POWER PRODUCTION BY NUCLEAR ENERGY

A CONSIDERABLE measure of agreement was revealed at the discussion on power production by means of nuclear energy held in the hall of Jesus College, Oxford, on August 30 as part of the International Conference arranged by the Atomic Scientists Association.

Lord Cherwell, who opened the discussion, held that great harm has been done by the exaggerated stories which have appeared in the Press, suggesting that these new sources of energy would usher in the millennium. As only about one twentieth of the national effort in Great Britain is devoted to producing and distributing power, and the greater part of this is in costs of distribution, there would be only a small gain even if power could be produced at no cost at all by atomic energy, and of this there is at present no prospect whatever. To pretend, as has been suggested, that it would lead to a 4-hour day or 20-hour week is, therefore, manifestly absurd. On the other hand, these tales have provided an admirable opportunity for every country in the world to produce bombs under the guise of developing atomic energy. He doubted whether Governments would have provided the large sums of money which had been made available in various countries for nuclear research if this had been merely directed to civil use; it seemed to him that the military aspects were the driving force and the industrial applications were the excuse. Why otherwise should expenditure on purely peaceful research, that is on metallurgy, or on plastics or on getting power from sunlight, which would probably yield a bigger return than expenditure on nuclear energy, be on such a comparatively small scale if indeed it were incurred at all by many governments?

There would probably be valuable applications of atomic power production for special purposes, such as warships or even ordinary ships, or opening up desert countries; and great benefits would accrue from the use of tracer elements, and possibly there might be direct medical applications. For these reasons, research and development should, of course, proceed. But scientific workers should combine to decry the exaggerated tales which are going the rounds. They provide the excuse for any government minded to make bombs to insist on building large piles, and thus to make international inspection and control very much more difficult than would be the case if it were frankly recognized that such activities could be postponed without serious loss to the various nations. It is so vital to the survival of civilized life on the earth that some form of control be established, that anything which stands in the way of this should be avoided.

Prof. M. L. Oliphant, who was the first speaker in the ensuing general discussion, laid stress on the importance of finding a new source of power, particularly so far as Britain is concerned, now that there is so much reluctance to mine coal from the narrow seams prevalent in Great Britain. In certain other regions, for example, parts of Australia, a thousand miles or more from the nearest coal-field, some alternative source of power would be especially valuable, exposed as they are to such a variety of industrial vicissitudes. On the other hand, the uncertainty of being able to obtain the necessary amount of uranium to produce any notable addition

to world power supplies was mentioned, and it was emphasized by Prof. F. Simon that it may well be easier to derive energy from sunshine if a comparable effort in research and development were to be made. Indeed, he cast some doubt on the reality of the fuel shortage, observing how wastefully energy as a whole is used, not only in our inefficient domestic heating, but also in industrial processes. It seems to be generally agreed that the benefits to be expected from the use of nuclear energy would be in the main due to its special characteristics of great concentration per unit of weight and unit of volume, rather than to the total energy to be derived from fissionable elements.

Some of the foreign representatives (in particular Dr. L. Kowarski and Prof. F. Perrin from France) said that their countries were only interested in the power project and had no intention of making bombs; Prof. Oliphant thought it would be desirable to adopt this same line in Great Britain. Dr. H. L. Anderson told the Conference that atomic power was taken very seriously in the United States as being an important development the effects of which were likely to be felt quite soon, and that large industrial firms were pressing to have the whole matter thrown open to private enterprise to develop. A pile specially designed for production of useful power was being built, and it was expected that it would be possible to run a turbine within a year. But, of course, there was no promise that this would be an economic proposition.

Everybody agreed about the great importance of the use, for investigations and research, of radioactive tracer elements which may be obtained in abundance from piles. But many felt, as Dr. S. Devons pointed out, that fissionable elements might well prove more valuable to humanity on account of developments totally unforeseen than merely as substitutes for our present sources of power.

