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EUROPEAN CONFERENCE OF THE NUTRITION SOCIETY

July 5th, Morning Session:

Chairman, Sir Joseph Barcroft

Activities in Nutrition of the Ministry of Health in England during the War

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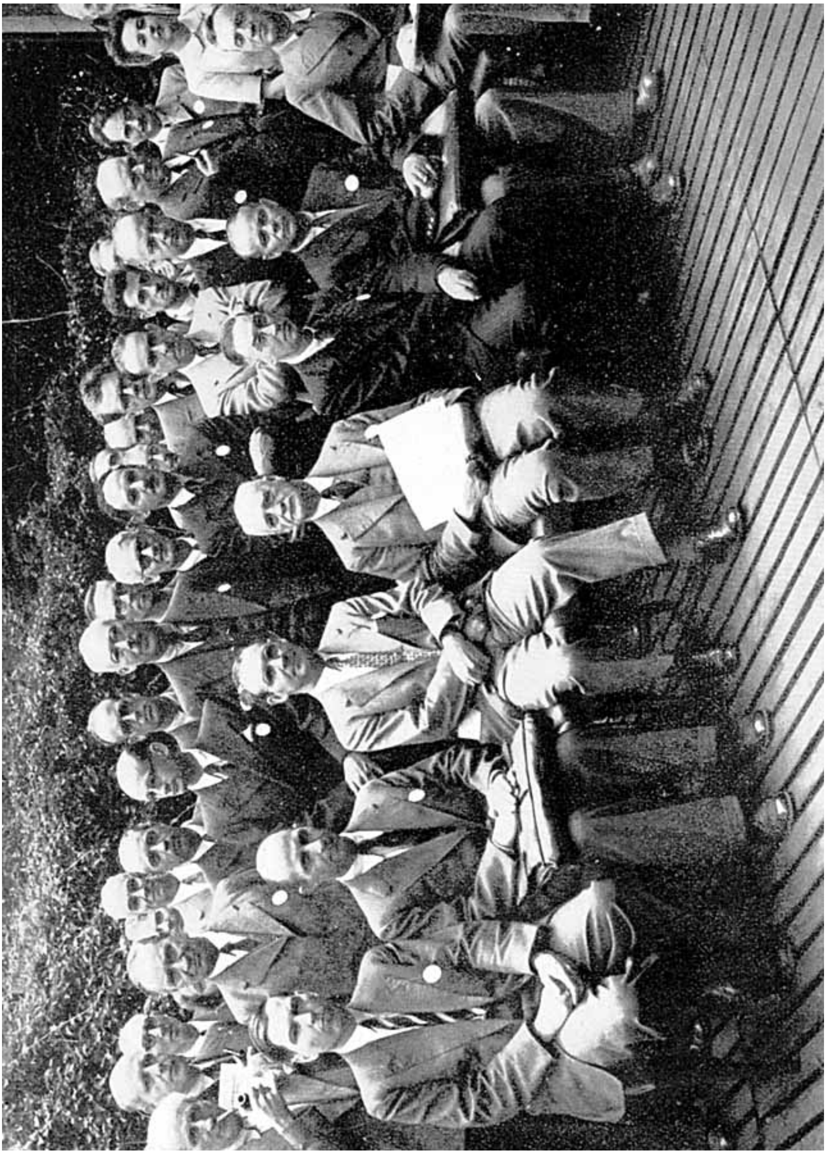
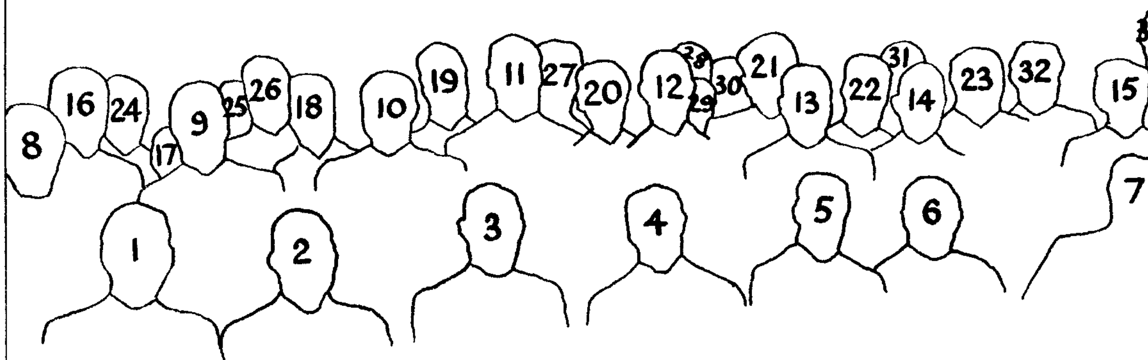
In a comprehensive picture of the nutritional activities of the Ministry of Health during the war some of its work during the 7 or 8 years preceding the outbreak of war must also be considered. At that time the Ministry of Food had not been established, and all the responsibilities of the Government for food and nutrition were borne by the Ministry of Health and by the Department of Health for Scotland. The two health departments had an Advisory Committee on Nutrition. Under the auspices of this Committee, surveys of food consumption and of expenditure by families on food, clothing, rent and other necessities were conducted all over the country. The Committee also started a systematic collection of statistics showing food production from home agriculture, imports and exports of different foods and the gross amounts of different foods available for human and for animal consumption.

The possession of this and other information obtained by other institutes and organizations, particularly the Rowett Research Institute at Aberdeen, was of great assistance in enabling the Government to plan the war food-policy on a scientific basis. The war food-policy of this country was the first real attempt to feed the people of the United Kingdom in accordance with the scientific principles of nutrition.

The three cardinal principles of this policy were:

(*a*) Production by home agriculture, and importation, of maximum amounts of the foods required to maintain the population in health and efficiency;





European Conference of The Nutrition Society, July, 1946

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(b) the distribution of foods of special value for health in accordance with physiological needs and irrespective of the family income;

(c) the maintenance of an elastic reserve of unrationed foods, bread being first and potatoes second in importance, to cover variations in energy needs.

These principles are still in operation, except for (c) since bread has recently been rationed.

The Ministry of Food was established on the outbreak of war, and it has always maintained close collaboration with the Ministry of Health. By 1941 the war food-policy was in full operation and it became obviously necessary to define more strictly the functions of the two Ministries. The Government decided that the Ministry of Health should be charged with the responsibility for nutritional policy. This responsibility it still holds.

Towards the end of 1940, the Ministries of Food and Health decided that it was desirable to carry out surveys of family diets on an extensive scale and at regular intervals, in order to ascertain how the rationing system was working out in practice. The Ministry of Health, which had had pre-war experience of this technique, assisted the Ministry of Food in launching these surveys. Some of the first of these surveys to be carried out have been published recently by my colleague, Dr. Bransby (1946). After some months the Ministry of Food took over the entire conduct of these surveys.

In 1942 the Ministry of Health began to carry out systematic surveys of the nutritional state of samples of the population of all ages and occupations all over the country. The surveys are being continued and the results are published at intervals. The results have shown that the nutritional state of the population has been well maintained during and since the war. Very few cases of deficiency disease have been seen. The method employed is the so-called clinical method, but aids to diagnosis such as the slit lamp and special tuning fork, are used. In addition, when considered necessary, samples of blood are analysed by the Oxford Nutrition Survey.

In 1943, at the request of the Ministry, the Medical Research Council conducted a large-scale survey of the haemoglobin content of the blood of people of all ages and occupations all over the country. The results showed that there was no increase in the incidence of anaemia, and indeed suggested some decrease in anaemia amongst women and children. A survey of the incidence of rickets, carried out by the British Paediatric Association in association with the Ministry in 1943, showed no evidence of an increase.

Since 1940 the Ministries of Education and Health have been making systematic studies on the growth rate of many thousands of school-children. In 1940–41 there was some evidence of a decrease in the growth rate compared with pre-war years, but by 1943 this decrease had been more than made up, and in 1944–45 the growth rate was better than before the war. Dr. Bransby, who bears the chief responsibility for these studies, has also been investigating the influence of season and of climatic conditions on the growth rate. Some interesting results have been obtained and some have been published.

The commencement of air bombardment raised doubts in the minds of many people as to the sufficiency of our national diet in vitamins for the maintenance of morale and physical efficiency. The notion prevailed in many quarters that the strain of war in some way increased the requirements for vitamins and that people would probably be able to work harder and stand the strain of war better if they had more vitamins. The Ministry did not subscribe to these theories, but nevertheless considered it desirable to carry out large-scale feeding tests to ascertain the effects of adding extra vitamins to the diets of schoolchildren and factory workers. The tests were carried out between 1941 and 1944 in various places, including much-bombed London. The tests lasted about a year and the results showed that the extra vitamins had no discernible effect on the growth rate, state of health, physical efficiency, incidence of disease or absence from school or from work.

The Ministry collaborated with the Medical Research Council on researches into the nutritive value of food yeast, the aetiology of gingivitis and dental disease and on the compilation of tables showing the composition of foods. Reports on these studies have been published by the Medical Research Council.

Physicians working for the Ministry also conducted therapeutic trials to throw light on the aetiology of follicular keratosis. They concluded that this condition, as generally seen in Great Britain, is not related to deficiency of vitamins A or C as had frequently been asserted. They also studied at some length the incidence of corneal vascularization and concluded that true corneal vascularization is very rarely found and, when it does occur, the cause is rarely dietary deficiency of riboflavin.

These were the main activities of the Ministry of Health in the research field during the war. I have referred to them and to other matters at greater length in the Milroy Lectures for 1946 (Magee, 1946).

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Bransby, E. R. (1946). *Brit. med. J.* i, 832.
Magee, H. E. (1946). *Brit. med. J.* i, 475.

Investigations of Human Nutrition in the United Kingdom during the War

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General Policy

The degree of extraction of flour was increased to economize wheat; priority was given to milk production, as milch cows give a higher return than other animals in nutritive value for human consumption; the supply of citrus fruits, which are a sure source of ascorbic acid in months when little can be got from vegetables, was cut to vanishing point. Consequently, special attention was given to the nutritive value of flour and milk, and to the amount of ascorbic acid in vegetables.

Individual Foodstuffs

Flour

A full account of investigations, made before February, 1945, into the structural composition of the wheat berry and the composition and nutritive values of flours of different degrees of extraction is given in the report of a conference of The Nutrition Society (1946). A further investigation into the composition of flours is reported by McCance, Widdowson, Moran, Pringle and Macrae (1945) and more data are to be found in the papers of McCance (1946) and Chick, Copping and Slack (1946). Repeated estimations of the composition of commercial National Wheatmeal flour have been published (Ministry of Food, Scientific Adviser's Division, 1942, 1, 2, 1943, 1944, 1, 2, 1945, 1946). These showed that content of riboflavin fell after the addition of Canadian G.R. flour and that of riboflavin and aneurin fell after October, 1944, when the extraction was reduced to 82·5, and later to 80, per cent. The percentage of fibre declined during 1942–44.

Phytic Acid. The experiments of McCance and Widdowson (1942–43) and of Krebs and Mellanby (1943) confirmed the belief that the large amounts of phytic acid in flours of 92 and 85 per cent. extraction interfere with the absorption of calcium. Widdowson and McCance (1942, 2) found evidence that phytic acid reduces also the amount of iron absorbed.

The effect of the method of baking on the amount of phytic acid broken up in the process was studied by Widdowson (1941) and Mellanby (1944). Cruickshank, Duckworth, Kosterlitz and Warnock (1945) found that the phytic acid in oatmeal was split in the intestine to a much greater extent than that reported for wheat flour by McCance and Widdowson (1935, 1942–43).

Flour Policy. The practical problem of milling a flour to contain a large proportion of the vitamins of the wheat berry, without the coarser and darker fractions, is discussed in *High Vitamin Flour* (Ministry of Food Cereals Research Station, 1944). A conference convened by the Ministry of Food (1945) proposed standard contents of aneurin, nicotinic acid and iron desirable for flour.

Milk

With the reduction in the amount of imported butter the amount of vitamin A in milk became more important. Morton, Lord and Goodwin (1941), Kon and Thompson (quoted by Kon, 1945) and Lord (1945) followed the variations of the vitamin A content of butterfat during the year in Scotland, southern England and the Midlands. Henry and Kon (1942) followed the seasonal changes in the content of vitamin D.

More dependence was placed on evaporated, condensed and dried milk than before the war. Henry, Houston, Kon and Osborne (1939), Houston, Kon and Thompson (1940) and Henry, Houston, Kon and Thompson (1944) showed that the loss of nutrients in processing was negligible, except of vitamin B_1 and ascorbic acid. The loss of vitamin B_1 and ascorbic acid increased on storage. The biological value of the protein was little affected by processing, but fell when dried milk was stored.

Foods Containing Ascorbic Acid

Special mention should be made of the studies of the ascorbic acid content of raw and cooked vegetables made by Chappell (1940), Olliver (1940, 1943) and Lampitt, Baker and Parkinson (1945, 1, 2, 3, 4, 5).

The losses in cooking have been studied thoroughly (Allen and Mapson, 1944). It appeared that in domestic cooking the chief loss was due to

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TABLE 1

COMPOSITION OF CANTEEN AND BRITISH-RESTAURANT MEALS

Source	Calories	Total protein g.	Fat g.	Ca mg.	Ascorbic acid mg.
1. Thirty-six British Restaurants	—	—	—	—	Eight not over 10 Nine, 11 to 20 Fourteen, 21 to 40 Five over 40
2. Industrial canteens	600	17	25	230	Mean 16
	860	20	37	260	" 14
	710	31	20	340	" 13
	950	40	43	380	" 34
3. Forty-one British Restaurants	494 to 1797 Twenty-six under 633	—	—	Twenty-eight under 266	—
4. Schools					
Senior	714	29	22	264	20
Junior	601	22	19	184	15
Infant	466	18	16	160	13
5. Schools	—	—	—	—	Mean 15 Range 8 to 72
6. Training school . .	1069	37·8	—	471	15·6
7. Industrial canteens					
A	760	24·5	26·5	266	27
B	724	23·0	25·7	285	28
C	358	19·4	15·8	251	37
8. Schools					
Junior					
Winter, 1943 . .	519 to 958	—	—	—	—
Summer, 1944	533 to 898	—	—	—	—
Senior					
Winter, 1943 . .	703 to 723	—	—	—	—
Summer, 1944	622 to 1092	—	—	—	—
9. Schools					
Senior, boys . .	668	28	25	243	22
Junior, 8 to 10 years . .	486	16	19	145	17
10. British Restaurant	560	18	17	—	9
11. Schools, fed from central kitchen					
Day, unspecified	624	16·5	19	—	7
Secondary . .	—	—	—	—	13·2
Nursery	—	—	—	—	3·3
Elementary					
Over 12 years	—	—	—	—	3·7
8 to 12 years . .	—	—	—	—	3·2
Under 8 years . .	—	—	—	—	1·8

1. Pyke (1944).
2. Pyke (1945).
3. Abrahams (1944).
4. Bray, Chattaway, Happold, Happold, Kerly, Magill, Morkham, Norris and Thorpe (1945).
5. Booth, James, Marrack, Payne and Wokes (1942).
6. Cook, Davidson, Keay and McIntosh (1944, 2).
7. Thompson (1945).
8. Chattaway, Happold and Happold (1946).
9. Kerly, Morkham and Magill (1946).
10. Quoted by Stewart (1944).
11. Macdonald (1943).

