be open to continuous review in the light of humane scientific opinion. This proposal has aroused some keen hostility, but with the lapse of time further consideration may perhaps show it to be a logical development of the existing practice; one which might in Great Britain be adopted by administrative action and in foreign countries be embodied in that legislation which is long overdue in almost all of them.

Need for Discussion

The question where the line ought to be drawn between the claims of science and those of laboratory animals is an excessively difficult one about which normal decent people disagree. The only means for arriving at an ideally just solution is frank discussion among humane men of science. But here a real difficulty arises. Anything which may be said in such a discussion is liable to be seized upon, torn from its context, misunderstood and distorted by controversialists who will make an unscrupulous use of it for their own purposes. This fact, and the resentment felt by men of science at the calumnies to which they have been subjected, are obstacles to frank discussion; but they are obstacles which must be over-ridden because obscurantism is an intolerable evil. Moreover, anti-vivisectionist attacks on science are greatly helped by the suspicion that men of science cannot care much about avoiding cruelty since so few of them ever mention the subject except in self-defence.

At all events, here are excessively difficult ethical problems that deserve an increasingly complete solution, and in view of their technical character nobody except humane men of science can solve them.

ANIMAL AND VEGETABLE FOODS

ON January 20, the Nutrition Society held a symposium at the London School of Hygiene and Tropical Medicine on "The Comparative Merits of Animal and Vegetable Foods in Nutrition". Prof. R. C. Garry, in the chair, introduced the subject by referring to the tradition held abroad that the British are great meat-eaters. Economic conditions, he said, are forcing us to reduce our consumption of meat, and a careful examination is needed to consider the nutritional effects of such a change in our food habits.

The need for a source of protein in the diet has been understood for a hundred years. At the turn of the century, German workers demonstrated that individual proteins differed in their nutritive value, and advocated the use of diets high in protein, and with a large proportion coming from animal foods. More recent work has caused some modification of this view.

Dr. G. R. Tristram read an introductory paper on "The Biochemistry of Animal and Vegetable Proteins" in which he said that there is no difference clearly separating the biochemical properties of the pure proteins so far isolated and examined. However, many of the proteins obtained from seeds are partially deficient in one or more of the essential amino-acids. The protein preparations so far obtained from leaves have a more balanced composition. In a normal foodstuff the aggregate of proteins tends to be better balanced in composition than individual members. The non-protein nitrogen fraction of the food may also be of importance. Choline is known to have a methionine-sparing action, and methionine itself has been found to occur free in some plant tissues.

Dr. K. J. Carpenter then spoke on "Relative Nutritional Values of Animal and Vegetable Proteins for Animals". For the rat, the animal feeding stuffs are generally higher in biological value than are the vegetable materials. The experiments used for these determinations are not invalidated by the discovery of the 'animal protein factors', and the differences are explicable in terms of amino-acid composition. For cattle and sheep the proteins of the common feeding-stuffs are approximately equal in biological value, regardless of their amino-acid composition. This may be explained by the synthetic powers of the alimentary micro-flora in ruminants. The practical question for pigs and poultry, continued Dr. Carpenter, is to determine the relative value of different proteins as supplements to a cereal mixture. For this purpose fish meal and milk products are superior to the oil meals, although soya-bean meal is of exceptional value. Recent work at the Rowett Research Institute has indicated that grass proteins are also of lower value than had been predicted from their amino-acid analyses. In some cases the partial deficiencies of the vegetable materials can be compensated by feeding them at a higher level.

The "Conversion Factors of Vegetable and Animal Food for Human Consumption" were discussed by Dr. K. L. Blaxter, who said that Prof. W. C. Rose has recently determined the human requirements for the individual essential amino-acids. It is therefore possible to calculate the production, from an acre of land under various crops, of the vitamins and amino-acids, calculated in terms of man-year requirements. The vegetable crops satisfy greater requirements if used directly for feeding than if used indirectly for meat and milk production. Nevertheless, the provision of requirements by the cereals is unbalanced and lacking in vitamins and protein relative to the provision of calories. In the example of wheat and sugar-beet production, the nutritional value of the crop in terms of 75 per cent extraction flour and refined sugar is significantly supplemented, especially in protein, by the milk production that can be obtained from feeding the by-products—millers' offals and sugar-beet tops—without the use of more land. Animal and vegetable foods are therefore to some extent complementary rather than alternatives.

Dr. D. A. Boyd then discussed the efficiency with which different classes of stock convert vegetable into animal products. The efficiency of energy conversion is approximately 19 per cent for bacon and milk production, and only 7–10 per cent for beef, mutton and egg production. A national balance-sheet of food production and imports shows that, of 21·7 million tons of starch-equivalent fed annually to animals in Great Britain, only 1·9 million tons starch-equivalent is obtained in animal products. This is an overall yield of about 1 : 11, whereas a ratio of 1 : 6 would be expected. This suggests scope for increasing efficiency. The man-hours of labour needed for the production of 1 cwt. of starch-equivalent from animal foods are also considerably in excess of those needed for cereal production. On this basis, wheat is the crop produced with least labour.

