the quinquennial reports of the Geological Survey of India, and (*d*) various reference books and papers published by scientific and technical societies. Many of these contain compilations from returns issued by various countries. Considerations of strategy

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and propaganda render some of the figures suspect. For example, who would trust the figures from Nazi Germany in the pre-war years ? A further difficulty arises in the statements of available resources, namely, the differing connotation of the expression "estimated resources", for it is often difficult to say to what extent these are "proved" and "unproved, but probable". The propaganda value of generous estimates has not always been overlooked. In this connexion, the Institution of Mining and Metallurgy has for many years endeavoured to obtain clarity and uniformity in the use of language relating to such resources. Statistics inevitably become out of date with the lapse of time, but much of the information relating to the mode of occurrence of the materials and the potentialities of the various fields will undoubtedly serve as a reliable foundation for subsequent work. Much sorting out and collation of details will be involved, and revision of data will be necessary, but the task is laborious rather than difficult. Further, much valuable information about known resources and estimated reserves is locked away in the archives of mining companies. How far is such confidential matter to be made available ?

Scientific workers, especially those not engaged in the war effort, could get to work at once on these preliminary compilations, but I believe that the complete data which should serve as a guide for post-war planning can only be compiled by an international commission after the War.

Compilations of this kind are doubly necessary, first for the reason mentioned above, that political action can be effective only if it is based on knowledge of the location and magnitude of natural resources, and secondly because minerals are wasting assets. Therefore, policy must be framed on the reasonable expectation of life. Chemists are already providing us with substitutes for many raw materials, and they (and metallurgists) would doubtless find it of advantage to be told what mineral substances were likely to be in short supply : they might then direct their energies into the most useful channels.

It may justifiably be said that hitherto the minerals containing rare elements have been discovered either by accident or incidentally in the search for, or exploitation of, common metals. The increasing importance of the rare elements in the fields of metallurgy, illumination, etc., suggests that the time has come for systematic prospecting.

In certain cases, a particular mineral has been discovered in workable quantities at such a few localities on the earth's surface that the establishment of a monopoly or quasi-monopoly has become possible. If the terms of the Atlantic Charter are to be fulfilled, the continuance of such a state of affairs may well require action ; it will certainly demand consideration. We are here brought up against those political problems which are inappropriate to this Conference, but it will do no harm if we are induced privately to ponder over questions of ways and means—licensed working, cartels, compulsory purchase, subsidies, sanctions and international policing.

Investigation of mineral resources must have the twofold aim of discovering new supplies and of maintaining the activities, so far as possible, of existing undertakings. Obviously, exploration must be kept ahead of exploitation. Large portions of the earth's surface have already been surveyed, often thoroughly so far as common minerals are concerned, but less intensively in the case of rare elements. However, there are considerable areas of which our knowledge is scanty. A decade ago, we should have said that the outstanding examples were the U.S.S.R. and China, occupying respectively a sixth and a ninth of the earth's land surface. The U.S.S.R., fully alive to the importance of the task, has built up a geological survey with a staff said to number 10,000 (as compared with staffs of hundreds or less in other countries). As a result, although much remains to be done, knowledge of the mineral resources of the U.S.S.R. has increased enormously ; indeed, the U.S.S.R. may prove to be the most nearly self-supporting political unit in the world as regards essential minerals. China, however, still provides vast fields for exploration and, although some of its useful minerals are being exploited, many more are doubtless latent. Smaller areas of the earth's surface are also incompletely explored ; others, especially those blanketed by superficial deposits, may yield their secrets under the combined efforts of geologists and geophysicists.

In order that these areas may be examined and their resources developed, geologists and mining engineers will be needed in considerable numbers. As Britain was the cradle of geology, and as her sons have long been in the habit of penetrating the unknown in all parts of the world, it is but fitting that we should be prepared to carry on the tradition. Small countries like Britain, Holland and Switzerland have long exported geologists (and imported their earnings), especially since the limited mineral resources at home provided few careers for them. Latterly, larger countries such as the U.S.A., the Dominions and Germany have followed suit. I believe that the powers of resistance, adaptability, field-sense and sound training of British geologists fit them peculiarly well for this work. But of late years we have been faced by an increasing shortage of geologists in Great Britain, largely because of public unawareness of the importance of the subject and its consequent neglect in our educational system.

After the War of 1914–18, although there had been no pre-war insufficiency as now, we experienced an acute shortage of trained men. I venture to issue a warning that, after the present conflict, which has diverted many geologists into other fields of activity and denuded the universities of students in training, the deficiency will be still more serious. Other European countries are not likely to be able materially to relieve the situation ; indeed, a number of them were importers of British geologists before the War. We should find it deplorable if we could not play our part in the active exploration that post-war conditions will necessitate, and we may therefore insist that it would be a good stroke of national policy to begin training geologists without delay. It used to be said that trade follows the flag, but for many years past it has been evident that trade follows the hammer and a nation's goods the mining engineer. To revert to China, for example, we may remember with pride that Chinese geologists (from the distinguished director of the Geological Survey, Dr. Ting, down through his staff) have been trained in British universities. It will be unfortunate if such a valuable link in the chain of co-operation does not lead to the forging of others in the future.