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extraction of the ascorbic acid by the cooking water, while in cooking on a large scale ascorbic acid was destroyed by the action of oxidase, while the temperature was rising, before the enzymes were destroyed.

Values for the ascorbic acid content of cooked vegetables are given by Olliver (1940, 1943), Booth, James, Marrack, Payne and Wokes (1942), Ungley (1943), Lampitt, Baker and Parkinson (1943), Pyke (1944), Thompson (1945) and Jenkins (1946).

The seasonal variation in the amount of ascorbic acid in the food served in institutions, even where special attention is paid to maintaining a good supply of vegetables and to good methods of cooking, is illustrated by Harris and Olliver (1943); the daily total rose after new potatoes came in, reaching a maximum in August-September and falling to a minimum in March and April.

Composition of Meals in Institutions

Numerous investigations have been made into the composition of meals provided in school canteens, factory canteens, and British Restaurants; results are given in Table 1.

Consumption of Food

Amounts of Foodstuffs

The amounts of foodstuffs "going into consumption" are given in *Food Consumption Levels in the United States, Canada and the United Kingdom* (Special Joint Committee Set up by the Combined Food Board, 1944), referred to hereafter as F.C.L., also in the *Monthly Digest of Statistics*. It is clearly stated in F.C.L. that the amounts given are calculated from estimates of total food imported or produced, and are not amounts of food bought retail, which are considerably lower. Details of the rationing scheme, meals in canteens, the control of distribution of milk, and the Vitamin Welfare Scheme are given in *How Britain was Fed in War Time* (Ministry of Food, 1946).

Some further details are given by Drummond (1946).

The results of the following surveys, made before and during the war, may be compared.

Survey	Date	Place	Social class	Author
Pre-war A	1934	Newcastle	Typical working class	Newcastle-on-Tyne City and County (1934)
B	1935–37	West Riding of Yorkshire	Typical working class All families Expenditure on food per head per week: 8/– and over 5/– to 7/11¾ 2/– to 4/11¾	Potts (1939)
C	1935	Unspecified	Middle class	Widdowson and McCance (1936)
D	1936–37	Throughout Britain	Income per year: AA £1000 and over A £500 to £999 B £250 to £499 C £125 to £249 D Under £125	Crawford and Broadley (1938)

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Survey	Date	Place	Social class	Author
Pre-war E	1936–37	Three public schools	Public school boys	Widdowson and McCance (1942, 2)
F	1937	Merthyr Tydfil Gateshead Bermondsey Camberwell	Pregnant women. Income, less rent per head per week: (1) Over 40/– (2) 25/– to 40/– (3) 15/– to 25/– (4) 9/– to 15/– (5) 6/– to 9/– (6) Less than 6/–	McCance, Widdowson and Verdon-Roe (1938)
G	1937–38	Throughout United Kingdom	Working class	Ministry of Labour (1941)
H	1938	Carnegie Survey		
	(*a*)	throughout United Kingdom	(1) Poorest 10 per cent. (2) Next 20 per cent.	—
	(*b*)	Glossop	(1) Income over 7/– per head per week (2) Income under 7/– per head per week	Quoted by Lewis-Fanning and Milligan (1944, 1, 2)
War I	1941 Mar./Dec.	Various throughout United Kingdom	Working class. Expenditure on food per head per week: (1) 13/– and over (2) 11/– to 13/– (3) 9/– to 11/– (4) 7/– to 9/– (5) 5/– to 7/– (6) Under 5/–	Bransby (1946, 1)
J	1941 April/May	—	Middle-class women	Widdowson and Alington (1941)
K	1942	—	Public school boys	Widdowson and McCance (1942, 2)
L	1941 Sept. 1942 May/July 1943 April/June	(1) Clydeside (2) Dundee (3) Aberdeen (4) Dundee	Heavy workers, 1941, 1942–43 Families of Forces, 1942, 1943 Poor families, 1942, 1943 Old age pensioners, 1942	Department of Health for Scotland (1944)
M	1942	Glossop	Working class	Lewis-Fanning and Milligan (1944, 1, 2)
N	1943–44	Stoke-on-Trent and Salford	Schoolchildren, Aug.–Sept., 1943 March, 1944	Bransby and Wagner (1945)

Since 1942 the War-time Food Survey, organized by the Ministry of Food, has been carried out in representative areas. Except for a few fragments the results of this survey have not been published.

The main changes in the amounts of food "going into consumption" are shown in Table 2. According to Drummond (1946) there was little difference between the supply in 1945 and that in 1943, except for an increase of about 12 per cent. in the consumption of potatoes, over 30 per cent. of fruit, and about 20 per cent. of poultry, game and fish.

TABLE 2

Changes in Amounts of Food Going into Consumption per Head per Week

Food	1934–38	1940	1941	1942	1943
Fresh milk, pints	3·35	3·55	3·92	4·35	4·5
Milk, total equivalent, pints	4·11	4·97	4·24	5·03	5·4
Cheese, oz.	2·55	2·35	2·38	4·08	3·4
Butter, oz.	7·6	4·1	3·1	2·4	2·3
Margarine, oz.	2·8	4·7	5·5	5·4	5·5
Cooking fat, oz.	2·9	2·8	3·1	3·7	3·6
Butcher's meat, oz.	29·9	27·0	22·0	21·3	20·4
Offals, oz.	2·1	2·2	1·9	1·7	1·7
Canned meat, oz.	0·9	0·3	0·7	2·2	2·5
Poultry, game, rabbits, oz. ..	2·4	2·3	2·0	1·7	1·6
Bacon and ham, oz.	8·0	6·2	5·9	5·6	5·8
Eggs, shell and dried, oz. ..	7·5	7·0	5·7	6·3	7·0
Fish, oz.	5·7	3·1	3·2	3·7	3·1
Sugar, oz.	27·5	20·3	18·6	19·4	19·0
Potatoes, oz.	54·5	55·0	63·0	76·5	79·0
Fresh vegetables, oz. ..	45·1	42·2	50·4	57·1	61·7
Flour, oz.	60	64	73	70	71

The methods employed in surveys D and G (p. 216) were not wholly satisfactory. However, the results obtained agree well with those of F.C.L. for foodstuffs, such as milk, butter, and margarine, which are commonly bought in fairly constant amounts week by week and of which fairly accurate records of production and distribution have been kept. The figures for sugar in F.C.L. are considerably higher than those found in surveys, because they include amounts used commercially, as in jam.

The actual changes in the consumption of individuals have been very different from those in the total consumption of the nation, because inequalities of consumption between classes and districts have been reduced by the control of distribution, by the special allowances for

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certain groups and by an increase of purchasing power for food, due to a rise in the "food values" of wages and reduction of unemployment.

When we compare the rations with the amounts consumed before the war we find that the rations were for:

Butter and margarine below all, including the poorest groups;

Butcher's meat below all, except West Riding, average (12·1 oz.);

Bacon below all, except average in West Riding (2·6 oz.) and boys in two public schools (2·2 and 2·0 oz.);

Sugar much below all (*e.g.*, poorest in West Riding, 13·9 oz.).

The effects of rationing of these foodstuffs appear when the surveys made before and after the war are compared. These surveys show also the increase in consumption of milk, even in 1941 (H and I (*a*) 2); and of bread and flour. The consumption of potatoes found in most of the war-time surveys was higher than in the West Riding (which is surprisingly low); but actually less in L (1942) than in H (*a*) 2.

In 1941 Bransby (survey I) found that the distribution of food was still very unequal; even in 1943 (survey L) there were still considerable inequalities.

The greatest improvement was in the distribution of milk. In 1941 Bransby (1946, 1) found that there was still a wide difference between groups, but by 1943 the striking contrast between the amounts consumed in the towns of northern and southern England had disappeared. There was little difference between the amounts per head bought by middle- and working-class families, except during summer months when milk was plentiful (figures quoted by Kon, 1945). This change in distribution of the increased milk supply chiefly applied to children and pregnant and nursing women. The percentage of children taking milk in school increased from 55·6 in 1939 to 79·8 in 1942. In the survey of Bransby and Wagner (1945) the average amount of milk per child was five pints per week.

The National Milk Scheme, which allowed one pint of milk free or at a reduced price to pregnant and nursing women and to children up to their fifth year, started on July 21st, 1940 and, by November, 1941, 80 per cent. of those so entitled were getting milk under the scheme. An investigation in East London (unfinished) showed that 57 per cent. of pregnant and nursing women were getting over 18 oz. of milk a day, and 24 per cent. over 23 oz. while, according to the survey of the diets of pregnant women made by McCance, Widdowson and Verdon-Roe (1938), before the war only 37 per cent. got over 10 oz. and even in the wealthiest group only 31 per cent. got over 20 oz. The number of meals supplied to children with the extra allowances of meat and other rationed foodstuffs rose steadily. After 1944 extra meat rations were allowed to pregnant women.

Changes in the Nutritive Value of Food Consumed

The estimates given in F.C.L. (Table 3) are considerably higher than the amounts supplied by food as purchased. Insufficient allowance was made for losses between production or import and retail sale. The difference is seen by comparison of those figures with the estimates found from surveys.

TABLE 3

NUTRIENTS AVAILABLE FOR CIVILIAN CONSUMPTION PER HEAD PER DAY IN THE UNITED KINGDOM

(Special Joint Committee Set up by the Combined Food Board, 1944)

Nutrient	1934–38	1940	1941	1942	1943
Calories	2984	2772	2795	2864	2827
Protein, g.	81·4	79·6	83·4	88·6	87·1
Animal protein, g.	43·0 (36)*	38·3 (31)*	36·0 (29·5)*	40·6 (33)*	40·1 (33)*
Fat, g.	129·5	118·5	111·5	116·8	112·8
Calcium, mg.	694	675	705	854	1054
Vitamin A, I.U.	3868	3320	3634	3857	3882
Vitamin B_1, mg.	1·20	1·30	1·35	1·77	1·92
Riboflavin, mg.	1·58	1·59	1·58	1·95	2·06
Nicotinic acid, mg.	18·0	17·4	16·8	18·2	18·6

* See this page below.

Calories. For example, the calories found in the War-time Food Survey (Drummond, 1946) were some 20 per cent. less than given in F.C.L. These amounts are slightly less than the allowances of the U.S.A. National Research Council (1945). The number of calories eaten by children in Salford and Stoke-on-Trent in 1943–44 (Bransby and Wagner, 1945) was well up to standard, but the investigation by Chattaway, Happold and Happold (1946) in Leeds shows that this level was not reached everywhere.

Protein. Whatever its actual value, the amount of animal protein is a rough index of the quality of the diet as a whole. From comparison of the figures given by F.C.L. from 1941 to 1943 with those given by the Committee on Haemoglobin Surveys (1945) and by Drummond (1946) we may conclude that the figures of F.C.L. are about 7 g. too high, and obtain the figures given in brackets in Table 3.

Vitamin A. The validity of the estimates of the vitamin A value of diets is doubtful owing to uncertainty about the amounts of vitamin A in butter consumed before the war and to variations in the carotene content of vegetables and in the degree to which carotene is absorbed. All that can be said is that the amounts of the animal foodstuffs that supply preformed vitamin A fell but that, at the same time, a steady supply of preformed vitamin was ensured by standardizing the amount in the ration of margarine, and that the amount of carotene consumed rose considerably.

Vitamin B Group. The change in the degree of extraction of flour raised the amounts of *nicotinic acid*, *riboflavin*, and other vitamins of the B group; the amount of riboflavin was further raised by the greater consumption of milk.

Ascorbic Acid. No allowance was made in F.C.L. for losses in cooking in estimating the consumption of ascorbic acid. The amount supplied by fruit, which loses little in cooking, fell, according to F.C.L., from 28·3 mg. daily in 1935–39 to 10·1 mg. in 1943–44. This fall must have involved a fall in total intake in spite of the increased consumption of

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vegetables. The loss is more serious if the seasonal variation of the supply from vegetables is taken into account. Oranges supplied a considerable amount of ascorbic acid during the winter and spring months (see Ministry of Labour, 1941), when the amounts obtained from vegetables are low (Harris and Olliver, 1943).

Calcium. The amount of calcium rose with the increased consumption of milk.

Diet in Hospitals

Special and long overdue attention was paid to the food of nurses and patients in hospitals. The investigations of Wills, Mackay, Bingham and Dobbs (1942) suggested that nurses in hospitals in the country were relatively badly fed. The King Edward's Hospital Fund for London (1943) found that, in some instances, calories, fat, vitamin A and ascorbic acid were low in nurses' diets. In the same hospitals the diets supplied to patients did not supply adequate calories, protein, fat, vitamin A or ascorbic acid. The low levels of vitamin A were due to the scanty use of green and yellow vegetables. The lack of ascorbic acid was aggravated by excessive losses in and after cooking. Stewart (1944) found the amounts of protein and ascorbic acid in patients' diets low. Both he and Lyall (1945) laid stress on the large proportion of the patient's food that was supplied by friends and relatives.

Adaptation of the Diet to War Conditions

The surveys of diets of middle-class women and of boys in public schools show how the calorie intake was maintained by increased consumption of bread and potatoes. But this degree of adaptation was not universal, and extra difficulties arose owing to conditions caused by bombing. Hence the fall in the average calories of the diet of the country as a whole in 1941. Adaptation was incomplete in other ways; the boys at two of the public schools (Widdowson and McCance, 1942, 1) did not get their full allowances.

