Survey deals with routine inquiries, some of which entail lengthy researches. A service of a similar nature dealing largely with inquiries from the Dominions, India and the Colonies is provided by the Mineral Resources Department of the Imperial Institute. This Department publishes monographs on economic minerals and valuable statistical reports on world mineral production.

The staff of the Geological Survey, however, is limited in number, its members rarely reside for long in any particular place, and they are unable, therefore, to record the innumerable temporary sections and exposures that are constantly being produced. The local geologist, whether university or lay, has opportunities of acquiring a detailed knowledge, especially of the superficial deposits, which is denied to his Government colleague. It is to the local geologist that the civil authorities, if necessary through the offices of the regional commissioner, should turn for geological information on such matters as the proper siting of shelters, supplies of sand, and questions of a kindred nature. So far as I am aware, this has been done in few cases; the results of this neglect can be seen all over the country. A similar absence of consultation between the military authorities and local geologists is indicated, for example, by the flooding of military works, the perilous position of certain tank blocks especially along rivers, and the instability of costly excavations. It is happier to record that in a few cases this desirable liaison has been established. Good work was done by some local geologists in indicating sources of sand for sandbag-filling in the early days of the War. Moreover, hundreds of thousands of pounds were saved in transport costs in London alone by following advice on the location of sand deposits given by the Geological Survey.

A very important war-time activity of the Geological Survey is connected with water supply, and many of the War-time Pamphlets deal with supplies from underground sources for various parts of the country. Movements of population, the formation of great military camps and aerodromes, and the construction of immense factories all raise problems in water-supply. Time was when a camp site was decided upon and then a water-supply demanded, but I understand that this procedure has now been changed. It is obvious that an accurate assessment of the present supply from underground sources, of emergency and even long-range supplies, has to be made, and especially in the so-called invasion areas. Piped supplies are liable to interruption by enemy action, and so the storage of water for fire-fighting in vulnerable districts may give rise to geological inquiry.

At the beginning of these remarks, I recalled the case of the scandalous neglect of geological advice at an aerodrome site, and I repeat that as complete a knowledge as possible of the geological conditions, both as regards water supply and foundation factors, at sites projected for costly camps, aerodromes and factories, is an obvious precaution. The Geological Survey and non-Government geologists are engaged in a certain amount of preventive work along these lines.

Readers of the more popular Press may have seen very remarkable accounts of some of the underground factories, stores and the like which have been constructed. Before the expenditure of vast sums of money on these great mining and engineering works, with their attendant housing and transport schemes,

it is clearly a matter of common-sense to study in detail the prime control, the nature of the rocks and their arrangement. Here, again, the geologist has been utilized. The roughness of the geological story of Great Britain has resulted in our possessing a great number of suitable rocks suitably arranged for this purpose. A similar foresight is necessary in the construction of deep air-raid shelters and, again, most of our large towns have a fortunate geological past. At this point, non-geologists should ponder as to why London has its Underground, and draw a little comfort in these hard times.

What has been said above deals largely with the use, or non-use, of geological knowledge, but it has also been suggested that the best use of the geologist is to let him carry on with his usual work. This suggestion has not always been followed, and often it is the geologist himself who decides on a change of occupation. In certain branches of the Forces, a geological training is an advantage. All geologists can read maps and most can make them, some are expert drillers and others are familiar with mining and excavation methods. Men who have earned their living for years by the interpretation of aerial photographs should be employed in similar work in the Services. I have heard of an ex-geologist airman who finds his way about above England by his geological knowledge. There is a niche somewhere in camouflage for a geologist who will prevent the breaking of all geological rules in one small scheme, just as in happier times Hollywood might be persuaded to hire a geologist who would make sure that a film alleged to be in a Jerusalem setting would be set in Jerusalem geology, and not in that of California.

Such are some of the ways, then, in which geological knowledge and geologists are and are not being used in the war effort. The full employment of both can follow only from an adequate realization by the directorate of the possibilities of service.

MECHANISMS OF VISION

By PROF. SELIG HECHT

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THE symposium on visual mechanisms held on September 24 during the Fiftieth Anniversary Celebrations of the University of Chicago brought together some of the diverse methods and points of view found in the study of vision. Of the eight papers, three were concerned with the structures, materials and energy relations of the eye itself; one considered vision merely as an indicator of the state of the nervous system under anoxia; while the other four explored the relations between sensory phenomena and the central nervous system.

The morning session began with a report by Prof. Selig Hecht on the minimum energy required for vision. New determinations made under the best physical and physiological conditions yield values between 2.2 and 5.7×10^{-10} ergs, which correspond to 58 and 148 quanta of blue-green light (510 m μ). This is at the cornea. After corrections for reflexion from the cornea, for scattering and absorption by the ocular media, and for transmission by the retina, the range of 58–148 quanta at the cornea becomes 5–14 quanta absorbed by the retina. Since the stimulated

retinal area contains five hundred sensitive elements, a 2-quantum absorption by any one element is unlikely. Therefore, in order for us to see, only one light quantum need be absorbed by each of 5-14 retinal rods.

