

## EFFECTS OF CARBON DIOXIDE ON THE HEART AND CIRCULATION

**I**N his presidential address to the Physiology Section of the thirty-first Indian Science Congress held in January, Dr. S. N. Mathur discussed the physiological importance of carbon dioxide. Carbon dioxide has generally been regarded as a toxic waste product which the body seeks to eliminate as rapidly as possible, but it is now well recognized that it has certain beneficial actions as well. Originally a necessary evil, it has, in the course of evolution, so inextricably worked its way into the body machinery that it has come to be indispensable for certain physiological processes. The necessity of carbon dioxide for maintaining the pH of the blood and the activity of the respiratory centre is, of course, well known; its importance for the proper working of the cardio-vascular system is less well appreciated, and this field, in which Dr. Mathur has made important observations, may be worth a brief review.

The fundamental experiments have been made on anaesthetized cats and dogs. The carbon dioxide content of the blood was increased by inhalation of carbon dioxide and decreased by forced breathing (hyperventilation). The most striking effect is on the arterial blood pressure, increase of carbon dioxide causing a rise of pressure, decrease a fall. This effect is due to the direct action of carbon dioxide on the vasomotor centre, the normal 'tone' of which is dependent on the continual stimulus of carbon dioxide. In addition, carbon dioxide has a peripheral action on the capillaries causing dilatation, which tends to cause a fall of blood pressure; normally, however, the central effect predominates and the net result is a rise.

In anaesthetized animals, increase of carbon dioxide causes slowing of the heart (sometimes there is a transitory initial acceleration). The slowing is partly reflex from the rise of blood pressure, but is mainly due to the direct action of carbon dioxide on the cardio-inhibitory centre. Conversely, hyperventilation causes acceleration of the heart.

Increase of carbon dioxide causes a considerable increase in the stroke volume of the heart, so that, despite the reduced heart-rate, the total output per minute is increased. The increase in stroke volume is due to increased diastolic filling, and it was thought that this was simply due to the rise of venous pressure which usually occurs. Dr. Mathur has shown, however, that the increase in cardiac output can occur quite independently of the rise of venous pressure, and he believes that carbon dioxide has a direct action on the heart-muscle, increasing the diastolic relaxation of the ventricle. When the carbon dioxide is reduced by hyperventilation, the cardiac output falls owing to reduced diastolic relaxation of the ventricle. He emphasizes this beneficial action of carbon dioxide on the heart in promoting diastolic relaxation and so allowing greater filling, which, owing to the intrinsic properties of cardiac muscle, automatically gives rise to increased output. He believes, further, that this increased cardiac output is an important contributory factor to the rise of blood pressure.

Previous workers had usually reported a reduction of cardiac output following administration of carbon dioxide. Dr. Mathur found that the increase of output with carbon dioxide was only to be obtained during the first hour or two of the experiment,

while the heart was 'fresh'; after several hours of anaesthesia, the heart became 'stale' and then carbon dioxide caused a reduction of output. This seems to explain the discrepancies in the reported results. It seems rather surprising that an increase of carbon dioxide above the normal level should actually improve the efficiency of the heart. The general outcome, however, is quite clear, that a normal level of carbon dioxide in the blood is necessary for the maintenance of normal vasomotor tone, normal heart-rate and normal diastolic relaxation of the heart; these must all be reckoned as beneficial effects.

The general interpretation of these cardio-vascular responses to an increase of carbon dioxide is that the circulation-rate is increased in order to hasten removal of carbon dioxide. The slowing of the heart is, therefore, somewhat surprising; an acceleration would seem more appropriate. Dr. Mathur regards the slowing as a protective device, enabling the heart to conserve its energy so that it can survive longer under asphyxial conditions. It remains to be seen, however, if the slowing is a general phenomenon; perhaps it only occurs under anaesthesia. In man, inhalation of carbon dioxide always causes acceleration. In the whole animal the problem is complicated by the fact that the increased respiratory movements cause changes in the venous return which reflexly affect the heart-rate and the output. It is very difficult to disentangle these effects from the direct effects of carbon dioxide, and the whole problem requires further analysis.

O. A. TROWELL.

## ECONOMIC EXPLOITATION OF EUROPE AND ITS CONSEQUENCES

**T**HE analysis of German economic policy for Europe which was issued by the Royal Institute of International Affairs in March 1941 under the title "Europe Under Hitler: In Prospect and Practice" has now been followed by a further study, "Occupied Europe: German Exploitation and its Post-war Consequences"\*. The measure of the change in the situation during the three years may be seen in the structure of the two booklets. The first emphasized the two parts of German economic policy: a short-term plan for the duration of the War; and a long-term plan for the permanent organization of Europe. The first booklet discussed both, but while the first part of the new study examines Germany's domination over occupied Europe and the mobilization and exploitation of its resources up to the autumn of 1943, the implications of a permanent German 'New Order' are no longer considered. Instead, the second part dealing with the post-war period discusses some of the problems to be faced during and after liberation, and in a couple of dozen pages gives a lucid account of the implications of German domination and the conditions which any plans for rehabilitation and reconstruction must seek to meet.