To introduce the afternoon session, Dame Harriette Chick spoke of the work done at the Lister Institute on the improvement of vegetable proteins by admix-

ture. In some cases there is important supplementation within a single foodstuff. For example, a mixture of wheat bran and white flour is of greater value for the rat than when each is fed separately. The non-protein nitrogen in potato juice is also of supplementary value to the purified preparations of potato 'tuberin'. This cannot be explained by the amino-acid content of the juice. In these trials with vegetable proteins young rats attained a reasonable growth-rate, but were not able to rear a second generation. In the light of recent American work, this may be explained by the rats having carried a reserve of vitamin B_{12} from their suckling period sufficient for the next few weeks, but not sufficient for a whole life-cycle. For short-term growth, a mixture of soya flour 56 per cent, malt extract of barley 34 per cent and white flour 10 per cent is, on an equal nitrogen basis, equal to whole milk for rats.

Dr. Lucy Mills continued with an account of the results she has obtained in the treatment of 'malignant malnutrition' or 'kwashiorkor' among Zulu children. The condition appears to be identical with the 'fatty liver disease' in the West Indies. After the babies have been weaned from the breast, they receive no cow's milk, or even grubs and locusts as in some primitive societies, and are fed only on porridges made from cereals with occasional green vegetables. They appear to be healthy until the sudden onset of diarrhœa and an œdema, accompanied by low levels of serum albumen. The œdema then usually clears up and the condition enters an atrophic stage. The mortality-rate for children taken to hospital at this stage and put on a normal diet has been in the region of 50 per cent. Post-mortem examination shows a consistent mild normochromic anæmia and an enlarged liver with fatty infiltration. The only treatment so far tested which is really effective is to force-feed the curds from skimmed milk, with nothing else, for several days. There is some evidence that this condition is caused specifically by a deficiency of animal protein. It occurs even when calorie intake is normal. Dr. A. P. Meiklejohn, in the discussion, emphasized the widespread occurrence of this condition and the importance of further research into methods for its treatment and prevention.

A paper on "The Nutritional Adequacy of a Vegetable Substitute for Milk" was then read by Dr. R. F. A. Dean. Of all the constituents of milk the protein fraction is, he said, the most difficult to replace from vegetable sources. Some recent trials have been carried out with children in a home in Germany. Over a sixteen-week period a control group received a diet of butter, potatoes, bread and milk cooked into semolina pudding. Other groups received the same diet with the milk replaced by a soya–barley–wheat mixture. The vegetable mixture, relative to milk, was still slightly deficient in some of the amino-acids; but, when it was fed so that 13 per cent of the calories came from proteins, growth was as good as with the milk ration in which only 11 per cent of the calories came from proteins. Slight changes in the method of cooking the soya flour were, however, liable to produce digestive troubles. When young rats were fed on the vegetable mixture they stopped growing after twelve weeks. This was corrected by the addition of vitamin B_{12} to the diet. The children might have shown a similar deficiency if fed on the all-vegetable diet for longer periods.

In the general discussion which followed, it was agreed that there can be no hard-and-fast rule as to the minimum human requirements for animal (including milk) proteins. Experiments suggest that with a very careful choice of supplementary proteins and with vitamin-rich foods, an adequate all-vegetable diet can be constructed. Nevertheless, in the practical world there appear to be sound reasons for the scientific approval of mankind's enjoyment of animal foods, whether they take the form of roast beef, cheese or merely caterpillars.

K. J. CARPENTER

RECENT THEORIES OF TRANSPORT PROCESSES IN LIQUIDS

By DR. R. EISENSCHITZ
Queen Mary College, University of London

THE properties of matter in thermal equilibrium can be derived from general principles which are very closely related to the laws of thermodynamics[1] and have a similarly wide range of validity. There is, however, no corresponding general theory determining those properties of matter which are associated with the rate of an irreversible process, such as viscous flow or thermal conduction. This lack of general principles is particularly unsatisfactory with regard to the properties of liquids. There are a number of successful kinetic explanations of some of the properties of the liquid state[2,12], but they are usually not capable of generalization.

In the past four years a new start has been made with the kinetic theory of liquids with the object of substituting methods based on the fundamental principles of dynamics for the arbitrary hypotheses which have often been invoked. In this article the problems, methods and achievements of the recent theoretical work are reviewed with particular reference to the explanation of irreversible processes.

Flow of Momentum and Energy

In the kinetic theory of gases, the flow of momentum or energy which is observed in measuring the viscosity or thermal conductivity of a gas is considered to be due to the momentum or energy which a molecule carries with itself when moving through empty space between collisions. Every molecule is supposed to contribute the product of its momentum and its velocity in the case of viscous flow, and the product of its kinetic energy and its velocity in the case of thermal conduction.

It has been felt for some time[4] that, in liquids, momentum and energy should be considered as transmitted by the action of intermolecular forces rather than by the movement of molecules. The mechanism of transmission has been fully recognized in the case of dense gases (ref. 5, chap. 16), crystals[6], solutions of electrolytes[7] and finally of liquids.

If momentum and energy are transmitted by the intermolecular forces, it is no longer possible to speak of contributions of single molecules but only of pairs of molecules. Every pair contributes to the flow of momentum the product of the intermolecular distance times the intermolecular force, so that the rate at which oriented momentum is added to one molecule is the same as the rate at which it is withdrawn from the other. With regard to the transmission of energy, we can assume that one of the molecules of the pair is at rest, since on the average it is, in fact, at rest. Then the pair contributes to the flow of energy, first, a term which is equal to the product of the potential