On the whole, the discussion proceeded on sober lines, and the balanced view prevailed that the world is not entering upon an 'atomic age' in which power would be plentiful and cost virtually nothing, but that atomic energy has great possibilities which should be explored and developed.

HUMAN ECOLOGY IN RELATION TO THE PHYSICO-CHEMICAL FACTORS

A DISCUSSION on "Human Ecology in Relation to the Physico-Chemical Factors" was held at the Royal Society on May 30.

Prof. J. B. S. Haldane, who opened the discussion, pointed out that a human environment may be specified by the time of exposure to it, and by its various constituents, which may be scalars (for example, partial pressure of a gas or temperature) or vectors (for example, acceleration). There are safety regions within which less than a certain fraction of those exposed are affected in a specified way. Human response to some variables is far less constant than to others. He instanced the wide differences in response in subjects exposed to high-pressure oxygen and the variability in response of the same subjects on different exposures. On the other hand, the response to low oxygen pressure is much more constant between individuals and on successive exposures.

Many factors, such as carbon dioxide and high-pressure oxygen, interact to increase the reaction for some values and decrease it for others. Thus carbon dioxide added to high-pressure oxygen increases the severity of reaction, but 3–5 per cent of an atmosphere of carbon dioxide will reduce the symptoms of moderate anoxia. Carbon monoxide and anoxia are additive in the reaction produced at moderate pressures, but at high pressure animals can survive high carbon monoxide concentration.

The difficulty of measuring the reaction produced in human subjects is considerable; in the response to high oxygen pressure, twitching of the lips often precedes generalized convulsions and has been used as a measurable end-point in many experiments, but is not reliable. In the case of anoxia, the conditions under which 50 per cent of subjects retain consciousness for a specified time can be used as a safe end-point.

Prof. D. Brunt then outlined the optimal conditions of climate for human comfort. He suggested that the ideal outdoor climate would permit a clothed man (a) to walk at 3 m.p.h. in bright sunshine without sweating appreciably, and (b) to rest in bright sunshine or to stand in the shade doing light work in air movement of 17 ft./minute without body cooling. This necessitates at 60 per cent relative humidity an air temperature not exceeding 68° F. for (a) and not less than 66° F. for (b); the optimum temperature is 67° F. A nude man should require a temperature 4° F. higher. The upper limits of tolerable conditions are set when the body is unable to prevent rise of rectal temperature, and heat stroke may occur.

Increasing air speed allows greater temperatures to be tolerated, but the highest wet-bulb temperature which can be tolerated falls with increasing dry-bulb temperature. When the comfort limits are surpassed, the rate of rise of body temperature is determined by the wet-bulb temperature almost independently of the dry-bulb temperature. But for comfort the dry-bulb temperature is important. He instanced the use in India of water-soaked curtains over doorways, the effect of which lowers the dry-bulb temperature without affecting the wet-bulb temperature. Very many years experience show that this method of cooling the air inside buildings is very effective in increasing comfort.

Prof. Brunt discussed equations relating heat loss to the physical factors involved in climate for both comfort and avoidance of heat stroke under various conditions. He pointed out that the 70° isotherm runs through many of the centres where early civilizations developed, and suggested that until man began to be able to control his indoor environment he was restricted to the neighbourhood of that isotherm.

The physiology of men working in a very hot environment was considered by Dr. E. A. Carmichael, who illustrated this from recent research at the National Hospital, Queen Square, London. The reaction of a man in a hot environment depends not only on immediate conditions but also on his previous experience. When a man from a temperate environment is suddenly exposed to heat, his heat-regulating mechanism at once reacts to the situation; but there is also a slower adapted process resulting from repeated exposure or when living in the tropics. This acclimatization raises the level for efficient physical or psychological work and for breakdown. The unacclimatized man shows great increase in

heart-rate, blood flow to the skin increases, and the rectal temperature rises. At 94° F. wet bulb, circulatory collapse may occur and the man faint. The heart-rate at successive exposures rises less and there is less liability to faint as adaptation of the cardiovascular system occurs. This may be partly due to an increased blood volume.