Distribution was still very unequal in 1941 but, according to the War-time Food Survey (Drummond, 1946), there was subsequently little difference in nutritive value between the diets of working- and middle-class families. Supplies of vegetables and milk rose considerably in later years of the war; 85 per cent. extraction of flour was enforced in 1942 and lend-lease supplies of meat began to come over in 1942. The number of meals supplied in schools, factory canteens and British Restaurants (Table 4) grew rapidly after 1941; in 1941 the dislocation caused by bombing made the provision of meals difficult, and 1941 was, therefore, the worst year.

Methods of Assessment of the State of Nutrition

Vital Statistics

Malnutrition lowers the resistance to tuberculosis, and the death rate from it has not been affected by the new chemotherapeutic remedies. Further evidence on the effects of diet on tuberculosis was produced by Day (1942), who found that tuberculous subjects gained weight when more sugar was added to their diets.

Prematurity is considered to be the chief single cause of death during the first month after birth (Baird, 1943; Asher, 1946; Evans, 1946).

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Cameron and Graham (1944) found that the diet during pregnancy of the mothers of premature and stillborn babies was much inferior to that of mothers of full-term babies and that the incidence of premature and stillbirths was reduced by improvement of diets. We should, therefore, pay special attention to the tuberculosis death rate, the incidence of stillbirths and the neonatal mortality rate.

TABLE 4

INCREASE IN NUMBER OF MEALS IN SCHOOLS, CANTEENS AND BRITISH RESTAURANTS

School meals		British Restaurants		
Date	Percentage of schoolchildren taking school meals	Date	Number	Total meals per day
June, 1940	2·7	June, 1941	777	167,000
May, 1941	5·1	Dec., 1941	1207	325,000
May, 1942	12·8	Dec., 1942	1959	568,000
May, 1943	22·4	Dec., 1943	2119	619,000
June, 1944	30·7	Dec., 1944	1931	540,000
June, 1945	37·0	—	—	—
June, 1946	43·0	—	—	—

Industrial Canteens and Catering Establishments, Staff Dining Rooms, Luncheon and Other Clubs

Date	Number of establishments	Number of meals per week
May, 1941	14,700	16,600,000
Jan., 1942	23,700	53,400,000
July, 1943	31,700	60,600,000
Dec., 1944	34,800	62,200,000

Rate of Growth

Heights and weights of children are commonly published as averages without any indication of the spread; Benjamin (1943) has published tables showing the distribution of height and weight measurements of London elementary schoolchildren made during 1935–38.

Tuxford (1942) proposed a revised form of his index for use in the assessment of the nutritional state of children. J. Yudkin (1944, 2), in a study of Cambridge children, found that this index revealed no difference between children of families of different economic status, although the children from the poorer families were lighter and shorter than those from the better-off ones.

Bransby studied the significance of height and weight data. He compiled standards of yearly weight increment from the data collected in 1941–42 and 1942–43 by the Ministries of Education and Health (Bransby, 1945, 1). The actual weight increment and the actual weight increment expressed as a percentage of the standard were compared with the nutritional status as assessed clinically. On the average a direct relationship was found between nutritional grade and both weight increments, but the correlation was low.

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Bransby (1945, 2) found that gain in weight in several localities was irregular, being usually at its lowest in April to June; he concluded that seasonal variations in weight gain have been accepted too readily as natural and proper phenomena whereas they are, at least to some extent, due to growth rates less than the optimum, depending on the state of health. From study of data supplied from Christ's Hospital and Glossop, he considered that height and weight curves are preferable to weight and age curves in assessing the adequacy of growth, but he found that there was a considerable discrepancy between assessment of health and nutritional status as made by clinicians and as determined by growth curves. Benjamin (1943) also found that the increase of height of London schoolchildren in 1935–38 was maximum in late spring and minimum in mid-autumn. In the rate of growth of boys at two public schools seasonal variations were observed by Widdowson and McCance (1944) which might be related to observed seasonal changes in the metabolism of calcium (McCance and Widdowson, 1943).

Degree of Saturation with Ascorbic Acid

Harris (1943) followed the relation between the amount of ascorbic acid in the diets of boys in a residential school and the number of doses of ascorbic acid needed to reach saturation (method of Harris and Abbasy, 1937). The saturation test gives a satisfactory indication of the habitual level in the diet, when this is fairly uniform.

Atkins (1943) found variation in response that could not be accounted for by variation in diet. He found that the effect of saturation wore off quickly, but Durham, Francis and Wormall (1946) present evidence that some effect may persist for three months. Prunty and Vass (1943) studied the relation between the concentration of ascorbic acid in the plasma and the results of saturation tests.

Richter and Croft (1943) and Lloyd, Sinclair and Webster (1945) studied the estimation of ascorbic acid in blood.

Gingivitis. In view of the swelling and bleeding of the gums seen in scurvy, it is natural to consider that gingivitis may be caused by deficiency of ascorbic acid. Several investigations on the relation of gingivitis and stomatitis have been made during the war; these are discussed in a memorandum issued by the Bureau of Nutrition Surveys (The Nutrition Society, 1944). The conclusion drawn in this memorandum is that "while, therefore, gingivitis may be due to lack of ascorbic acid and may be cured by dosage with ascorbic acid, it cannot be regarded as specific evidence of ascorbic acid deficiency". Stamm, Macrae and Yudkin (1944) found no evidence of gingivitis that could be cured by ascorbic acid among personnel of the R.A.F. whose diet supplied from 17 to 26 mg. of ascorbic acid daily. No relation was found between the incidence of hyperkeratosis of hair follicles or "folliculosis" and state of nutrition with respect to ascorbic acid by McIntosh, Moore, Keay and Cook (1946) or by Durham *et al.* (1946).

Vitamin A

Vitamin A in Plasma. Methods for estimating vitamin A and carotene were studied by S. Yudkin (1941, 1) and Hoch (1943, 1). The concentration of carotene in plasma rose and fell with the amount in the diet (Hoch, 1943, 2; Accessory Food Factors Committee, 1945). S. Yudkin (1941, 2) found the level of vitamin A to vary little in the same individual. In Steven's (1942) experiment the fall in the concentration of vitamin A in the plasma of subjects living on a diet free from vitamin A, was obvious within one to three months, but in the Sheffield experiment (Accessory Food Factors Committee, 1945) little sign of change was seen before twelve months in most of the subjects studied.

Dark Adaptation. Yudkin, Robertson and Yudkin (1943) discussed the value of various methods. They found that results obtained on an individual varied little from time to time. The shape of the adaptation curve varied from one individual to another; these variations are the cause of discrepancies between the results obtained by different investigators. They considered that the best criterion of dark adaptation for the detection of vitamin A deficiency is the final rod threshold. Further development of instruments for testing dark adaptation were described by Godding (1945). Livingston (1944, 1, 2) devised a method of taking perimetric measurements with the fully dark-adapted eye and demonstrated the impairment caused by lack of oxygen.

S. Yudkin (1941, 2) considered that, when the concentration of vitamin A in the plasma is above a critical level characteristic of the individual, the final rod threshold is independent of this level, but when the concentration falls below the critical level the threshold rises. This agrees with the results of the Sheffield experiment.

Yudkin *et al.* (1943) found that the threshold was lowered by treatment with 24,000 I.U. of vitamin A or 20,000 I.U. of carotene, for several weeks, in a surprisingly large number of apparently normal subjects. Kohn, Milligan and Wilkinson (1943) found that, when the lowering of the threshold after treatment with vitamin A was 0·5 log unit or more, the diet, in most cases, supplied less than 30 I.U. vitamin A per kg. per day. In Steven's (1942) study the threshold rose appreciably after from 43 to 87 days on the low vitamin A diet, but in the Sheffield experiment the threshold did not rise to a marked extent until after a year on the diet, which contained minimal amounts of vitamin A, although it showed a slight temporary rise in the winter.

Hyperkeratosis. The relation between *hyperkeratosis follicularis* and vitamin A deficiency is disputed by Stannus (1945, 1, 2); McIntosh *et al.* (1946) found no relation between the occurrence of folliculosis (which the authors considered to be an earlier stage of follicular keratosis) and the concentration of vitamin A and carotenoids in plasma. According to Cook, Davidson, Keay and McIntosh (1944, 1) the diet of the subjects of this study had supplied fairly satisfactory amounts of vitamin A.

Superficial Changes in the Eye. Kruse (1941) described changes in the sub-epithelial layers of the cornea, detectable with the slit-lamp microscope, which he considered were the result of deficiency of vitamin A. However, Kodicek and Yudkin (1942) considered that these changes were not related to deficiency of vitamin A, evidence for which should be looked for in the epithelial layer. No such changes were found in the Sheffield experiment.

Vitamin D

Radiological examination has been regarded as the final appeal on the question of the presence of rickets. However, in the survey organized by the British Paediatric Association (1944) not only was rickets diagnosed clinically nine times as often as radiologically, but also the radiologists differed among themselves. In other investigations (Chisholm, 1933; Graham, 1944; Krestin, 1945; Corner, 1944) clinician and radiologist agreed better. Corner (1944) found that in most cases plasma phosphatase was above 15 (King-Armstrong) units per 100 ml. when rickets was diagnosed clinically. In Graham's (1944) series clinical evidence was found in 28·3 per cent. and the phosphatase was raised in 28·2 per cent. The inorganic phosphorus in serum was under 3·0 mg. per 100 ml. in 43·8 per cent. and under 3·5 mg. in 66·5 per cent.

Aneurin

Saturation tests were devised by Wang and Yudkin (1940) and Harris (1943).

Nicotinic Acid

Ellinger and colleagues (Coulson, Ellinger and Holden, 1944; Ellinger and Coulson, 1944; Coulson, Ellinger and Smart, 1945) showed that nicotinamide-methochloride (N-methylnicotinamide) was the main product of the metabolism of nicotinic acid and nicotinic acid amide; they used measurement of the excretion of this metabolite under basic conditions and after a dose of nicotinic acid amide, as an index of the state of nutrition with respect to nicotinic acid. The amount of nicotinamide-methochloride found in the urine might be more than the nicotinic acid in the food would account for (Ellinger and Coulson, 1944). Part of the supply of nicotinic acid might be derived from that synthesized by bacteria in the intestine (Ellinger, Coulson and Benesch, 1944). King (1943, 1, 2, 3) produced evidence that ulcerative stomatitis, with Vincent's organisms, occurred when resistance was impaired by various causes, of which deficiency of nicotinic acid is one, and that dosing with nicotinic acid hastened cure. Coulson, Ellinger and Smart (1945) did not find that the incidence of gingivitis bore any relation to the state of nutrition as revealed by the nicotinamide saturation test.

Riboflavin

Stannus (1944) reviewed the effects of deficiency of riboflavin. He stressed the need to distinguish between "angular stomatitis" and "cheilosis". Copping (1944–45) reviewed some aspects of riboflavin deficiency in man.

Scarborough (1942) considered that, though circumcorneal injection might be an early sign of riboflavin deficiency, it could not be accepted unless supported by other clinical findings. Kodicek and Yudkin (1942), Gregory (1943) and Ferguson (1944) insist that deficiency can be diagnosed only when the true cornea is invaded by loops of capillaries. Both Gregory and Ferguson describe the normal variation of the limbic plexus.

Lyle, Macrae and Gardener (1944) found a high degree of vascularization of the cornea, on their system of scoring, on stations of the R.A.F. at which most of the food was tinned, and fresh fruit and vegetables were

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scarce. They did not consider that the vascularization could be due to deficiency of riboflavin, as it was severe where milk and liver were abundant.

Macrae, Barton-Wright and Copping (1944) found that the average daily intake of riboflavin in messes of the R.A.F. in Britain was 2·0 mg. for men and 1·8 mg. for women. Since Lyle *et al.* (1944) had found no signs of riboflavin deficiency among the personnel, it was concluded that normal adults need less than 3 mg. daily.

Haemoglobin

To clear up the confusion due to the use of different, arbitrary "normal standards" in haemoglobinometry, the Traumatic Shock Committee of the Medical Research Council (1943) recommended the use of the Haldane method, and a permanent standard for use with this method was adopted (British Standards Institution, 1942). Investigations in connexion with the haemoglobin survey of 1943 (Committee on Haemoglobin Surveys, 1945) brought out differences between readings made by different individuals and differences between readings made by the same individual in different conditions. According to Mackay, Wills and Bingham (1946) these differences between individuals seem to be constant.

It follows from these investigations: (1) that comparisons should be made only between results obtained by methods that have been standardized against the approved Haldane apparatus or by measurement of oxygen or iron; and (2) that no conclusions should be based on differences between the results of two surveys which lie within the probable range of differences between the readings of different individuals or between the readings made by the same individual, whichever may be appropriate.

The 100 per cent. of the approved Haldane method, as read by most observers, is equivalent to 14·8 g. (King, Gilchrist and Matheson, 1944) or 14·7 g. (MacFarlane and O'Brien, 1944) of haemoglobin per 100 ml.

Mackay, Dobbs and Bingham (1945) found that addition of iron, in physiological amounts, had no effect on the concentration of haemoglobin in the blood of children, although iron, in doses much above the amounts that occur in food, raised the concentration (see Davidson and Donaldson, 1944). In investigations on anaemic sub-standard recruits, Case (1947) found that the haemoglobin rose under the conditions of training at a physical development centre, but was not affected by treatment with iron.

Evidence of the association of anaemia with low economic levels was produced by J. Yudkin (1944, 2, 3) and by Mackay *et al.* (1946).

Results of Assessments of the State of Nutrition

Vital Statistics

Tuberculosis Mortality. There are two factors, not directly connected with nutrition, which should be borne in mind when considering the state of health during the war years:

(*a*) Hours of work increased in 1940 and, in 1944, were still above the level of 1938 (Central Statistical Office, 1946). Many more women were employed in industry in 1943 than in 1939 or, for that matter, in 1917, and, in 1940 and 1941, the intensity of work was very great.

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(*b*) The number of civilian casualties in London (Table 5) is a rough index of the intensity of bombing. Apart from direct injury or effect on diet, bombing affected health by causing crowding in shelters and dislocation of traffic with consequent long and tiring journeys to and from work. These factors alone may be held sufficient to account for the rise in the tuberculosis death rate in England and Wales in 1940–41. In 1942 the death rate fell again and in 1944, in spite of the renewed attack with flying bombs and rockets, it was well below the level of 1939 (Ministry of Health, 1946).

