come down from the hills in the winter. Therefore, before the true significance of this correlation could be assessed it would be necessary to find the proportions of sheep and cattle above and below the 600-ft. level at all times of the year.

These various analyses provide striking, if only circumstantial, evidence of a connexion between the movements and distribution of British and Continental starlings and the incidence of foot-and-mouth disease; but there are certain facts contrary to this general conclusion which must be mentioned. In the first place, experiments with captive starlings have indicated the great difficulty of inducing birds to transmit the virus of foot-and-mouth disease, and it may be that some special condition, such as illness, is required before the bird can act as a carrier. In this connexion it will be noticed that although many millions of starlings must have entered and moved about the British Isles between 1900 and 1937, only 349 unexplained outbreaks of foot-and-mouth disease occurred in the whole period. A second point of difficulty is presented by the great epidemic of foot-and-mouth disease which appeared in Europe immediately after the period surveyed in Tables 2 and 3, and the numbers of these outbreaks, if included, would considerably alter the shape of Graph 3. In the autumn and winter months of 1938-39 there were almost as many outbreaks of foot-and-mouth disease in Sweden as in the whole of the previous thirty-eight years, and similar conditions prevailed all over the Continent. However, an epidemic of this magnitude would be expected to present abnormal features, and it seems that the spread of the disease northwards across Europe may have been due to unusual factors.

It is difficult to see how proof or disproof of a thesis that the starling is an important carrier of foot-and-mouth disease can be obtained, and certainly many factors other than the starling must be involved in greater or lesser degree. Latitude, weather, and several species of birds may exert an effect, and possibly also there exists in some species of wild mammal a natural reservoir of disease⁷ although, if this last contention is correct, it is difficult to understand why many more outbreaks do not occur. At the present moment it does not seem possible to do more than put forward the suggestive but inconclusive evidence.

¹ Stockman, S., and Garnett, M., *J. Min. Agric.*, **30**, 681 (1923).

² Thomson, A. L., *NATURE*, **113**, 52 (1924).

³ Bullough, W. S., *Proc. Roy. Soc. Lond.* (in the press).

⁴ Bullough, W. S., *Phil. Trans. Roy. Soc. Lond.* (in the press).

⁵ Bullough, W. S., *Ibis*, **6**, 225 (1942).

⁶ Marples, B. J., *J. Anim. Ecol.*, **3**, 187 (1934).

⁷ Elton, C., Progress Report of the Foot-and-Mouth Disease Research Committee, **5**, 379 (1937).

CANTEEN FEEDING

By F. LE GROS CLARK and DR. N. W. PIRIE

MUCH has been written, in *NATURE* and elsewhere, on the relative merits of research that has absolutely no practically useful end in view and of research that it is hoped will lead to improvements in practice. The latest meeting organized by the Nutrition Society was held on May 30 to consider "Problems of Collective Feeding in War Time", and it gave invaluable evidence on the ease with which nutritional and biochemical research could produce immediately useful results without coercion of the

research worker or any sacrifice of interest in the more fundamental aspects of science. Few research workers can have attended the meeting without being impressed by the extent to which pure scientific research was needed as a preliminary to the solving of the very practical problems of food distribution and cooking. If more meetings can be held at which men of science have the opportunity of learning about the problems that arise in practice, it is very probable that much of the necessary practical research will in fact get done with no greater interference with the freedom of choice of the individual research worker than we had in the last years of peace. It is greatly to be hoped therefore that the Nutrition Society will organize other conferences along the lines of the one that has just been held.

Squadron-Leader J. Salmon described the standard conditions in the Royal Air Force. An aircraftman's mess can serve a thousand meals at a time; it is often necessary to have two sittings for meals because of the unanticipated growth of a station. The mess is under the control of a catering officer, if there are more than six hundred men on the station, and a mess committee; close attention is paid to the general wishes of the eaters, for no choice of food is available. The amounts of rationed food drawn by the catering officer are rigidly controlled, and he is encouraged to draw his full rations so that an average of 3,500 calories a day for each man and 2,800 for each woman can be maintained.