Because this number of events is so small, it may be derived from an independent statistical study of the relation between the intensity of a light flash and the frequency with which it is seen. Such experiments yield values of 5-7 for the number of critical events involved in threshold vision. Biological variation does not alter these values essentially, and the agreement between directly determined values and those derived from statistical considerations may be considered significant.

The results bear on the nature of the fluctuations shown by an organism in its response to a stimulus. The assumption has generally been that the stimulus is constant and the organism variable. The present considerations, however, show that at the threshold it is the stimulus which is variable and that the nature of its variability determines the fluctuations encountered between response and stimulus.

The light-sensitive substance of the retinal rods is visual purple. Prof. Arlington C. Krause, of the University of Chicago, has prepared enough visual purple so that common chemical procedures may be used for its study. He reported that visual purple consists of 50-65 per cent protein and 35-50 per cent lipid. The protein, though not well characterized, is conjugated with a complex lipid of fairly large molecular weight. The lipid contains nitrogen, sulphur and phosphorus fatty acids, and an unsaturated chromophore group, which may be carotenoid but is probably neither vitamin A nor carotene.

Several new substances can be isolated from the retina. Provisual red absorbs light between 340 and 416 m μ , gives an antimony trichloride reaction, and on hydrolysis yields fatty acids and visual red. Visual red absorbs only in the violet and ultra-violet, and also gives an antimony trichloride reaction. The yellow colour of bleached visual purple is due to visual yellow and indicator yellow. Visual yellow contains no nitrogen, phosphorus, or sulphur, and is insoluble in water. Indicator yellow contains both nitrogen and phosphorus, and is water-soluble.

Prof. Krause emphasized the similarities in light sensitivity and structure shown by visual purple and by cyanine dyes used for sensitizing photographic emulsions.

One of the outstanding characteristics of the central nervous system is its high metabolism and its great sensitivity to the lowering of the oxygen tension of the blood. Since visual impulses ultimately register in the central nervous system, visual function should be disturbed under anoxia. Prof. Ernst Gellhorn, of the University of Illinois, reported just such changes in brightness discrimination, visual acuity, colour perception, visual fields and negative after-images, and emphasized the rapid reversal of the effects by inhalation of oxygen. Since all these effects have in common the sensitivity of the nervous system to anoxia, it is concluded that they are an expression of this common factor. (It should be recalled that the retina also has a high metabolism and is sensitive to oxygen; indeed the recent work of Craik shows that visual function may be disturbed by local anoxia at the eye.)

Prof. Gellhorn presented evidence to show that the central nervous system possesses a progressively increasing sensitivity to anoxia in proportion as one

goes to higher levels. This is illustrated by the effect of anoxia on eye movements: those which are elicited reflexly are less affected by anoxia than those which are cortically determined.

The final morning paper was by Prof. Heinrich Klüver, of the University of Chicago, who summarized the difficult and beautiful experiments with Rhesus monkeys made before and after removal of the striate cortex. By use of the pull-in technique, it was possible to measure the visual capacities of such animals in considerable detail. The results show striking differences between operated animals in dim illumination and in bright illumination. Dark-adapted animals without any geniculo-striate system are still able to discriminate the brighter of two stimuli under a variety of modes of presentation of the two stimuli. The just recognizable brightness fraction $\Delta I/I$ lies between 0.23 and 0.29. The same differential fraction is obtained for area discrimination of equally bright surfaces, and for distances (squared) of otherwise equal fields. This indicates that it is the total luminous flux which is recognized, rather than its distribution in space. A difference in total amount of light is distinguished whether it is achieved by distance or by area or by brightness variation. Form perception is thus permanently lost.

All this is at low illumination and involves only the dim vision of the duplicity theory. Indeed the effectiveness of the spectrum bears this out, because it yields a luminosity function similar to the scotopic luminosity curve of the human eye. For higher illuminations involving light adaptation, the operated animals lose all trace of differential response.

In the normal monkey, recognition of differences in brightness or area or colour are not seriously affected by the way in which the stimuli are presented. It is as if these properties remain relatively constant despite marked changes in stimulus constellation, and thus provide the animal with a stable visual world. The removal of the geniculo-striate system seems to eliminate these constancies irretrievably.

The afternoon session was opened by Prof. Theodore J. Case, of the University of Chicago, with a paper on occipital alpha waves. Under normal conditions, these rhythmic brain potentials from the two sides are in phase and approximately equal. Occasionally persons appear in whom there exists a gross difference in size of the occipital waves from the two sides, whereas the frontal alpha waves are equal. Such individuals possess lesions in the occipital or temporal lobes, usually involving the optic radiations that pass through these structures, and therefore causing partial blindness (homonymous hemianopsia) on the side opposite the lesion.

Examination of more than a hundred persons with supratentorial lesions showed that whenever the optic radiations were involved, there was always a substantial difference between the occipital alpha waves on the two sides, so much so that a gross difference in occipital waves may be considered almost a diagnostic sign of occipital or temporal lobe lesions. Since an interruption anywhere in the geniculocalcarine pathway interferes with the occipital alpha waves of that side, and at the same time destroys vision, it may well be that the alpha waves actually exist in the optical radiations as an intrinsic rhythm upon which impulses from the visual organ impinge to form patterns for the mediation of vision.