The high mortality from tuberculosis among women aged 15 to 25 years has been ascribed to employment in industry (Hart and Wright, 1939). A higher proportion of the female population was drawn into industry in 1943 than in 1918; but there is a striking contrast between the great increase of deaths from tuberculosis in the employable age groups in England and Wales in 1914–18 and the actual reduction in 1939–43 (Stocks, 1944, 1, 2).

The so-called "incidence" of tuberculosis is actually a measure of the numbers notified. Even in 1944 one case in seven had not been notified before death. With changes in the extent of inspection due to examination for the Services and mass radiography, no significance can be attached to an increase in the number of cases detected. Stocks (1944, 1, 2) concluded from the age distribution of notification that half the war-time increase of notifications could be attributed to the medical examination of persons who would not have been examined but for the Military Service Acts. Although Scotland suffered much less than England and Wales from bombing, the number of deaths from tuberculosis in Scotland rose above the 1938 level by 20 per cent. in 1940 and 22 per cent. in 1941 and was still raised by 15 per cent. in 1944. The increase in the number of notifications rose to 2523 in 1943 and 1983 in 1944. This increase cannot be ascribed to the introduction of mass radiography since, by the end of May, 1945, only 30,280 persons had been so examined and 180 active cases detected. According to Laidlaw and MacFarlane (1941) the increase was mainly in the group of males aged 15 to 45 and of females aged 15–35. They attributed the increase to long hours of overtime, fire-watching and home-guard duties, and more frequent visits to dance halls

TABLE 5

SOME VITAL STATISTICS IN ENGLAND AND WALES AND IN SCOTLAND IN THE YEARS 1939 TO 1944

	England and Wales					Scotland	
Year	Death rate, tuberculosis all forms per 1000	Stillbirth rate per 1000 births	Infant mortality rate per 1000 births	Neonatal mortality rate per 1000 births	Total civilian casualties in London	Total number of deaths from tuberculosis all forms	Total notified cases of tuberculosis
1939	0·620	38	51	28	4	3526	7097
1940	0·692	37	57	30	7973	4003	7722
1941	0·692	35	60	29	4661	4175	8294
1942	0·616	33	51	27	89	3998	9048
1943	0·619	30	49	25	517	3959	10,088
1944	0·583	28	46	24·5	4567	3935	9548

and the pictures. Among the families in Glasgow reported by J. Yudkin (1944, 3) only 6 out of 21 spent 7s. or over per head per week on food;

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this was low even if the families were those of the worse paid workers. It is possible that the food of the working class was worse in Scotland than in England, which should be revealed in the official surveys, and that the Scots were consequently less able to resist the adverse changes due to the war.

The increase of tuberculosis mortality in Scotland was outweighed by the decrease in England and Wales.

Some of the vital statistics discussed above are given in Table 5.

Height and Weight Increase

Babies. Huggett (1944) reported that the weights of babies born in four teaching hospitals in London and one borough were significantly lower in 1941 than in 1938–39 and in 1942. According to Lewis-Fanning and Milligan (1944, 1, 2, 3) boy babies in Glossop were lighter and shorter in 1940–42 than in 1933–36, but the weights and lengths of newborn girl babies had not changed appreciably.

Children in the First Year of Life. Lewis-Fanning and Milligan (1944, 1, 2, 3) found in Glossop that the smoothed curve of weight gain, during the first year of life for the years 1940–42, was higher than for the years 1933–36 (Hill and Magee, 1938, 1, 2). These weight curves compare favourably with those of New York babies (Merritt and Davidson, 1933).

Schoolchildren. Bransby (1944, 1946, 2) reviewed the reports of school medical officers. Generally, heights and weights up to 1943 tended to remain at or above pre-war levels. In a few areas decreased rates of gain in height and weight, mainly among the older children, occurred in 1940–41; these were generally, but not entirely, rectified by 1943. In 1944 there was no consistent change from 1943. Over the whole period, in 21 localities, according to the reports of school medical officers, the average increases of height and weight of both boys and girls, of corresponding ages, from before the war up to 1944, were $\frac{1}{4}$ to $\frac{1}{2}$ in. and $1\frac{1}{2}$ to 2 lb. According to the special inquiry boys increased between 1940 and 1944 by $\frac{1}{4}$ in. and 1 to $1\frac{1}{2}$ lb., girls by slightly over $\frac{1}{2}$ in. and 3 to $3\frac{1}{2}$ lb. Lewis-Fanning and Milligan (1944, 1, 2, 3), following up the same set of boys throughout, showed that the rate of growth fell below the pre-war standard in 1941, but recovered in 1942; the improvement began about the end of 1941.

In London (Daly, 1944) average heights declined during the earlier years of the war, but improved later. By 1943 they had reached the 1938 level in the south-east district and had risen above the 1938 level in the better-off north-west district. London children suffered more than children in most towns from the effects of bombing; it is not surprising that their growth should have been affected. No deterioration of average height and weight was found among boys and girls at public schools by Armattoe (1943, 1, 2) in 1942, or by Billington, McCance and Widdowson (1943) among boys in 1943. In Cambridge, which is not included in Bransby's 21 localities, schoolchildren were appreciably heavier on the average in 1943 than in 1942.

J. Yudkin (1944, 5, 6) found, in September, 1942, that children of school age in Aberdeen, Dundee and Glasgow were, on the average, nearly $1\frac{1}{2}$ in. shorter and 4 lb. lighter than Cambridge schoolchildren.

During the years 1939–42 the average heights and weights of children in Glasgow improved by $1\frac{1}{2}$ in. and 4 lb. Yet, using as standards the heights and weights of London schoolchildren aged 5 to 14 in 1938 and the standard given by Paterson and Smith (1942) for children under 5, Yudkin found that 54 per cent. of the Glasgow children were below, and 15 per cent. above, the standard height; 62 per cent. were below, and 16 per cent. above, the standard weight.

Adolescents. Bashford (1942, 1943) reported that boy entrants to the Post Office, aged 14–$14\frac{1}{2}$ were taller in 1941 and 1942 than in 1938; girl entrants were taller in 1942.

Adults. J. Yudkin (1944, 4) reported changes in weights of the same group of workers in a factory in Birmingham from 1941 to 1943. The average gains in weight of workers under 20 years old were: men 8 lb., women over 5 lb.; gains of workers over 20 years old were, for men over 1 lb., for women 3 lb.

Among 61 women working in factories and 34 housewives, Wilson (1945) found that approximately equal numbers had lost and gained weight in the interval between autumn 1942 and spring 1944. The maximum gains in weight were for factory workers 24 lb., and for housewives 29 lb.

General Health

Since 1942 the Ministry of Health has been conducting systematic surveys of the state of nutrition of samples of the population. During the first period the surveys were made by Dr. Sydenstricker and subsequently the methods which he introduced were used.

The incidence of folliculosis, gingivitis and corneal vascularization found in these surveys, and the conclusions as to the general state of

TABLE 6

RESULTS OF SYSTEMATIC SURVEYS OF THE STATE OF NUTRITION OF SAMPLES OF THE POPULATION, CARRIED OUT BY THE MINISTRY OF HEALTH

Type of sample	Period	Size of sample	Nutrition: Good	Fair	Poor	Folliculosis per cent.	Gingivitis per cent.	Corneal vascularization per cent.
			Per cent.					
Pregnant and nursing women	June, 1942—Jan., 1943	920	87	13	0·2	1·3	—	1·5
	Jan., 1943—July, 1943	190	93	7	0	1·6	—	7·9
	Oct., 1943—May, 1944	196	98	1·3	0·3	9·0	8·2	1·0
	June, 1944—March, 1945	462	97·8	2·2	0	4·5	17·7	0·2
	June, 1945—Dec., 1945	312	97·4	2·6	0	5·1	14·4	0·3
Adults, mainly factory workers	June, 1942—Jan., 1943	1224	86	14	0·8	7·5	—	1·6
	Jan., 1943—July, 1943	503	87	13	0·6	7·7	—	1·2
	Oct., 1943—May, 1944	2918	98	2	0·1	16·2	17·0	3·4
	June, 1944—March, 1945	1269	95·7	3·9	0·4	8·7	11·3	0·3
	June, 1945—Dec., 1945	1270	95·1	4·8	0·1	6·5	11·3	0·5
Schoolchildren 8 to 15 years	June, 1942—Jan., 1943	2037	63	34	2·7	13·0	—	0·6
	Jan., 1943—July, 1943	1564	77	21	1·6	21·0	—	2·2
	Oct., 1943—May, 1944	2295	87	9	1·3	38·0	16·0	1·6
	June, 1944—March, 1945	2099	90·6	9·1	0·3	26·8	7·2	0·3
	June, 1945—Dec., 1945	2238	94·1	5·7	0·2	17·7	7·7	0·2

nutrition, are given in Table 6. The apparent improvement after 1943 may have been due in part to the places selected for investigation. Most of the areas for the first survey were chosen because they had been depressed economically before the war. The places for subsequent surveys were not chosen for economic reasons, although some had been depressed.

J. Yudkin (1944, 5, 6) using as objective indices of the state of nutrition, the height and weight, haemoglobin level and dynamometer grip, found that children in Aberdeen, Dundee and Glasgow were below the standard of children in Cambridge and London. He considered that Sydenstricker's report on children in these cities was unduly favourable. Also, Pierce (1944) classified children in Oxfordshire towns and villages, in Walthamstow, and in Birmingham, seen in May–July, 1943, into two classes on clinical grounds: (*a*) healthy, those who were robust and of normal weight and those who were thin, but otherwise well; (*b*) those who were thin, tired or asthenic, and those showing obvious signs of ill-health. The percentage in class (*a*) ranged from 43·5 in Birmingham to 71·35 in Oxfordshire towns.

Wilson (1941, 1942) distinguished a higher category, "excellent"; the sum of the percentage in categories "excellent" and "good" was roughly equal to the percentage in the "good" category of the Ministry of Health survey. It seems that the standard used in the Ministry of Health survey was relatively low, but that fact does not vitiate comparison between the results, found at different times, of surveys in the same series. The children which Wilson examined were aged 6 to 7 and 10 to 11 years, at a school in Oxford and in the country round, in December, 1939, February, 1941, and June, 1942. Between 1941 and 1942, the younger children in the rural schools improved; the older children and the children of both age groups in Oxford city did not change appreciably. No cases of phrynoderma, xerophthalmia, congested gums or bad nutrition were found.

Wilson (1945) examined also: (1) three hundred and seventy-four women, working in three types of factories, (*a*) large and well equipped, (*b*) where little female labour had been employed before the war, with canteen arrangements generally unsatisfactory, (*c*) small factories, in which the workers had previously been men only and conditions were unfavourable; (2) two hundred and eighty-nine housewives of comparable status and income. These women were examined five times between August, 1942, and March, 1944. They were classed into four categories: excellent, good, slightly subnormal, and bad. The changes in weight have been mentioned already. There was evidence of deterioration during about 18 months, which was worst among the factory workers classed as excellent. About one-third of those classed as slightly subnormal improved. The deterioration was associated with complaints of fatigue and took place in spite of improvement of working conditions, including provision of canteen facilities in factories, and increased earnings among housewives.

Morbidity Survey

Although the general death rate and tuberculosis death rate in England and Wales have fallen, it is often said that minor ailments have increased. Since 1944 the Ministry of Health has attempted to estimate the incidence of illnesses that are not notified. Random samples of over 2000 persons are questioned periodically about the number of illnesses experienced

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in the preceding three months. The results are published in the *Monthly Bulletin of the Ministry of Health*. No definite trend has been discovered, though the proportion having mild or moderate illnesses in the winter 1944–45 was little over one-third of that in 1943–44 (Ministry of Health, 1944, 1945, 1, 2, 3, 4, 5).

Ascorbic Acid

The variation in the results of tests of ascorbic acid nutrition with season is obvious in several investigations, particularly those of Francis and Wormall (1942, 1944), Durham *et al.* (1946) and Prunty and Vass (1944). This variation must be borne in mind when the results of tests made in different years or at different places are compared. There is evidence of a change for the worse between 1938 and 1941 (Harris, 1940, 1943) and between 1940 and 1941 (Francis and Wormall, 1942), but not of any definite change since then.

It has frequently been found that the concentration of ascorbic acid in the plasma of pregnant women falls as pregnancy advances. Craig, Lewis and Woodman (1944) did not find an appreciable difference between the average amounts of ascorbic acid excreted, after a test dose, by pregnant and non-pregnant women, or between the amounts excreted in the first 28 weeks and after the 29th week. Young, King, Wood and Wootton (1946) and Hoch and Marrack (unpublished) found little change in the concentration of ascorbic acid in the plasma of pregnant women with the advance of pregnancy. Only about one in four of the subjects studied by Hoch and Marrack were taking the supplements of fruit juice available.

In some experiments, in which supplements of ascorbic acid and other vitamins were given, reduction of the incidence or severity of gingivitis was detected. In view of the careful work of Linghorne, McIntosh, Tice, Tisdall, McCreary, Greaves and Johnstone (1946) it seems reasonable to suppose that a certain number of the subjects were not getting the optimum amount of ascorbic acid. No special incidence of signs of ascorbic acid deficiency was found among schoolchildren in Stoke-on-Trent and Salford (Bransby, Burn, Magee and MacKecknie, 1946), whose diets supplied less than the average amounts found at the time, well under 20 mg. daily.

There is, therefore, no evidence of any general deterioration of health owing to reduction of the supply of ascorbic acid, but there was some increase in the number of cases of scurvy in 1941. The number of cases admitted to the Hospital for Sick Children, Great Ormond Street, London, rose from 2 or 3 per year in 1938–40 to 8 in the first 10 months of 1941 (Paterson and Daynes, 1941). The number admitted to hospitals in Glasgow and Edinburgh increased considerably in 1941 and then fell to the previous level. According to the War-time Food Survey, the average consumption of ascorbic acid in these cities was much lower than in most towns in Britain (Macmillan and Inglis, 1944). In Glasgow Royal Hospital for Sick Children a second peak of scurvy occurred in 1943 (Wallace and Adler-Tanz, 1944).