Experience has shown that, to avoid waste, it is best to serve moderate helpings and allow those who wish more to get further helpings. In the discussion there was agreement that catering in the R.A.F. is better than in the other Services, but that there is still room for improvement. The old adage "God sends the food but the Devil sends the cooks" seemed to sum up the view of several critics, and the sensible suggestion was made that cooks should be paid extra if only for the reason that they could then lose pay if they cooked badly. Other speakers mentioned the difficulty found in getting women with cooking experience in civil life to take up cooking in the W.A.A.F.s. in spite of the extra pay that is in fact given.

Works canteens and British Restaurants are presented with a somewhat different problem, for they do not have a guaranteed clientele but have to attract diners by the quality of the meals served. How successful they are at doing this is shown by Lord Woolton's opening statement that 94,000,000 meals a week are now served "off the ration", and by the great extension of the works canteen system. Miss I. M. Clift said that there are now 7,500 industrial canteens—five times as many as in 1940—and she described vividly the methods used in her canteen to popularize the eating of foods to which the workers were unaccustomed. The mass-psychological aspect of these canteens was also referred to by Miss M. C. Broatch in her paper on school canteens. The first principle is that a novel food should appear as an extra rather than as an alternative and that at the beginning it should be in short supply; furthermore a choice of meats and vegetables on each day and a different choice on each day of the week is an advantage. It is interesting to learn that 40 per cent of the workers in one factory choose wheatmeal bread rather than white when a choice was offered, for before the introduction of the 85 per cent extraction loaf it was often stated that the British public insisted on white bread.

Miss M. Abrahams described measurements made on the meals served in forty-one British Restaurants. The calorie value ranged from 494 to 1,797 per meal; only six gave more than 1,000 calories. The prices ranged from 8d. to 1s., and the calories per penny from 41 to 163, with only seven Restaurants giving more than 100. Part of this variation is deliberate, for Dr. M. Pyke had already said that the Ministry of Food tried to get bigger meals served in those Restaurants that tended to cater for heavy workers, but it was suggested that much of the variation was unintentional and to be deplored. The Londoners Meals Service makes every effort to serve children with a uniform balanced meal of an agreed protein, fat and carbohydrate content, and this organization is now supplying London school-children with fifty thousand meals a day. These meals contain as much meat as the meal that works canteens serve to heavy workers; there has been some opposition to this practical appreciation of the fact that a growing child needs more protein than a normal adult, but headway is being made in most areas.

In considering the nutritive value of the food served in these various canteens most of the speakers concentrated on ascorbic acid. This preoccupation with only one out of some hundred known essential metabolites was deplored by several speakers, notably Squadron-Leader T. F. Macrae and Mr. A. L. Bacharach, but it is presumably inevitable on account of the greater difficulty with which the other minor dietary constituents can be estimated.

It was clear in the discussion of most of the papers that the academic research workers tended to turn automatically to calories, protein and ascorbic acid as the criteria of a good meal. This suggests that work should be undertaken to see whether an ordinary British meal that is adequate in these three respects is likely to be adequate in other respects also, for, if this were true, it would greatly facilitate the problem of inspection.

The various factors that lead to unevenness or inadequacy in the consumption of ascorbic acid were considered in some detail. In the first place a better selection of vegetables could be planted and more care could be taken to ensure that green-stuff is available all the year round. Prof. J. R. Marrack pointed out that, in the bulletin issued by the Ministry of Agriculture, kale is scarcely mentioned whereas considerable attention is paid to parsnips. The former is a valuable source of ascorbic acid in the spring whereas the latter is almost valueless from this point of view. With green vegetables speed is essential in distribution; a cabbage that has taken 3-7 days in getting from the field to the kitchen will have lost half its ascorbic acid in the process. The potato is more stable, but there is loss during the correspondingly longer period for which it is generally stored.