The first part of the booklet points out that, whether by military or political measures, the Germans have bereft all the occupied countries of their freedom. All resources, both material and human, have been mobilized for the benefit of Germany and often transferred to Germany, while under the

\* "Occupied Europe: German Exploitation and its Post-War Consequences. Pp. 75. (London: Royal Institute of International Affairs, 1943.) 1s. 6d.

blockade and war conditions, even the neutral countries can only maintain their economic life by diverting a high proportion of their normal trade to Germany or to countries under her domination. Sweden, for example, is now entirely dependent for supplies of coal, and for many other commodities, on imports from Germany, and in return continues to export to the Reich high-grade iron ore and other materials urgently required for the German war economy. Continental Europe has been taking about two-thirds of Sweden's export trade, of which Germany receives some half. Again, Germany has been forced by events to concentrate more on short-term plans for the mobilization of resources for their immediate effect than on long-term policy for the 'New Order', and the factors which govern the economic policy for any territory are the current requirements of the German war machine and the need for the maintenance and security of the German home front.

The fundamental difficulty in Germany's war economy problems is a shortage of man-power. The social and industrial consequences of the German exploitation of the human and material resources of the occupied countries, and the resultant food situation, need only to be pondered to realize how grave are the implications for the post-war period. The pamphlet, however, also directs attention to the enormous demand for fuel and power created by Germany's war economy, together with the shortages resulting from the British blockade of overseas supplies of oil and also raw materials. The extensive development of substitute raw materials and the power requirements of industry, as well as the demands of transport and the armed forces, have placed a tremendous burden on available supplies of coal, wood and electricity. The manufacture of substitutes is estimated to demand a third of the total output of electricity in the Reich and about one-fifth of the output of coal. Moreover, while Germany has gained control of all the main sources of coal in Europe, she has apparently been unable appreciably to increase production. The whole transport system under the control of Germany is now suffering from severe strain, motor transport has had to be cut to the barest minimum, sabotage is an increasingly important element and the railways of occupied Europe are being taxed and drained to the limit regardless of ultimate or immediate deterioration.

Agricultural production is being adjusted to serve Germany's special needs, with compulsory delivery at stable prices and the control of harvesting, enforced by heavy penalties. The long-term policy has attempted to increase production in the low-yield areas with adjustment in Western countries in consequence of the shortage of feeding stuffs, which has involved a compulsory decrease in draught animals, cattle, pigs, and other livestock. This policy has not conduced to willing co-operation from farmers in the Scandinavian countries and the Netherlands, and many factors have operated against the policy of increasing the production of oil seeds in south-eastern Europe. Improved weather conditions in 1943 more than compensated for shortage of labour, fertilizers and equipment. The yields of crops increased and the position as regards vegetable oils improved. With regard to industrial raw materials, in spite of the opening of mines and exploitatic of resources, the lack of certain raw materials is still a problem which must be intensified by the loss of the manganese

resources at Nikopol and bombing policy in the west, with the destruction of molybdenum mines in Norway, for example. In the U.S.S.R. the withdrawal of practically all skilled labour by the Russians, and their 'scorched earth' policy, made it difficult for the Nazis to execute plans for rapid economic development, and apart from manganese the gain in raw materials appears to have been small.

The review of the mechanism of economic exploitation adopted by the Germans in accordance with their policy of organizing the maximum development of essentials in their own interests draws largely on the Inter-Allied Information Committee's report, "The Penetration of German Capital into Europe". It is, however, well that it should be widely realized that as the occupied areas are released from enslavement they will be faced not only with conditions of starvation, destitution and probably, in consequence, disease, far more widespread and acute than in 1918-19, but also, in consequence of this exploitation, with far-reaching disintegration and breakdown of their national economies. Unless the British and American peoples fully understand the position, they can scarcely be expected to make the sacrifices that will be involved in their own standard of living.

While it is difficult to forecast the dimension or order of the problem of relief and rehabilitation, the second part of this booklet at least gives a succinct account of the immediate needs which the United Nations Relief and Rehabilitation Administration and similar bodies will have to face, whether the release of occupied areas is gradual or the collapse of Germany sudden. Detailed planning of long-term reconstruction has as yet only reached the stage of initial discussion and investigation, though the pamphlet gives some indication of the factors that may determine it—the development of synthetic and substitute materials, of hydro-electric power and transport, agricultural policy and adjustments; but the provision of relief and rehabilitation will be, as Sir Frederick Leith-Ross has pointed out, the test of the capacity of the United Nations to rebuild a more prosperous world and to give freedom from want in their territories. The Royal Institute of International Affairs in this pamphlet has done something to make plain what this will involve in terms of the continuance in the immediate post-war period of the shortages and rationing, controls and restrictions of war-time.

---

## THE NUCLEOLUS

THE nucleolus was first figured in 1781 as a spot in the centre of a round or oval body (the nucleus) in epithelial cells of the eel. Since then it has been described in the nuclei of almost every type of plant and animal cell. Many interpretations were offered of its nature and function. Perhaps the view most widely accepted until very recent years was that it acted as a focus for the elaboration of chromatin which passed from it to the chromosomes as they developed through the prophase. During the last decade the use of Feulgen's reaction for the staining of nuclei has given a new impetus to the study of the nucleolus. This stain showed that at no stage does the nucleolus contain chromatin. Feulgen's stain, together with other modern cytological methods, has made possible the tracing of nucleolar behaviour through all stages of the mitotic and meiotic cycles, and has led to entirely new interpretations of the