Vitamin A

Vitamin A and Carotene in Plasma. Few results of surveys have been published. The large number of low values found by Cook *et al.*

(1944, 1) and McIntosh *et al.* (1946) among apprentices, taking an adequate diet and by the Oxford Nutrition Survey (Adcock and Fitzgerald, 1945) is remarkable. Hoch and Marrack (unpublished) found in January–February, 1944 that 19 nursing sisters all had over 100 I.U. vitamin A and over 50 I.U. total carotenoids in their plasma; out of 105 estimations of vitamin A and total carotenoids in the plasma of pregnant women attending the ante-natal clinic of the London Hospital, the vitamin A content was below 70 I.U. per 100 ml. in 6 only, although only one-quarter of the women was taking supplements of vitamin A; the value for carotenoids was below 50 μg. per 100 ml. in 13 only.

In an investigation of the capacity for dark adaptation of 1500 subjects, Robertson and Yudkin (1944, 1, 2) found that in groups of factory workers in Birmingham and Sheffield it was inferior to that of groups of nurses and of male and female students; also the adaptation of children in a country school was inferior to that of children in schools in Cambridge. The adaptation of factory workers who took 5000 I.U. vitamin A daily was improved after 5 months, while that of the country schoolchildren was not affected by treatment with vitamin A. S. Yudkin (1945) found no signs of deficiency of vitamin A in the R.A.F. whose diet supplied approximately 1000 I.U. preformed vitamin A and 3300 μg. β-carotene.

The incidence of "folliculosis" or other conditions of the skin, associated with deficiency of vitamin A, was reported by the teams of the Ministry of Health (Table 6) and by those conducting other surveys as follows. No case of phrynoderma or xerophthalmia was found among schoolchildren in Oxfordshire in 1939, 1941 and 1942 (Wilson, 1942), but a high incidence of folliculosis among a group of apprentices (Cook *et el.*, 1944, 2; McIntosh *et al.*, 1946). Follicular keratosis was seen in 11 to 15 per cent. of schoolchildren in Oxfordshire, London and Birmingham and in 33 per cent. of village schoolgirls, and xerosis in 11 to 21 per cent. of children (Pierce, 1944).

Owing to differences of standards it is doubtful if any conclusion can be drawn from comparison of the results with those of Pemberton's (1940) survey made in 1938.

Rickets

The main conclusion that can be drawn from the report of the survey conducted from mid-January to the end of February, 1943, by the British Paediatric Association (1944) is that severe untreated rickets is rare. A condition, diagnosed clinically as rickets, is, however, common in northern England, Scotland and Ireland. A high incidence of clinical rickets has been reported by Corner (1944) in Bristol (62 per cent.), by Graham (1944) in Glasgow (28·3 per cent. of children in hospital), and by Krestin (1944) in Preston (36·5 per cent.). Differences in the incidence reported may be due in part to differences in standards adopted by observers, but the same observer found no obvious rickets in Cambridge, and manifest evidence of present or past rickets in 34 out of 216 children in Glasgow (J. Yudkin, 1944, 5, 6).

According to the radiologists in the survey of the British Paediatric Association, only 1·7 per cent. of the children in the whole survey had evidence of rickets; the incidence was considerably higher in northern England, Aberdeen and Glasgow but not in Edinburgh, and Ireland. As individual examiners differ widely in their estimates of the incidence of

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rickets it is doubtful if any conclusion should be drawn from comparison of the results of the survey with the results obtained by Corner (1944) in Bristol in 1938–41 and by Chisholm (1933) in Manchester in 1928–30. Wilson (1941) considered that the diminution in the signs of rickets during two years among children, first examined by her in 1939, was more than could be accounted for by advancing age.

In the 1943 survey, rickets was less common among children who had been breast fed. However, neither Corner (1944) nor Krestin (1944) found a striking difference in incidence of clinical rickets between breast fed and artificially fed babies. Of 106 children who were considered to have rickets on radiological grounds, 77 had taken some preparation of vitamin D, while 725 children who had never taken any preparation of vitamin D other than milk and other foodstuffs did not show rickets radiographically. Unfortunately, the nature and amounts of the preparations of vitamin D taken by the babies who got rickets are not discussed in the report.

MacLennan (1936) drew attention to the high incidence of contracted pelvis of rachitic origin among women in industrial areas of Scotland, where the standard of living is low, and later reported (MacLennan, 1944) the risks to mother and baby from this type of contraction even when not severe.

Riboflavin

The incidence of corneal vascularization, of a type that might be considered evidence of riboflavin deficiency, was high among senior schoolchildren in Cambridge and among industrial workers and students in Sheffield; the industrial workers had glossitis as well. The incidence of angular stomatitis and rhagades found by Pierce (1944) was high. The only investigations that have been repeated among the same subjects are those of Wilson (1941, 1942); they show no evidence of an increase.

Lyle *et al.* (1944) found no signs of riboflavin deficiency among personnel of the R.A.F. in Britain, whose diet supplied on the average 2 mg. of riboflavin daily for men and 1·8 mg. for women (Macrae *et al.*, 1944).

Haemoglobin

In the survey of 1943, organized by the Committee on Haemoglobin Surveys (1945), 4561 men, 6787 non-pregnant women, 690 pregnant women, 2187 children, and 680 adolescents were examined by the standard Haldane method. The results of several other surveys made during the war are comparable, since the apparatus used for them was able to be standardized or the results were expressed in absolute terms. Most of the results obtained before the war are, however, expressed in terms of an arbitrary standard "normal", the value of which is unknown; in a few cases it has been possible to trace and evaluate these standards. Almost all the investigations, in which satisfactory methods were used and which were made before the war, were made on the poorer classes and unemployed persons, or on selected groups such as students, laboratory workers, doctors and nurses.

On the whole, the results obtained during the war compare favourably with those found elsewhere. For example, in the 1943 survey, the average among adult men was close to the average found by Nelson and Stoker

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(1937) in Kansas City and its neighbourhood. The average for adult non-pregnant women was close to the average found among selected groups of women in the U.S.A. The levels found in selected groups are as high as any found before the war, with the exception of the remarkably high figures found among women by Jenkins and Don (1933). The averages found among pregnant women in 1943 and later were high.

Progress During the War. During 1941 and 1942 low levels were found by Wills *et al.* (1942) among children, students and nurses, and by Davidson, Donaldson, Dyar, Lindsay and McSorley (1942) among children and pregnant women in Edinburgh. Particularly low levels were found in 1941 by Hamilton and Wright (1942) among women attending ante-natal clinics in south-east London; of these, many were not improved by treatment with iron.

Davidson, Donaldson, Lindsay and Roscoe (1944) observed an improvement in the schools and ante-natal clinics in Edinburgh between 1941 and 1944. The change in Edinburgh during this period is reported also by Roscoe and Donaldson (1946). J. Yudkin (1944, 4) found that the levels among men and women employed in factories in Birmingham were higher in July, 1942, than in September, 1941. There is, therefore, some evidence of deterioration during 1941, when food supplies were at their worst, with a subsequent improvement. Low levels were still found in 1944 by Cook *et al.* (1944, 1) among apprentices in Dundee, and the serum protein values also were low; these boys ate good dinners at their canteen but their total intake of calories during the day was surprisingly low (Cook *et al.* 1944, 2). Fullerton, Mair and Unsworth (1944) found low levels among nurses and adolescent girls and boys. It is possible that these adolescents suffered from the adverse effects of 1941 and, unlike the schoolchildren, had not recovered in the following year because they did not get school meals and milk.

Dental Caries

Mellanby and Coumoulos (1944) reported that a far larger percentage of 5-year-old children in London were free from dental caries by 1943 than in 1929 in the same area. In 1939 King had found that the percentage of children under 6 years old, free from caries in south-east London, was little higher than Mellanby had found in 1929. If the two areas of London can be compared, the improvement must have taken place during the war.

Mellanby and Coumoulos (1946) have reported further improvement in 1945. Oliver (1946) also noted a decline since 1939 in the proportion of children requiring treatment and in the size of cavities found. Mellanby and Coumoulos (1944) suggested that the improvement was due to the National Milk Scheme, the compulsory inclusion of vitamins A and D in margarine and of calcium carbonate in flour. Except for the addition of vitamins to margarine, none of these changes would have had time to affect the teeth of 5-year-old children in 1943.

Effects of Experimental Changes of Diet

Table 7 gives a summary of experiments on the effects of supplements of various nutrients. On the whole there is no evidence that the nutrients had any effect. When we take into account the long period that may

TABLE 7

EFFECTS OF EXPERIMENTAL CHANGES OF DIET

Author	Subjects	Supplements, daily	Duration	Difference between experimental subjects and controls
1. Asher (1944)	300 children, south London, October, 1940—May, 1941	4000 I.U. vitamin A 300 I.U. vitamin D 20 mg. ascorbic acid 200 I.U. vitamin B_1 360 mg. Ca 12 mg. Fe	3 months	No difference in weight
2. Glazebrook and Thomson (1942)	1500 students	50 to 100 mg. ascorbic acid	6 months	No difference in incidence of colds and tonsillitis. Reduced duration of tonsillitis and incidence of pneumonia and acute rheumatism
3. Kohn *et al.* (1943)	400 children in Glossop, half as controls	4000 I.U. vitamin A 600 I.U. vitamin D 50 mg. ascorbic acid 1 mg. vitamin B_1	9 months	Increased strength and endurance, otherwise nil
4. Bransby, Hunter, Magee, Milligan and Rodgers (1944)	1040 children, half as controls	4000 I.U. vitamin A 600 I.U. vitamin D 50 mg. ascorbic acid 1 mg. vitamin B_1 2 mg. riboflavin 20 mg. nicotinic acid	9 months	No difference in height, weight, condition of teeth, frequency of illness
	214 men	,, ,,	,,	No difference in haemoglobin, weight, blood pressure, output of work, absence from work
5. Bransby *et al.* (1946)	1620 schoolchildren, half as controls	As above except nicotinic acid amide in place of nicotinic acid	1 year	Slightly less gingivitis; no difference in caries. No difference in growth, strength, endurance, incidence of disease, hearing, absence from school
6. Jenkins and Yudkin (1943)	178 children, half as controls	5000 I.U. vitamin A 500 I.U. vitamin D 25 mg. ascorbic acid 1 mg. vitamin B_1	1 year	No difference in breath holding, vital capacity, pulse rate, endurance
7. Yudkin, J. (1944, 2)	1100 children, half as controls	5000 I.U. vitamin A 500 I.U. vitamin D 25 mg. ascorbic acid 1 mg. vitamin B_1	1 year	No difference in haemoglobin, pulse-rate, vital capacity, breath holding, strength and endurance, intelligence. Lower incidence and duration of colds. No change in dark adaptation
8. Fowke (1943)	214 girls 8 to 12 years old, 114 of these as controls	2000 I.U. vitamin A 100 I.U. vitamin D 35 mg. ascorbic acid 250 I.U. vitamin B_1 250 mg. Ca 10 mg. Fe	14 months	No difference in haemoglobin, height, weight, or incidence of illnesses
9. Harper, Mackay, Raper and Camm (1943)	69 cadets, 34 of these as controls	6000 I.U. vitamin A 1000 I.U. vitamin D 50 mg. ascorbic acid	21 weeks	Improved vital capacity, breath holding, endurance, resting heart rate. Fewer minor respiratory diseases and gastro-intestinal disturbances
10. Payne (1943)	40 children, half as controls	50 mg. ascorbic acid	4 months	No difference in behaviour, frequency or severity of illnesses

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elapse before a difference between full adequacy and complete absence of a nutrient begins to show its effects, as in the Sheffield experiment with vitamin A, we may question whether we should expect the effects of a difference between full adequacy and a possible 50 to 75 per cent. adequacy to appear within a year. Human beings are not satisfactory animals for experiments.

Pregnancy

The results of two large-scale experiments have been reported during the war. In the National Birthday Trust Experiment (Balfour, 1944) the supplements were, per fortnight:

Ostermilk, 1 lb.
Ovaltine, $\frac{1}{2}$ lb.
Marmite (or a yeast extract), 4 oz., or, alternatively,
Minadex, 8 oz.

The stillbirth and neonatal mortality rates were less in the Marmite or yeast-extract group than in the control group. The number receiving Minadex was smaller, but no significant differences between the mortality rates of this and the control group were found. The Ostermilk and Ovaltine may well have been the most valuable of the supplements, but the women did not necessarily get the full benefit of them, for, as found by McCance, Widdowson and Verdon-Roe (1938), women may take only a small fraction of such supplements, the rest going to the family.

In the experiment of the People's League of Health (1942, 1946) the daily supplements were:

Halibut liver oil, containing 1900 I.U. vitamin A and 900 I.U. vitamin D;
Vitamin B complex, containing 200 I.U. vitamin B_1;
Ascorbic acid, 100 mg.;
Calcium lactate, 0·26 g. Ca.;
Saccharated ferrous carbonate, 0·26 g. Fe.

The incidence of premature birth and of toxaemia of pregnancy was less in the group receiving supplements.

Dental Caries

Whyte (1943, 1, 2, 3) gave boys aged 6 to 16 years 2 oz. daily of a macaroon bar or fudge, which contained about 23 g. of sugar with a rather larger quantity of starch, for periods of 62 days with intervals of 62 days without sweets. The rate of increase of caries was definitely higher during the periods when the sweets were eaten than during the intervals. In another experiment (King, 1946) children of average ages 36 and 50 months, in two institutions, were allowed one or two boiled sweets, weighing 6·4 g., or a chocolate biscuit containing about 3 g. of sugar, in addition to their sweet ration and the sugar of their ordinary diet. The biscuits or sweets were eaten at night, after the mouth and teeth had been cleaned. No difference was found after 24 months between the subjects of the experiment and untreated controls.

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Research Work in Animal Nutrition in Great Britain during 1939–46

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Never in the history of mankind has so much thought been given to the planning of agricultural policy to meet human requirement as during these war years. Our planning was integrated with that of the other members of the British Commonwealth of Nations and with the policies of our Allies. The measure of interdependence achieved then is undergoing readjustment to peace-time conditions, but it is obvious that the need for concerted effort is even more necessary today than during the war. The university departments and research institutes concerned with the nutrition of animals contributed to the war effort in diverse ways. Many scientists volunteered for active service, some administered our food policy, others were retained to investigate potential food materials, self-sufficiency and methods of storing and conserving food. In the following brief survey time does not permit reference to all aspects of British work. Certain major aspects have been selected for review.

Planes of Nutrition

Realization of food shortage led to an investigation of the effect of a subnormal plane of nutrition on the development of the various tissues and functions and of the stage of development at which the ill effects of such undernutrition could still in some measure be overcome.