Many speakers referred to the eating of vegetables raw as a means of avoiding the losses that are often entailed in cooking. The consensus of opinion seemed to be that this would not altogether solve the problem and that it might lull the caterer, who does not consider closely what weight of material is actually being eaten, into a state of false confidence. Raw vegetables are bulky and, if served up as a salad with whole leaves, very little is actually eaten. If, on the other hand, the bulk is reduced by grating, ascorbic oxidase is liberated from the damaged leaf cells and causes serious destruction of the ascorbic acid. This destruction can be greatly minimized by shredding or slicing instead of grating, for in these circumstances

the proportion of damaged cells is smaller. Even if the vegetable gets into the diner's mouth with its ascorbic acid undiminished all is not necessarily well; for Dr. M. Pyke quoted an experiment in which 19 per cent of the ascorbic acid in a sample of sliced raw cabbage was destroyed in thirty seconds' chewing and 29 per cent in sixty seconds. In the subsequent discussion it was pointed out that further destruction probably took place in the alimentary canal before absorption had taken place and that, although it is likely that the destruction is due to enzyme action, this should have been confirmed by a similar experiment with cabbage in which the enzyme had been destroyed by boiling under proper conditions.

When green vegetables are being cooked what is to be aimed at is the most rapid possible destruction of ascorbic oxidase and the smallest possible loss of minerals and ascorbic acid in the water used for boiling. Many suggestions for achieving these two desiderata were made. Macrae said that the gradual addition of quartered cabbages to the boiling cauldron of water, at such a rate that the temperature never fell below 85° C., led to the preservation of most of the ascorbic acid; whereas 80 per cent was destroyed if all the cabbage was added at once so that the whole mixture fell to 60° or 70°. Dr. R. G. Booth described the successful avoidance of this loss in some British Restaurants by using a large number of small pots that can be heated rapidly. Dr. L. W. Mapson said that a smaller volume of water could be used for cooking if the vegetables were shredded first and suggested that the outside leaves of cabbage might be boiled in the water first and then removed before adding the shredded cabbage. By this means the cooking would be done in dilute ascorbic solution. The value of this suggestion depends on a number of quantitative factors that cannot be assessed on the spur of the moment in a meeting and there was no further discussion of the point. Several speakers pointed out that the extraction of ascorbic acid and minerals was only objectionable if the water were then thrown away but that it did not matter if the same water was used over and over again for boiling vegetables or if it was afterwards used for making soup or gravy; both procedures are in fact followed in many establishments.

If the problem of cooking large amounts of vegetables without serious loss of ascorbic acid has been surmounted, there is still an opportunity for loss if the food is kept hot for long before it is consumed. Mr. F. Le Gros Clark described the Russian pioneer experience in this field. In 1925 central kitchens sent out cooked food, in insulated containers, to factories, but this system was given up progressively from 1931 and thereafter they sent out food prepared and ready for cooking. This change is in accordance with British experience during the last few years and several speakers condemned the insulated container. Dr. Pyke found that after 2½ hours about half the ascorbic acid present in cooked greens or potatoes had been lost, but he pointed out that the final product might well be better than badly cooked vegetables prepared on the spot. It is clearly impossible to do all the cooking in a large canteen or mess immediately before the meal is served; and the cooks and catering officers should therefore be advised which food-stuffs are but little damaged by being kept hot until the rest of the meal is ready and which are seriously damaged. Several speakers mentioned the readiness with which scientific advice on these matters was accepted by cooks and catering officers.

The proceedings of this most successful conference fell into three parts: first, the organization and method of control of canteen feeding; secondly, the stability of ascorbic acid under the conditions of large-scale cookery; and thirdly, a buffet lunch in the production of which at least some of the principles on which there had been substantial agreement seemed to have been borne in mind.

DEGENERATION AND RELICT ADAPTATION

By PROF. JULIAN HUXLEY, F.R.S.