Following this paper, Dr. S. Howard Bartley, of Washington University, presented some correlations between vision and neurophysiology. First, he

compared the potential changes in the optic nerve on stimulation of the eye with the known corresponding sensory experience. A short, weak flash of light results in a simple optic nerve discharge without subsequent changes. In vision this is registered as a simple flash of light. With a longer or more intense flash, the optic nerve record is a series of fairly regular waves following the simple *on* response. Visual experience reports this as a brief period of just distinguishable flicker. With a still longer or a more intense flash, there appears a prominent secondary wave which replaces the train producing the flicker; it and the *on* response yield the paradoxical experience of seeing two flashes. The secondary wave drops out as intensity or duration is increased, and visual experience loses its duality.

When the cortical response is recorded, the results are not so clear, and frequently involve interpretation. The most interesting fact is that a strong repeated stimulus may force the cortex to set up a rhythm in tune with the stimulus.

The paper by Prof. Stephen Polyak, of the University of Chicago, was a brief summary of material since published as a volume, "The Retina", in the Anniversary Series of the Chicago University Press. The essential point is that the complex structure of the retina agrees with the complex nature of the visual process. There are at least thirteen different types of neurons in the retina arranged in three levels: the photoreceptors (rods and cones), the analysers and association neurons (bipolar cells, horizontal cells and probably amacrine cells), and the integrators (ganglion cells).

The relations among these elements are complex and stable, and are at least thirty-five in kind. Some indicate an analysis of impulses from the photoreceptors; others suggest 'final common path' functions; while still others may even be inhibitory. Besides the perception of light and of colours, the retinal structures lend themselves to an interpretation of the various aspects of space perception, in terms of the degree of individuality in the connexions of the three components.

The symposium was closed by Prof. K. S. Lashley, of Harvard University, who proposed a new theory of cerebral organization. Animals are capable of perceptual generalization. When trained to differentiate on the basis, say, of specific sizes, they carry this over to a variety of visual arrangements. An object retains its essential form though we view it from different fixation points. The problem is that while nerve impulses are transmitted over definite pathways, behaviour seems to be determined by masses of excitation within general fields of activity without regard to particular nerve cells.

The exact topographical projection of the retina on the striate area may not be primary, because the olfactory sense is also accurately projected, yet it does not correspond to olfactory space. It may be that the geometry of nervous integration is quite different from the geometry of the stimulus.

The surface of the cortex contains connexions which permit the passage of activity in all directions. From a single focus, excitation may spread over the whole cortex, and because of the refractory period this spread will be wave-like. From several foci, interference patterns will be formed extending over the whole cortical area. Thus a given retinal configuration can produce a characteristic pattern of standing waves on the cortex which then forms the basis for its recognition.

Motor responses also are generalized. A rat which has learned a maze can follow it with unpractised muscle groups; thus a rat with a cerebellum lesion will roll rather than crawl through the maze successfully. The essential equivalent of visual perception is thus translated into an essential equivalent of muscle function. This means a revision of current notions of sensory motor organization. There is demanded a much more diffuse and widespread connexion between sense organ and motor neurons, a connexion in terms of an overall pattern perhaps such as is suggested for sensory organization.

RECONSTRUCTION IN CHINA

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CHINA has already begun to plan her national reconstruction after the War. But given good plans for Chinese reconstruction, and given sufficient capital and raw materials, China may not be able to carry out her programme of reconstruction successfully and effectively unless she has adequate supply of scientific men, engineers and technicians. At present there is already great shortage of trained personnel in various fields, especially in science and technology. Due to the lack of library and laboratory facilities as a result of destruction by the Japanese, and also to the insufficient number of first-grade professors in China, the training of scientific and technical personnel for cultural and economic reconstruction in China will depend, more than ever before, upon sending students to study in American and British universities. Unfortunately, since the outbreak of the war in China, the number of students studying in the United States and Britain has been reduced by more than a half, while very few remain on the European Continent. Unless a well-planned programme for training men and women for the tasks of reconstruction is worked out well in advance, the shortage of scientific and technical personnel will be very much more acute when the War ends and reconstruction in industry and agriculture is begun.

Such a programme for training scientific and technical personnel for China calls for the active co-operation and assistance of Great Britain and the United States. It means that for many years to come, before the Chinese universities are re-equipped and brought up to modern standards, and have sufficient good teaching staff, Chinese students will continue to be sent by hundreds to the United States and Britain for scientific and technical education; it means that many American and British professors will have to be invited to teach in Chinese universities.

It was with this purpose in mind that I am visiting Great Britain and the United States as the representative on education of the Chinese Government to seek for co-operation and assistance from these two countries. As the project of inviting visiting professors to teach in Chinese universities cannot be carried out before the universities are sufficiently re-equipped, my negotiations in Great Britain have been confined to the arrangements for sending Chinese students to study in British universities or to obtain experience in factories. There are two parts in this project: (1) sending graduate students with two or three years of practical experience in China, either to study in a British university or to practise