Following on his own earlier work and that of Fraser (1939), Hammond and his colleagues at the Animal Nutrition Institute, Cambridge (Vergés, 1939; McMeekan, 1940, 1941; McMeekan and Hammond, 1940; Pomeroy, 1941; Wallace, 1944) have investigated the effect of variation in the plane of nutrition on the rate of development of the major tissues of the growing sheep and pig. They have also investigated the effect of such good and poor planes on the course of pregnancy in the ewe and on the birth weight of newborn lambs. At the National Institute for Research in Dairying at Reading, experiments are in progress to determine the effect of the plane of nutrition on the milk yield of the dairy cow with particular reference to its constituents.

Lowering of the plane of nutrition has little effect on the ewe in early pregnancy, but it has a marked effect during the last few weeks. The benefit derived from feeding at a high level during the later weeks is not far short of that derived from feeding at a high level throughout. The lambs, particularly the twins of ewes maintained on poor diets throughout pregnancy, are definitely below weight and more weakly than lambs born of mothers who have been on a plane of nutrition during the last four to six weeks of pregnancy such as to permit them to gain 9 kg. over their weight at mating. The udder of the dam and, in consequence, milk secretion are directly affected by the plane of nutrition during the last weeks of pregnancy. The distribution or partition of nutrients in the maternal blood-stream between foetal and maternal tissues is determined by the metabolic rate of the tissue concerned (Hammond, 1944).

Observations made by Pomeroy (1941) indicate that on a sub-maintenance diet fat development is particularly affected, muscle less so, and the skeleton shows the least effect. This differentiation is due to the rate of development of these major tissues, as fat is a late development and muscle occupies an intermediate position between fat and the skeleton (see also Hammond, 1942, 1944). Thus, a rapid early development and slow later development intensifies the proportion of skeletal framework and muscle in the carcass and inhibits the development of fat. This mode of feeding brings out the characteristics of the bacon type of pig, whereas the characteristics of the lard type are obtained by a slow early growth followed by rapid later growth on a high nutritive plane.

Some very interesting observations have been made on the factors which affect the composition of meat and fat (Hammond, 1940; McMeekan, 1940; Palsson, 1939, 1940; Hilditch and Pedelty, 1940, 1941; Hilditch and Zaky, 1941; Callow, 1944, 1945). Bodily conformation is affected by diet and by age, for the relative proportions of the organism are affected by both. With age the proportion of muscle increases and so the joints become more "blocky" and as such are more acceptable; having a smaller surface in proportion to weight compared to the joints of a younger animal, they dry out less on storage. Similarly, the *longissimus dorsi* of the loin chop thickens as the animal grows, as does also the high-priced loin (roasting joint). The early-maturing organs, such as the brain and eyes, continue to grow, whereas the heart, liver and lungs are affected to some extent, probably by a lowering of the plane of metabolism on the poor diet. Tenderness is affected chiefly by the size of the muscle bundles. The smaller these are, the more tender the meat. It is believed that this is a more important factor than the connective tissue. The flavour and colour of meat are closely related and depend on the amount of myoglobin. With age there occurs a concentration in colour (carotene); grass-fed beef has usually fat of a deeper yellow colour than stall-fed beef from roots.

By rearing animals on a high plane of nutrition and picking out, and breeding from, those which develop best in the late maturing parts, the livestock breeder has been able to develop improved breeds of pig, such as the Middle White.

Fat consistency, usually judged by the iodine number, normally varies from species to species. It is of chief importance in bacon pigs, and especially in hams for, owing to their long storage, there is danger of rancidity developing when the proportion of lower melting-point fats is high. The plane of nutrition, its qualitative nature, *e.g.*, amount of carbohydrate, and the rate of growth, affect fat firmness, for on a low plane of nutrition a higher proportion of body fat is formed from food fat; as the pig grows up it puts on fat more quickly, and under these circumstances the fat also becomes more saturated. The iodine number of the true back-fat falls from 71·5 at 4 weeks to 57·7 at 28 weeks old. Temperature also determines the nature of fat.

Iodinated Protein

The preceding paragraphs have been concerned with food intake as affecting the plane of nutrition. Other methods have been investigated for altering the metabolic plane. Earlier work in Canada and again in this country under Kay, the present Director of the National Institute for Research in Dairying, had shown that the feeding of dried thyroid gland or the injection of thyroxine caused an increase in milk secretion in dairy cows. Following an observation by Ludwig and von Mutzenbecher (1939) that casein, iodinated under specific conditions, yields thyroxine on alkaline hydrolysis, Young and Folley in this country suggested to the Agricultural Research Council that the administration by mouth of iodinated protein to increase the milk production of cows should be investigated. The full history of the development of this project has recently been published (Barcroft, 1945, 1), together with a series of papers by Blaxter (1945, 1, 2, 1946), Deansley, Emmett and Parkes (1945), Deansley and Parkes (1945, 1, 2), Pitt Rivers and Randall (1945), Robertson (1945) and Rowlands (1945). Iodinated ox plasma was first used, but the field results were not satisfactory and work was started on the iodination of groundnut protein, largely the globulin, arachin. In 1942 it appeared that casein would be available in bulk. Most of the metabolic and field experiments have been made with iodinated casein (Blaxter, 1946). The milk yield of cows can be substantially increased by feeding iodinated casein during the middle and later stages of lactation, and the optimal dose appears to be one which increases milk production by approximately 20 per cent., and if additional food is given to the cow the loss of weight due to hyperthyroidism is not apparent. In the course of the first small-scale intensive study several deleterious symptoms, chiefly of hyperthyroidism, were noted. To find whether iodinated casein treatment of cows in mid-lactation during the late winter months would be of practical value in increasing milk yields, a trial was carried out on 1008 dairy cows of all breeds. Before mixing the iodinated casein with the cake the former was tested for biological activity by observing the rate of metamorphosis in *Xenopus* tadpoles. The daily dose of 20 g. was contained in 1·8 kg. of cubes and was fed for six weeks. The mean increase in daily yield was 2·45 kg. or approximately 22·2 per cent. The cube without the iodinated protein might have increased the yield by about 0·5 kg. per day or less. The stimulation of milk production with lighter breeds suggests that the dosage might be reduced in the case of Ayrshire, Jersey and Guernsey cattle. First calvers did not increase in yield as markedly as mature cows. In early lactation the response is small, and at the end it is impossible to elicit a response. In mid-lactation the response increases as lactation declines. When treatment stops the yields remain elevated for several days and then drop severely, suggesting that iodinated casein treatment increases the senescence of the udder cells or, alternatively, that the thyroid is inhibited. Whether the depression is still present when more than a month has elapsed is as yet unknown. However, even if depression of lactation continued for 30 weeks the net effect would be an increase in milk production.

The average increase in heart rate of the treated animals was 10·2 beats per min., being smaller in first calvers than in mature cows. Gross overfeeding by giving three times the stated dosage resulted in severe hyperthyroidism. No adverse effect was noted in adult persons drinking considerable quantities of milk from treated cows.

Work at the Hannah Dairy Research Institute has shown that stimulation of milk production by means of thyroxine results in very marked negative nitrogen and calcium balance. When treatment is stopped the nitrogen balance rapidly becomes positive; that of calcium is more slowly adjusted.

Observations made at the National Institute of Research in Dairying, Reading, indicate that the administration of 1 g. of iodinated casein or more per day to pigs adversely affects their growth.

Protein Requirements and Metabolism

Woodman and Evans (1940, 1941, 1945, 2) have found that a diet made up of cereals and weatings, with a little fresh or artificially dried green food, and supplying 7 per cent. of white fishmeal or its equivalent of other protein food, from weaning until the pigs reach 41 kg. live weight, can provide all the protein that is necessary for quick growth and satisfactory carcass quality.

Halnan (1942) has investigated the use of day-old chicks as experimental animals for assessing the biological values of proteins by the slaughter method, that is, by comparing the nitrogen gains in the empty live-weight carcass with the digestible nitrogen consumed over a period of five weeks.

In the early days of feeding standards the nutritive requirements of an animal for any given purpose were stated in terms of digestible nutrients and standard nutritive ratios, *i.e.*, the proportion of digestible protein to digestible nutrients present in the ration was considered to determine the nutritive effect of the ration. Kellner accepted the view that the starch equivalent or fat-producing power of a feeding-stuff remained the same, even though the digestible protein content of the ration varied within fairly wide limits. Armsby (1922), by postulating his net-energy concept, supported this view. Halnan (1942) pointed out that the work of subsequent experimenters has thrown doubt on the soundness of this theory and that many workers have abandoned it and returned to the older conception of expressing feeding standards in terms of digestible nutrients and digestible protein. In this connexion it is of interest to consider a recent wide survey by Yates, Boyd and Pettit (1942) of all the available experimental material relating to the influence upon milk production of changes in the level of feeding and in the proportion of bulky foods. These workers have determined that increases in level of feeding to rates well in excess of conventional English standards, are capable of giving substantial increases in milk production, the physiological efficiency falling off as the food intake increases. Owing to the high overhead and maintenance requirements of the cow a fairly high level of feeding of about 1·45 kg. starch equivalent per 5 l. milk gave most efficiency at 1941–42 prices. There is no economic inducement to feed at excessive rates, and the chief danger in war time appears to be under-feeding, due either to too stringent rationing or to an attempt to keep too many animals in times of general food shortage. Provided total energy intake is maintained, substitution of part of a concentrate ration by bulky foods such as roots or hay, on an equal starch equivalent basis, does not influence milk yield. It is of interest that the results of these experiments show that, provided protein requirements are satisfied, the starch equivalent system gives a better assessment of the relative energy value of different foods than the food unit or total digestible nutrients system. The higher value set for true protein in the food unit system as compared with the starch equivalent system was introduced for dairy-cow rationing in the belief that protein provided more energy value in milk production than in the production of fat. This is apparently unfounded. The total digestible nutrients system operates in the opposite direction by over-valuing coarse fodders.

It has been found at the National Institute for Research in Dairying that the requirement for dairy cows is about 17 to 18 per cent. protein in the production ration.

A study of the efficiency with which farm animals convert feeding-stuffs to food for man has recently been made by Leitch and Godden (1941), the calculations being based on the standard Ministry of Agriculture rations for dairy cows and commonly used rations for other classes of stock.

Composition, Digestibility and Nutritive Value of War-time Feeding-stuffs

The composition, digestibility and nutritive value for pigs of various war-time feeding-stuffs have been determined in the Animal Nutrition Institute, Cambridge; among these substances are swill (Woodman and Evans, 1942, 1944, 1), potato cossettes, flakes and slices (Woodman and Evans, 1943, 1), potato peelings (Woodman and Evans, 1943, 2), grass cuttings and feeding on grass (Woodman and Evans, 1943, 3; Wallace, 1943), cooked potatoes and molassed beet pulp (Woodman and Evans, 1943, 4), palm-kernel meal (Woodman and Evans, 1945, 1), fodder cellulose from wheat straw, and artificially dried grass (Woodman and Evans, papers in course of publication).

Work has been done on the effect of milling control on wheaten offals (Woodman and Evans, 1944, 2), pea-canning by-products (Woodman and Evans, 1944, 3), horse-chestnuts (Woodman and Evans, 1946), and dried penicillin felts (Woodman and Evans, paper in course of publication).

At the National Institute for Research in Dairying the effect of the addition of yeast to the practical ration of the pig has been studied and the interesting observation made that lower reserves of vitamin A are present in the liver of animals treated with yeast, a finding which may be related to the earlier observation made in this Institute that yeast had a rachitogenic action on pigs when given to the extent of 8 to 20 per cent. of the dry matter of the diet (Braude, Kon and White, 1943, 1944).

At that Institute also studies have been made on (*a*) pulped mangold and biscuit waste, cooked potato flakes, acorns, horse-chestnuts, food waste, clostridium waste, and cocoa meal, in the diet of fattening pigs; (*b*) on the nutritive value of dried yeast, soda-treated straw and R.G. silage.

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The Nutrition of the Fowl, with Particular Reference to the Protein and Energy Requirements for Growth and Egg Production

Observations have been made on the value of whale meat as a constituent of chick diets and the influence of added proteins on the efficiency of utilization of the gross energy of a ration (Halnan, 1942). The relative efficiency of the fowl as a converter of feeding-stuffs into human food as compared with other species has been estimated (Halnan, 1944, 1).

The Digestibility and Metabolizable Energy of War-time Poultry Feeding-stuffs

Work has been done on the use of sunflower seeds (Halnan, 1943), the effect of war-time changes in milling practice on the composition and nutritive properties of fine and coarse wheat (Halnan, 1944, 2), and the metabolizable energy of raw and cooked potatoes and dried potato slices (Halnan, 1944, 3). It has been found that the digestive powers of the chick are as effective as those of the adult, and that urea is ineffective as a protein substitute for the fowl (Halnan, papers in course of publication).

Farm Self-sufficiency

This is being studied intensively on the dairy farm of the Hannah Dairy Research Institute, Ayr. The investigations have continued now for six years and the earlier results have been published (Wright, Fowler and Thom, 1943). A further paper on the subject is now being prepared. So far the results have been most promising. This Institute has succeeded in producing more than sufficient feeding-stuffs for its needs and has not had to purchase any imported feeding-stuffs. At the same time its milk production per animal has exceeded the average for farms in Ayrshire and there does not appear to have been any deterioration in the health of the herd or in the fertility of the land. The chief means adopted in achieving self-sufficiency have been the improved management and fertilizer treatment of grassland, the use of modern methods of grass conservation such as artificial drying, and the growing of increased acreages of arable crops. Special attention has been paid to the cultivation of feeding-stuffs rich in protein, such as beans, as a means of increasing the amount of available protein produced on the farm. With the object of attaining a maximum yield of beans, the effect of borax dressing on the growth and yield of this crop has been investigated (Owen, Snow and Thom, 1945). It was found that the basic manures used in this experiment contained sufficient boron for the requirements of the crop and that the added boron caused yellowing of the seedlings and tended to reduce the yield. It was, therefore, considered inadvisable to add boron to bean manures since there is a risk of toxicity to the developing plants.

Experiments have also been carried out to investigate methods of conserving grass, green cereal crops and legumes, and to determine by plot experiments how the yields of material rich in protein can be increased by improvements in management, by various nitrogenous treatments and by cutting at different stages of growth. Since results with such crops as those under investigation are liable to vary widely with climate, the investigations have been planned to extend over several years so that

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information on the effect of seasonal variations may be obtained. The results of this work have not yet been published.