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RECENT advances in biology have shed considerable light on the evolutionary fate of originally adaptive structures which have since become functionless. It is a commonplace that in the great majority of animals such organs degenerate and either disappear entirely or become vestigial, while often showing excessive variability. This tendency to degeneration (and excess variation) of functionless organs appears to be automatic in sexually reproducing organisms with any considerable degree of outbreeding, like the great majority of higher animals. In such cases, as Muller¹ has pointed out, mutation-pressure alone will tend to cause useless organs to degenerate. Sewall Wright², while agreeing with this view, believes that a more important factor operating in the same direction is the prevalence of multiple-factor (polygene) systems of genes with multiple (pleiotropic) effects, in the genetic make-up of organisms. Wherever this is so, "the evolutionary changes in a system of genes, some bringing increased development and others reduced development in those parts of the organism which are under direct selection, should have a net effect on *indifferent* parts in the direction of reduced development". Further, when linked polygenic systems exist (that is, polygene systems consisting of one or more sets of genes which show genetic linkage with each other) and two such systems are lodged in the same chromosome or chromosomes, then anything which promotes change in the one will, by virtue of the resultant general recombination, promote change in the other. Thus, if selection is acting to alter the main character controlled by one such system, while the character controlled by the second is selectively neutral or useless, the resultant recombination will 'break up' the useless character, and in virtue of the obvious tendency of change to be towards decreased efficiency unless kept up to the mark by selection, this will promote degeneration of the useless feature. Degeneration of useless organs is thus genetically inevitable, partly as the direct effect of mutation pressure, partly indirectly as a by-product of selection acting on polygene systems with multiple effects.

None of this reasoning, however, should apply in the case of organisms which do not practice outcrossing, that is, species (mostly plants) with complete obligatory self-fertilization, parthenogenesis or apomixis, or exclusively vegetative reproduction. For one thing, in them the recombination of 'loss' mutations is no longer possible, and in its absence degeneration should only be able to proceed with extreme slowness. Furthermore, since many loss mutations are deleterious to general viability, it seems probable that they need buffering to survive,

and for this again recombination is necessary, so that where recombination is impossible, mutant characters of this type will be automatically eliminated.

The result should be the opposite of that found in most higher animals, namely, the complete or almost complete persistence of originally adaptive structures in spite of their having become wholly functionless—'relict adaptations', one might call them.

The most natural place in which to look for such organs would be among the floral mechanisms of such higher plant species as have abandoned outcrossing for compulsory self-fertilization or apomixis. At first sight there would appear to be numerous examples of this. For example, in various genera of Compositae such as the dandelions (*Taraxacum*) and the hawkweeds (*Hieracium*), there exist a number of forms which appear to produce all their seed by obligatory apomixis. Yet in spite of this they continue to produce an abundance of showy flower-heads, obviously adapted to attract insects.

It might, however, be objected that the persistence of these erstwhile adaptations was due to the short time which had elapsed since the type had changed over from normal sexual reproduction to apomixis. We know of such instances in animals. For example, in the spruce sawfly *Gilpinia* (Diprion), there are two extremely close 'biological races' or species of which one shows obligatory parthenogenesis, while in the other parthenogenesis alternates with sexual reproduction (Balch, Reeks and Smith³). There can be no doubt that here obligatory parthenogenesis is a very recent acquisition, so that we should not be surprised at the persistence of organs subserving sexual reproduction, such as the spermatheca in the females, or the testes in the occasional but functionless males produced. However, in *Taraxacum*, Dr. W. B. Turrill informs me that apomixis may well date back at least ten thousand years, to the period when the ice was retreating.

On the other hand, there is a more serious objection to considering flower-heads such as those of dandelions as relict adaptations, namely, the presence of numerous 'correlated characters' which might still be regarded as having functional significance even after the main (entomophilous) function of the capitulum had been lost. Various parts of the mechanism must be useful in providing the developmental scaffolding for the production of the pappus, which is, of course, highly adaptive in regard to the dispersal of the (apomictic) seeds, and the long ray florets still play a part in protecting the central parts of the head during its closure at night, though this protection itself may perhaps be a relict adaptation, as it probably concerns the pollen. However, such considerations do not seem to apply in some of the obligate apomicts in grasses, where the floral mechanism was adapted to anemophilous cross-pollination, and yet survives its loss of function.

Still another complication exists, in the shape of the segregation which we now know to occur in various apomicts (Crane and Thomas⁴). This is due to crossing-over, the apomictic embryo presumably arising after the first meiotic division. This asexual segregation may well have been responsible for some of the swarms of forms found in apomictic groups. It will also give a certain amount of recombination, which in its turn will facilitate a certain amount of degeneration.

Another apparently good case, unless the change of reproductive method is very recent, is provided by the coral-root *Dentaria bulbifera*, which reproduces