Although it might at first sight seem that I had passed from international considerations to the more dangerous field of national interests and aspirations, I feel that, even if I had done so, I could plead justification ; and for the reason that, for many

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years to come, the universities and technicians of Great Britain must continue their practice of assisting other nationals to develop their own resources and of training them to be self-supporting. We have the brains, exceptional experience and facilities for carrying on the work; it would be regrettable if such advantages were not fully utilized, especially as the results could be appreciably amplified with the help of a little more State encouragement.

CENTENARY OF THE GOVERNMENT LABORATORY

DEPARTMENT OF THE GOVERNMENT CHEMIST

By Dr. A. G. FRANCIS, O.B.E.

In October 1842 a Laboratory was fitted up by the Board of Excise for the purpose of the examination of tobacco manufactured in the United Kingdom; Mr. George Phillips was appointed head of the Laboratory.

At first, work was confined to the examination of tobacco, but very soon comprised the examination of all excisable commodities. In the early years, Phillips and his collaborator Dobson carried out two notable researches. The first was the production of a method for the determination of the original gravity of beer, and the second resulted in the suggestion to use wood naphtha as a denaturant for spirits of wine. No better general denaturant has yet been discovered. By the time that Phillips retired in 1874, all public Departments sought the advice of the Laboratory and entrusted to it much of their chemical work.

Dr. James Bell, F.R.S., succeeded Phillips and was immediately concerned with the Food and Drugs Act, 1875, and later, with the Fertilisers and Feeding Stuffs Act, 1893. Both these Acts involved the Laboratory in considerable research into the composition and methods of analysis of foods and agricultural products.

Although a certain amount of routine testing had been carried out by the Board of Customs at the Custom House, it was not until 1875 that a scientific laboratory was set up there. The Food and Drugs Act placed upon the Board of Customs the duty of ensuring the wholesomeness of imported tea. The Custom House Laboratory developed along lines similar to those of the Inland Revenue Laboratory: there was some overlapping of work, with friction between the two departments. In 1894, therefore, the Treasury united the two laboratories under the superintendence of one administrative chief, Prof. (later Sir) Thomas Edward Thorpe, F.R.S., being appointed as the first Principal Chemist of the Government Laboratory.

At first Thorpe was concerned mainly with the reorganization of the two laboratories and in the design and equipment of a new building, which was erected in Clement's Inn Passage, Strand, and occupied in October 1897. Thorpe's tenure as principal was characterized by great activity and expansion in all sections of the Laboratory, and noteworthy investigations on problems affecting public health, as well as on revenue matters, were undertaken. The results of these investigations were published in numerous reports of departmental committees at the time. Thorpe also carried out some fundamental work, of which one example may be mentioned, namely, the determination of the atomic weight of radium. This work formed the subject of the Bakerian Lecture for 1907 to the Royal Society.

Thorpe retired in 1909 and was succeeded by Prof. (later Sir) James Johnston Dobbie, F.R.S. With the growth of the demand on the part of various public Departments for advice and assistance in matters involving chemical knowledge, the Treasury in 1910 felt that all Departments should be placed on the same footing as the Board of Customs and Excise as regards the use of the Laboratory. From April 1, 1911, Parliament provided for the expenses of the Laboratory under a separate vote. The Government Laboratory then became the Department of the Government Chemist, with Prof. Dobbie as the first Government Chemist. When the Laboratory became a separate Department, entry to the permanent scientific staff was thrown open to young chemists of high academic attainments and with experience in research or other post-graduate work.

In the next decade new work came mainly from the non-revenue departments. At the request of the Director of the Geological Survey and Museum, the chemical work of the Survey was taken over in 1913. During the War of 1914–18, much additional work was undertaken for the Admiralty, War Office, Air Ministry, Ministry of Munitions and the War Trade Department. This work involved a great deal of research into methods of analysis suitable for the special requirements of the various departments. Research was also concerned with the ultra-violet absorption spectra of alkaloids and of light elements. Interest in the welfare of factory workers continued and the Laboratory's work was included in the reports of the departmental committees set up by the Home Office. In this period, too, the disposal of works effluents in relation to the pollution of rivers and particularly the question of the disposal of flax-retting liquors occupied the attention of the staff.

The years 1920–35 saw a great expansion of the work of all sections of the Laboratory. There was much legislation involving action by Customs and Excise, with the result that the Laboratory was called upon to undertake new and varied problems. The Dyestuffs Act, 1920, the Safeguarding of Industries Act, 1921, and the various Finance Acts imposing new duties on silk and artificial silk and on hydrocarbon oils, the Import Duties Act, 1932, all meant that the Laboratory was called upon to undertake the analysis of a great number and variety of articles and to devise new methods of analysis. The cumulative experience of the Laboratory in the examination of a very wide range of articles over so many years enabled it to cope with this new work with little disturbance to its existing organization. This ready availability of the Laboratory was responsible in some measure for the smooth working of the Acts from the beginning.

Sir Robert Robertson, F.R.S., who had succeeded Sir James Dobbie in 1921, was called upon to undertake, for various Government Departments, a number of investigations of general interest to the public, of which the following instances may be given: the carriage of dangerous goods by sea, atmospheric pollution, the possible danger to health arising from the use of lead tetra ethyl in motor spirit, and the suitability of photography for use in copying documents. In addition, investigations of a different character included the recovery of radium from decayed luminous indicators, the determination of helium in natural gas, and the production of potash

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