Experiments on the development of marginal land have been proceeding for several years at the Rowett Research Institute.

Deficiencies and Excesses of Minerals in Relation to Animal Health

Cobalt

Workers in Australia and in New Zealand before the war had shown that crude iron salts helped to cure or prevent a disease of sheep and cattle characterized by rapid deterioration in health. Later work in these two countries showed that the cure was effected not by the iron itself but by traces of rare elements in the crude salts used in the course of treatment of the progressive debility and anaemia.

In Scotland, where the disease occurs in many parts of the country and has been recognized since 1831, it is known as "pine" or "pining", "vinquish", and "daising", and young cattle are also affected. Pining has also been reported from several areas in England and Wales. Pining in sheep may, however, be due to several causes, of which cobalt deficiency in the herbage is one of the chief. Parasitic infestation is undoubtedly also of importance. Sometimes there is a combination of these two factors. In Tiree, an island off the west coast of Scotland, the conditions under which pining occurs in cattle closely resemble those of "coasty" country in Australia, and the disease may prove to be caused by a dual deficiency of cobalt and copper. The role which cobalt plays in the nutrition of ruminants is not yet known but it is certainly essential. There is frequently anaemia in the pining animal but its degree does not parallel the severity of the illness. In the pining animals there is a reduction in blood volume and the first sign of improvement may actually be a fall in haemoglobin level. Workers at the Macaulay Institute for Soil Research and at the Animal Diseases Research Association's Institute at Moredun (Mitchell, Scott, Stewart and Stewart, 1941; Stewart, Mitchell and Stewart, 1941, 1942) have confirmed the earlier observations that pining in stock can be prevented by the addition of cobalt to the soil. This treatment increases the cobalt content to a value above which pining due to cobalt deficiency does not occur. Spectrographic analysis of the herbage grown on soil which has undergone cobalt treatment has shown in some instances a marked increase in the molybdenum uptake, the content approaching that of the "teart" herbages reported by Ferguson, Lewis and Watson (1940, 1943). Even 2 lb. cobalt chloride per acre in one area of Easter Ross caused a considerable increase in the molybdenum content of the herbage to a content at which "teart" is liable to occur. In another area treatment at even 10 lb. per acre did not increase the uptake of molybdenum to a dangerous extent.

The range of cobalt content of most soils so far examined is from 1 to 300 p.p.m. with a mode of 10 p.p.m.; most of the "pining" soils have less than 5 p.p.m. cobalt. Oral treatment prevents or cures the condition. Recently, cobalt has been given at levels of 100 mg. over a period of 10 weeks. In one experiment on lambs in Easter Ross a 22 per cent. difference in weight was found between treated and control animals. Caution must, however, be exercised in the general use of fertilizers rich in cobalt since it has been shown that the uptake of molybdenum increases with decreasing soil acidity.

The Ministry of Agriculture and Fisheries' Veterinary Laboratory, Weybridge, has been investigating "Bodmin Moor Sickness", a mixed disorder in which tick bite and cobalt deficiency are implicated.

No influence of iron or manganese has been experimentally detected in grazing animals in England.

Copper

It has long been known that in mammals copper is necessary for the utilization of iron in the formation of haemoglobin.

"Swayback" or "swingback", a disease of lambs similar to enzootic ataxia of Australia, is widespread in Britain. It is a nervous disorder accompanied by changes in the central nervous system, leading, amongst other things, to a spastic paralysis. The lesions arise while the lamb is still *in utero*. Following on the observations of Dunlop and Wells (1938) that by giving feeding licks containing 0·3 per cent. copper to ewes during gestation a reduction in the incidence of "swayback" in the progeny could be achieved, Innes and Shearer (1940) found that, in general, a lower level of haemoglobin existed in an area where "swayback" was enzootic, than among control ewes in a clear area. They found no correlation, however, between the anaemia of the ewes and the occurrence of "swayback" in the lambs. The blood copper of affected lambs was lower than that of lambs in non-affected areas. Low values were also obtained for the copper of the mothers' blood but low values were also found for the blood copper of ewes on "swayback" farms giving birth to normal lambs, and it appears, therefore, that the blood copper of the mother does not determine the development of "swayback" in the offspring. Eden (1941) obtained support for the last finding. Shearer, Innes and McDougall (1940) have shown that lambs and their mothers in affected areas in Derbyshire have liver copper contents lower than those found in healthy areas elsewhere, irrespective of whether the lambs are affected with "swayback" or not. The copper reserves in unaffected lambs, however, were somewhat higher than in affected lambs.

Analysis of the pastures reveals adequate amounts of copper. It may be that it is the availability of the copper which is affected. At the Ministry of Agriculture and Fisheries' Veterinary Laboratory, Weybridge, "swayback" has been produced experimentally by feeding susceptible ewes from a "swayback" farm with hay from that farm supplemented with concentrates low in copper. A ration equally low in copper, but derived from other sources, not only failed to produce the disease but permitted rapid elevation of blood copper in ewes from the "swayback" area.

Molybdenum

A diarrhoeic or scouring disease has been known to exist in Somerset for over 100 years. The affected land, extending to over 20,000 acres, is known locally as "teart" and the soil is related to the Lower Lias formation. Milk cows and young cattle are chiefly affected although sheep are also susceptible. Affected animals lose weight and develop harsh, staring coats, and their condition steadily deteriorates. Depigmentation of the hair occurs. The pioneer work of Ferguson *et al.* (1940) and Lewis (1943, 1, 2) demonstrated that the only peculiarity of this pasture was its high molybdenum content. They found "teart" herbage to contain 0·002 to 0·01 per cent. of molybdenum in the dry matter, compared with herbage of a nearby "non-teart" field, which usually contained less than 0·0005 per cent., and that "teartness" varied roughly with the molybdenum content. Clovers, in particular, took up a high content of molybdenum. "Teart" pasture can be produced artificially by top dressing with molybdates. Scouring rapidly occurs in beasts on such pastures. Ferguson *et al.* (1940) found that drenching or feeding cows with 2 g. of copper sulphate, and young stock with 1 g. of copper sulphate, per head daily cured or prevented scouring on very "teart" land.

Recent work at the Hannah Dairy Research Institute has shown that feeding copper at the rate of 5 g. $CuSO_4 \cdot 5H_2O$ per day for three weeks to a lactating cow caused a transient rise for about three days in the copper content of the milk. Ninety-nine per cent. of the total amount ingested was excreted in the faeces. It is thus unlikely that the ingestion of copper salts would have an adverse effect on the keeping quality of milk, particularly in respect of its vitamin C content.

Studies on the copper requirements of pigs reared indoors are still proceeding at the National Institute for Research in Dairying, at Shinfield, near Reading. No clue to the meaning of the craving which pigs undoubtedly have for this element has yet been obtained.

Magnesium

The studies of Duckworth (1939), Duckworth, Godden and Warnock (1940), Duckworth and Godden (1941), Duckworth and Warnock (1942), and Duckworth and Godden (1943) at the Rowett Research Institute, give support to the view that the hypomagnesaemic tetany of cattle and sheep is ultimately due to an endocrine disturbance. This view is shared by Green of the Ministry of Agriculture and Fisheries' Veterinary Laboratory. There is no evidence that this condition results from a deficiency of magnesium in the diet of affected animals. The foregoing workers have shown that in the skeleton there is a highly mobile reserve of magnesium, the outflow of which occurs rapidly in response to a dietary deficiency. Re-establishment of the reserve after depletion is slow and depends on the rate of mineral deposition, magnesium not being capable of entering the bone-salt crystal independently of calcium and phosphorus.

Hypomagnesaemia is a constant feature of grass tetany in cows and there is a tendency for low serum magnesium to be associated with low serum calcium.

Calcium

Bell, Cuthbertson and Orr (1941) have shown that with increasing percentage of calcium in the diet of growing rats the calcium retention, bending strength and twisting strength and also the thickness of the femur shell increase up to a level of 0·36 per cent. calcium in the dry diet; thereafter these values remain constant up to the limit investigated, namely, 1·4 per cent. Although the strength of the bone alters, the quality of the bone remains constant as recorded by the breaking stresses.

Kon at the National Institute for Research in Dairying is continuing his studies on changes in the requirement of calcium and phosphorus with age (Henry and Kon, 1945).

Studies on calcium and phosphorus have been proceeding at the Rowett Research Institute, Aberdeen, particularly in relation to phytic acid. The Macaulay Institute for Soil Research has been making wide surveys of both major and minor elements in the soil in relation to geological formation.

A comprehensive review on the subject of minerals in pastures has been written by Russell (1944).

Iodine

A survey of the iodine content of the drinking waters of many areas of Scotland, England and Wales, has been carried out at the Rowett Research Institute and investigations are proceeding to determine the effect of hard water on the availability of iodine.

Nutritional Role of the Micro-organisms of the Alimentary Canal

One of the most interesting developments in the physiology of nutrition is the study of the role of the microbial populations of the alimentary canal. Most work has been done on ruminants for the health of these animals is conditioned by the activity of these organisms.

Work along these lines, but from different angles, has been proceeding under Sir Joseph Barcroft at the Agricultural Research Council's Unit of Animal Physiology at Cambridge, and at the Hannah Dairy Research Institute, Ayr. Some studies by Baker, working under Professor F. G. Gregory, are also of considerable interest.

It is generally agreed that the digestion of carbohydrate in the rumen is brought about by the micro-organisms living there, and that the micro-flora plays a much larger part in these processes than the microfauna for, if the protozoa are removed by drenching the animal with a dilute solution of copper sulphate, the digestive processes continue relatively unhampered, though some measure of symbiosis is not ruled out.

The exact nature of the role of the micro-organisms has been studied by two main schools. One school stressed the nutritional importance of the volatile fatty acids found in the rumen which are the result of the activity of the micro-organisms (Phillipson, 1942; Phillipson and McAnally, 1942; Barcroft, McAnally and Phillipson, 1944, 1, 2). The second school pointed out the importance of the microbial substance as a source of carbohydrate, protein and the B group of vitamins (Baker, 1942, 2; see also Baker, 1942, 1). On the basis of direct microscopic observation of rumen contents Baker showed that the micro-organisms convert the starch and fibre of the diet into microbial starch. He believes, too, that these organisms, laden with starch, pass through the fore-stomachs into the small intestine, where the starch is hydrolysed to glucose by the pancreatic and intestinal amylases. It is, of course, equally possible that, during the time taken to pass from the rumen to the small intestine, the micro-organisms use up their store of polysaccharide by auto-fermentation, with the production of volatile fatty acids.

That the micro-organisms act as a source of protein has been shown by the maintenance of condition following the replacement of part of the

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protein of the diet by simple nitrogenous derivatives such as urea (Owen, Smith and Wright, 1943). The urea is used as a source of nitrogen by the micro-organisms, the protein of which has a high biological value and subsequently becomes available to the animal. Pearson and Smith (1943, 1, 2, 3) have shown that when rumen liquor from a steer with a permanent rumen fistula is incubated *in vitro* with urea and either glucose or maltose, there is a significant increase in the amount of protein present.

It is highly probable that the ruminant utilizes both the products of the activity of the micro-organisms, the volatile fatty acids, and the organisms themselves. It has so far proved impossible to estimate how much, if any, of the microbial protein and polysaccharide passes from the fore-stomachs to the small intestine *per diem* and how much of this is available to the animal. Until the problem of determining the quantity of digesta passing from the abomasum is solved, and the measurements made, it will be impossible to assess with any degree of precision the nutritional significance of the rumen micro-organisms to the animal.

Considerable quantities of volatile fatty acids are produced in the rumen of sheep after a meal (Phillipson, 1942; Phillipson and McAnally, 1942). Ingestion of diets rich in soluble carbohydrate results in a rapid production of volatile fatty acids, with lactic acid as a probable intermediary. Introduction of solutions of glucose, fructose or sucrose directly into the rumen through a fistula, produces a similar rapid rise in volatile fatty acids. With diets of hay supplemented by bran and oats, or hay alone, there is a much slower rise in the concentration of volatile fatty acids, and similar results were obtained when starch or cellulose was introduced directly into the rumen. Phillipson and McAnally (1942) have shown that the concentration of volatile fatty acids is high in the rumen and low in the abomasum, and they put forward the suggestion that these compounds are absorbed from the rumen, reticulum and omasum. Barcroft *et al.* (1944, 1) and Barcroft (1945, 2) have shown that in the sheep there is a high concentration of volatile fatty acids in the blood flowing from the rumen, reticulum and omasum, whilst in the blood from the abomasum, small intestine and systemic circulation the amounts of volatile fatty acid are negligible. The blood from the caecal veins also contains significant amounts, and this is in agreement with the observation that the intestinal contents are subjected to a second fermentation in the caecum. Direct measurement of the rate of absorption of volatile fatty acids from the rumen and reticulum alone, indicates that a significant proportion of the animal's caloric requirements could be obtained from these compounds if they were so used, apart from the amounts absorbed from the omasum and caecum.

The nature of the volatile fatty acids present in the rumen has been investigated. Mangold (1929) has stated that the following acids have been observed: formic, acetic, propionic, *n*-butyric, *iso*butyric and valeric. Barcroft *et al.* (1944, 2), on the basis of the rate of steam distillation of the volatile fatty acids obtained from the rumen of sheep, considered that acetic acid was the principal component, and was associated with small amounts of higher fatty acids; they obtained no evidence for the presence of formic acid. More recently Elsden (1945) has reported that acetic, propionic and butyric acids are invariably found in the rumen of the sheep, and frequently a higher acid, probably a valeric isomer Acetic acid accounts for 55 to 75 per cent. of the total. The question of formic acid is still undecided. Cellulose, glucose and lactic acid are rapidly fermented *in vitro* by rumen contents with the production of acetic, propionic and butyric acids. Propionic acid is the major component in all cases; very little, if any, butyric acid is formed from cellulose. The fermentation of glucose *in vitro* closely resembles that *in vivo*. The fermentation of dried grass *in vitro* yields the same four acids, but with acetic acid predominating.

Of the vast numbers of micro-organisms found in the rumen only four species have been definitely associated with the fermentation of carbohydrate. They are: (1) the untyped, iodophile coccus, isolated in pure culture by van der Wath, and observed but not isolated by Quin and by Elsden; (2) the yeast-like organism and *Schizosaccharomyces ovis*, first recorded by Quin; (3) the iodophilic types including cocci, sarcinae, spirilla and rods (Smith and Baker, 1944) which synthesize polysaccharide when incubated with soluble carbohydrate; and (4) untyped members of the species *Propionibacterium*, first reported by Elsden (1945).