Sweating is the most important control of temperature in a hot environment. With acclimatization, sweating commences at a lower rectal temperature and the rate of sweating increases. Under severe conditions with subjects at work, sweating may reach 60 c.c. per minute for short periods. With longer exposure sweat loss decreases and the salt concentration of it rises. This is suggested as due to fatigue of the sweat glands, as less osmotic work has to be done in the production of sweat with increased salt content. This fatigue of the sweat glands during work becomes less after many days continuous exposure. This may be due to hypertrophy of the glands, an increase in the number functioning, redistribution of blood or endocrine activity. This stresses the need for adequate replacement of fluid and salt. If not made good, heat cramps following a fall in plasma chlorides may occur. Acclimatization appears to occur in the same way in subjects repeatedly exposed in a hot chamber and in those living in the tropics.

Limiting conditions for psychological efficiency are lower than those for physical efficiency. The effective temperature scale does not emphasize the very narrow limit at high wet-bulb temperatures between effective temperature allowing efficient work and that producing breakdown. Nor does it sufficiently emphasize the deleterious effect of still air on working men. The experiments and observations under desert conditions show that men left to themselves drank water insufficient to replace their fluid loss although satisfying their thirst. It is questioned whether thirst is an accurate index of water needed, and it is necessary to force water and salt intake; this should be done until the daily urine secretion exceeds 500 c.c.

Dr. B. H. C. Matthews then described human tolerance and reaction to low partial pressures or oxygen, both as seen on rapid ascent in aircraft, in low-pressure chambers and on mountains.

The tolerance limits of low oxygen pressure are very different in acclimatized men; thus climbers have reached 28,000 ft. on Mount Everest. This height produces unconsciousness in a few minutes and death in less than an hour in men acclimatized to sea-level. The symptoms seen in man due to low oxygen pressure are due primarily to the reactions of the central nervous system. Peripheral tissues are little affected at oxygen pressures producing unconsciousness. The abnormalities of increasing severity from 10,000 ft. to 20,000 ft. are those of the central nervous system, particularly the higher functions. Above 20,000 ft. unconsciousness may be expected in a large proportion of subjects after a short interval. Above 25,000 ft. there is considerable possibility of death if the exposure exceeds 15 minutes.

The oxygen saturation of the blood is not the only factor in producing symptoms. Subjects vary in the degree of hyper-ventilation in response to oxygen lack, and this leads to varying degrees of alkalosis caused by the lowering of carbon dioxide in the blood by hyper-ventilation. Following hyper-ventilation, convulsive movements are common. Subjects not exhibiting much hyper-ventilation

frequently become unconscious without exhibiting hyper-excitability of the nervous system. Subjects at 22,000 ft. breathing air may become unconscious for a minute or less when given pure oxygen; this may be a reaction to the change in acidity of the blood brought about by sudden oxygenation.

By acclimatization a man is able to live and work at altitudes up to 18,000 ft. for long periods. The ultimate tolerance of the acclimatized subject is at present unknown. The principal changes that are seen are an increase in the oxygen capacity of the blood and red cell count, increased pulmonary ventilation with a lowered carbon dioxide level in the blood, the alkalosis being compensated by the kidneys to restore the pH to normal with a lowered alkali reserve; this takes many days for full development. Finally, changes in tissue oxidase systems occur, so that the performance of a man with an oxygen saturation of, say, 60 per cent improves greatly if he is acclimatized. The relative sensitivity of the respiratory centre to low oxygen and to changes in carbon dioxide partial pressure shows wide individual variations.

Human tolerance of acceleration depends on the posture of the body and the axis along which acceleration acts. For accelerations acting from feet to head, unconsciousness is produced if the acceleration exceeds about seven times that of gravity for five seconds. This limit is determined by failure of the circulation to maintain blood supply to the head. It is preceded by failure of vision. For shorter durations, much higher accelerations can be tolerated. For 0.1 sec., twenty times gravity can be tolerated if the body is adequately supported. The limit here is set by the mechanical strength of the body, for at high values of acceleration the large forces accelerating the body may lead to disruption of its parts.

Dr. G. L. Brown considered human tolerance to oxygen, nitrogen and carbon dioxide at raised partial pressures. Any of these may poison the central nervous mechanism of man. He emphasized the wide variation in individual tolerance and the day-to-day fluctuation in a single subject even when living under strictly standardized conditions. The prevention of convulsions through high oxygen by the use of anti-convulsants has not been successful in man. High oxygen concentration poisons enzymes concerned in carbohydrate metabolism of the brain; protective agents effective in isolated brain slices have not yet been extended to man. The cerebral intoxicant action of high partial pressures of carbon dioxide have become a serious problem in some forms of diving. Experimental work shows that 15 per cent carbon dioxide causes unconsciousness in all subjects provided that sufficient oxygen is present. If the oxygen is also low, the experiment is terminated by a feeling of suffocation and inability to maintain the large tidal volume.

There appears to be an additive effect between carbon dioxide and nitrogen intoxication. Poisoning with carbon dioxide at high oxygen concentrations closely resembles the effect of very low oxygen pressure. Performance of skilled tasks deteriorates, but convulsion, the common result of high oxygen pressure alone, is never seen. The effect of nitrogen at 10 atmospheres pressure resembles that of a general anaesthetic. The intoxication produced prevents clear thinking or performance of skilled tasks. The initial symptoms are of short duration, but there remains mental impairment of which the subject is unaware.

After exposure to toxic levels of oxygen and carbon dioxide, however, symptoms develop after return to normal conditions. Acute intoxication with carbon dioxide (15 per cent) leaves little after-effect, whereas 6 per cent carbon dioxide, which can be tolerated for hours, evokes severe effects on return to air. Vomiting and severe headache are very common. Withdrawal of nitrogen associated with a fall of pressure may lead to bubble formation within the tissues, with serious consequences. There is little evidence of any adaptation as a result of repeated exposure, and little evidence of sensitizing effects.

Sir Joseph Barcroft summed up the discussion, stressing the similarities in human reaction to any large change in his normal environment. All appear to lead to failure of co-ordination of activity in the cerebral cortex, thus producing symptoms in patterns that are often closely related; he suggested that a common factor lies behind all the reactions described, namely, that the cells of the brain are unable to continue their normal carbohydrate oxidations when the physico-chemical state of the blood supplying them is displaced from normal in any direction.

A quantitative human ecology must take into account the interaction of numerous environmental factors, and the variability of the response, as well as the influence of acclimatization or sensitization. Work done by various groups of physiologists in connexion with the War constitutes the beginning of such an ecology.

B. H. C. MATTHEWS

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THE CONVERSION OF CAROTENE INTO VITAMIN A

By DR. R. F. HUNTER

THE conversion of β -carotene into vitamin A which occurs *in vivo* is represented in many standard works by means of the hydrolysis equation:

Apart from the fact that we can trace no example of a hydrolytic fission of such a type in the literature, various *ad hoc* experiments on the hydrolysis of colloidal solutions of β -carotene with water, aqueous organic solvents in the presence of mild alkali and various emulsifying agents such as lecithin, sodium cholate, and polyglycerol esters, under pressure, have failed to furnish any evidence of the formation of vitamin A alcohol¹. The mechanism of conversion is still obscure, but the 1:2-ratio for biological activity of α - to β -carotene^{2,3} and the similar 'half activity' of semi- β -carotenone⁴ and cryptoxanthin⁵ indicate that this involves fission of the central double bond of β -carotene⁶.

It is generally assumed that the site of the conversion is the liver. Moore⁷ showed that when massive doses of carotene were fed to rats, it persisted apparently unchanged throughout the alimentary tract while high concentrations of vitamin A appeared in the liver. The storage of vitamin A in this organ, which plays an important part in regulating the concentration of the vitamin throughout the rest of the body, indicates that it is intimately connected with the process. Moreover, when the liver is poisoned or damaged⁸, there is a decrease in vitamin A forma-