Barcroft *et al.* (1944, 2) have shown that volatile acids are in fact absorbed into the blood coming from the rumen, that this organ and the reticulum, omasum and caecum are the only parts of the alimentary tract from which any considerable absorption occurs and that the amount of volatile acid absorbed, about 100 g. per day, is sufficient to supply an appreciable part of the energy requirements of the animal. The utilization of acetic acid by the heart is as good as of glucose (Barcroft, McAnally and Phillipson, 1943). The results obtained here fully confirm the previous inference that absorption of volatile acids occurs from the rumen. The fact that absorption in the omasum is less, although still significant, suggests that this organ, in addition to giving the solid ingesta a final comminution before they enter the abomasum, also removes the remainder of the volatile acids from them so that the material entering the abomasum is almost free from these acids.

The mixture of volatile acids present in the caecum of the pig and the caecum and colon of the horse is essentially the same as that present in the rumen of ruminants. In all these organs fermentation of carbohydrate, of which cellulose is an important component, is known to occur. It must, however, be allowed that the products of fermentation of the individual carbohydrates in these organs are not known; consequently, this mixture of volatile acids may be characteristic of fermentation of carbohydrates other than cellulose.

Studies on the biosynthesis of the B vitamins has been proceeding at the National Institute for Research in Dairying. Refection renders rats in some respects akin to ruminants, and a study of digestive phenomena in the refected rat may help to throw some light on these processes in the bovine.

Vitamin Studies

The National Institute for Research in Dairying and the Institute of Pathology of the Royal Veterinary College have found that the daily requirement of nicotinic acid for the normal growth of young pigs is of the order of 8 to 10 mg. Four mg. is insufficient to prevent deficiency. After having reached about 150 lb. pigs continue to grow in the absence of nicotinic acid supplements. It is unlikely that this is due to intestinal synthesis of the vitamin as succinyl-sulphathiazole given by mouth has no effect on the growth rate (Braude, Kon and White, 1946).

In the course of investigating the value of yeast for pigs (Braude *et al.*, 1943, 1944) an interesting observation was made at the National Institute for Research in Dairying where it was found that pigs receiving this foodstuff had lower reserves of vitamin A in the liver than those which received no yeast. The effect of feeding yeast to cows and pigs on their vitamin A metabolism is being studied. Also in progress is a more general investigation on the vitamin A metabolism of rats and pigs.

Braude, Kon and Thompson (1946) have studied the vitamin content of sow's colostrum, and this work is now extended to cover the milk of the sow throughout her lactation period.

This same Institute found that there were no significant differences in the concentration of ascorbic acid, aneurin and riboflavin in the milks of cows receiving diets with normal or low starch equivalents or with low protein content. However, when the cows were turned out to grass the rise in the solids not fat of the three groups was accompanied by an increase in ascorbic acid, aneurin and riboflavin.

Joint work at the Dunn Nutritional Laboratory and at the Institute of Animal Pathology, Cambridge, has shown the importance of colostrum as a source of vitamin A to the newborn calf. The vitamin appears to be more readily absorbed from colostrum than from oily materials such as halibut liver oils (Moore, Davies, Blakemore and Worden, unpublished data).

Moore and Wang (1943) at the former laboratory have shown that when rats are given vitamin A in excessive dosage in the form of the crystalline acetate this leads to ill effects. Hartwell's observation that uterine haemorrhages may occur in pregnant rats given an excess of cod liver oil has been confirmed.

At the Animal Diseases Research Association's Institute at Moredun, Edinburgh, it has been found that the feeding of vitamin A-rich concentrates to stall-fed dairy cows when their rations are deficient in vitamin A, has no effect on the vitamin A or carotene content of the colostrum (Stewart and McCollum, 1942).

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July 5th, Afternoon Session:
Chairman, Dr. J. Hammond

Nutritional Investigations in Denmark during the War, 1939–45

Professor L. S. Fridericia† (State Vitamin Laboratory, Blegdamsvej 21, Copenhagen, Denmark)

The nutrition problems of Denmark during the war were fewer than in any other occupied country. Denmark is a country overflowing with dairy products, eggs, bacon and meat, and with a considerable surplus of animal products available for export. During the occupation agriculture suffered less in Denmark than in other occupied countries because the Germans did not want to kill the goose that laid the golden eggs, and animal production only decreased by some 20 per cent. Nevertheless, Danish housewives in the towns did not have less trouble than their English colleagues and, in spite of rationing and rigorous price control, it was difficult for people of small means to make both ends meet.

Diet and Nutritional State of the Danish People in War Time

Full records exist of the nutritional conditions in Denmark during the war. Immediately after the outbreak of war the Danish Government appointed a Nutrition Council with the Director of the Danish Health Service, Dr. Frandsen, as chairman. The purpose of the Council was to advise the Government about rationing and to watch the nutritional state and health of the population; it carried out investigations covering the whole period of war, including the examination of the families of workers, unemployed, and clerks in the towns, of smallholders and workers in the rural districts and, in addition, infants and schoolchildren. The Ernaerings- og Husholdningsnaevnet (the Nutrition and Household

† Professor Fridericia died in February, 1947.

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Committee) prepared reports on nutritional surveys and investigations concerning the state of nutrition and health of the Danish population in the years 1941–45 which have not yet been published.

The consumption of food was computed from controlled housekeeping records, and the state of nutrition was assessed from measurements of height and weight, of haemoglobin content, of capacity for dark adaptation, and of serum protein and serum ascorbic acid. The serum protein was estimated by the specific-gravity method of Linderstrøm-Lang (Linderstrøm-Lang and Jacobsen, 1940). The accuracy of the method was tested by comparing the results with those of the Kjeldahl method, and maximum deviations of only 0·2 per cent. serum protein were found by Dr. H. Lieck and Dr. J. Bing (unpublished).

The serum content of ascorbic acid was estimated by the method of Farmer and Abt (1935). Dr. Lieck in the State Vitamin Laboratory found almost complete agreement between the results of this method and of the dinitrophenylhydrazine method of Roe and Kuether (1943). In an analysis of spinach he found very good agreement between the results of biological tests on guineapigs and of both the above-mentioned methods (Lieck, unpublished).

The results of the investigations of food consumption and of the state of health of the people were gratifying through all the years of the war. The rations supplied the usual amount of bread but only about half the amount of butter, fat, and sugar eaten before the war. The diet had to be changed to some extent, but the amount of food was sufficient in all groups. The average Calorie intake was, in towns, 3200 for employed and 2900 for unemployed workers, and in the rural districts 3700; the protein intake was 80 to 90 g., all values being given per consumer unit per day (Ernaerings- og Husholdningsnaevnet, unpublished).

Physical examinations did not show any pronounced deterioration of the state of nutrition. Even the growth of the infants and schoolchildren was satisfactory. There was, however, a small, gradual, but statistically significant, decrease in the average values for haemoglobin content, capacity for dark adaptation and perhaps for serum protein, but pathological values were not reached, and manifest deficiency was just as scarce as in normal times (Ernaerings- og Husholdningsnaevnet, unpublished).

The frequency of rickets among infants in the first year of life was investigated by Professor Oluf Andersen and Dr. Rothe-Meyer (unpublished), diagnosis being made by X-ray examination of the wrist. In the spring 22 per cent. of infants had rickets, but in the summer and autumn only 1·4 per cent. A closer examination showed that infants between 5 and 13 months of age, who, in the winter had been bottle-fed for more than four months, showed an especially high incidence of rickets.

Vitamin Content of Danish Butter

The Nutrition Council, in co-operation with other institutions, sponsored various investigations of the composition of common foods. Monthly analyses of the content of vitamin A and carotene in the butter from 10 dairies all over the country were made for two years in the State Vitamin Laboratory (Karen Svanhof and W. Hjarde, unpublished). It was found that from May to October the combined content of vitamin A

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and carotene rose from about 27 to about 34 I.U. per g. From October to April there was a gradual fall to about 14 I.U., and from April to May a sudden rise to 27 I.U. In the summer 28 per cent. of the activity was derived from carotene, and in the winter only 16 per cent. The estimations were made spectrographically and chromatographically, as well as biologically with rats, and the results by these different methods agreed well. The vitamin content of various other animal products and of dried vegetables was determined. The latter gave rather variable results and further work is planned.

War-time Bread in Denmark

The Danish national bread is the dark, 100 per cent. extraction, rye bread. During the war it contained 15 per cent. of fine bran, and the daily ration was about 250 g. (9 oz.) for adults, and more for persons doing heavy manual work. The daily ration of wheaten bread was only 70 to 80 g. ($2\frac{1}{2}$ oz.) from flour of 80 per cent. extraction. The State Vitamin Laboratory in collaboration with a big bakery and a mill made comprehensive investigations of the composition of the war-time rye bread and of wheaten bread from flour of 70 to 100 per cent. extraction. The work was done by Dr. Uhl, the late Mrs. Svanhof, and Messrs. Lorenzen, Hamman and Porsdal (Svanhof and Uhl, 1944).

Among the many results obtained it should be mentioned that the daily Danish bread ration contained 23 mg. iron and about 1 mg. aneurin, that is to say, two-thirds of the highest standard for the aneurin requirement.

In 1940 work of Dr. J. S. A. Pedersen and Professor Møllgaard at the Veterinary High School in Copenhagen aroused keen interest in the phytic acid question which resulted in the appointment by the Academy for the Technical Sciences of a committee to investigate the problem (Pedersen, Hoff-Jørgensen, Andersen and Porsdal, 1946). As is well known, Mellanby (1925) observed in 1922 the rachitogenic effect of some grain products, and Bruce and Callow (1934) connected this effect with the phytic acid content. Dr. Pedersen, however, in 1940, found that the variation in the rachitogenic capacity of different cereals does not depend on differences in phytic acid content, but on the presence or absence of the enzyme phytase destroying phytic acid. The rachitogenic cereals lack phytase, the non-rachitogenic ones contain it.

Part of the phosphorus of flour is bound in phytic acid and is available only if the acid is broken down; Harrison and Mellanby (1939) adduced evidence that phytic acid was rachitogenic not because its phosphorus was bound but because it decreased the availability of calcium. The later work of McCance and Widdowson was not known in Denmark during the war.

Under the charge of the Danish Committee, Dr. Pedersen and Dr. Hoff-Jørgensen found that phytic acid in the food decreased the intestinal absorption of calcium in pigs and dogs (Pedersen *et al.*, 1946; Hoff-Jørgensen, 1946) but increased that of phosphorus; Hoff-Jørgensen, Andersen, Begtrup and Nielsen (1946) found the same in infants in the first year of life, and Hoff-Jørgensen, Andersen and Nielsen (1946) in 10-year-old boys.

On the basis of these results the Committee recommended the addition of 1 per cent. of calcium phosphate to wheat flour and oatmeal. The rye bread constituted a special problem. Most rye bread contains no phytic acid because its dough undergoes a lactic acid fermentation during which the enzyme, phytase, breaks down the phytic acid, but acid-free and phytic acid-containing rye bread also is prepared. Hoff-Jørgensen and Porsdal (Pedersen *et al.*, 1946) found, however, that acid-free rye bread could be prepared free of phytic acid when a special bacterial culture was used and when sodium carbonate was added to the dough. The practical problem of phytic acid was solved through these investigations.

Another calcium problem was raised by the rat experiments of Schmidt-Nielsen and Schmidt-Nielsen (1944) in the laboratory of Professor Krogh. They found that with a low vitamin D intake food mixtures containing spinach and diets containing oxalic acid caused an inhibition of the growth of rats and a fall in their serum content of calcium. Additional vitamin D gave normal growth and serum-calcium content, but the bone ash was still low.

Methods of Food Preparation and Institutional Meals

Dietary research of a purely practical kind was carried out as usual by the State Council of Domestic Science (Statens Husholdningsraad, 1946), most of whose members are delegates from the big Danish organizations of housewives. The war-time investigations dealt with the composition, vitamin content and treatment in the kitchen of different sorts of vegetables, with the losses of nutrients, especially minerals and vitamins, in the cooking of common dishes, and with methods for the domestic preservation of fruits, vegetables and meat.

The dietary department of the Health Service carried out as usual investigations into the dietaries, food services and meal planning of public institutions and homes for children (unpublished reports to the Danish National Health Service for 1939–45).

Vitamin Studies

About 50 scientific papers on vitamins were published during the war, many of them in *Acta medica scandinavica*. Short summaries of them will appear in a book called *Danish Scientific Activity during the War*, which will be published shortly. Only a few of these papers can be mentioned. First, there are those about vitamin K, which is a Danish product, discovered and described by Professor Henrik Dam of the Technical High School in Copenhagen, who received the Nobel prize in 1944 during his stay in the United States. In collaboration with the paediatricians, Professor Plum and Dr. Tage-Hansen, he published a paper on the effects of lack of vitamin K in normal and sick children (Dam, Tage-Hansen and Plum, 1939, 1). During the war Plum, Tage-Hansen and their collaborators published several papers on the prevention of vitamin K deficiency in newborn children and on the cause of their low blood content of prothrombin (Dam, Tage-Hansen and Plum, 1939, 2; Thordarson. 1941; Tage-Hansen, 1940).

Of work on other vitamins there are the papers of Dr. Torben With (1940) on the absorption of vitamin A and carotenoids and their storage in the liver, which he found to be a rapid process, going parallel with the absorption itself. Other workers dealt with the quantitative estimation of various vitamins, for instance, Broge (1945) with carotene, Bandier

(1940) with nicotinic acid, Rehberg (1943) with ascorbic acid, Bang (1944) and Wassman (1944) with aneurin, and Kjølhede (1943) with tocopherol.

Kjørboe (1944) found that deficiency of vitamin A did not alter the course of inhalation-tuberculosis in guineapigs, but deficiency in ascorbic acid made the tubercle bacilli multiply and spread more rapidly than in well nourished animals.

It may appear strange that it was possible to do all this research work during the German occupation, but the work in the laboratories continued almost as before the occupation. The Germans did not interfere except that they imprisoned some university professors, and others had to escape by illegal crossing to Sweden in fishing boats or to England in military aeroplanes.

The remaining Danish nutrition workers have been isolated and cut off during the war, and now look forward to a vivid scientific intercourse with their gallant British friends, who liberated their country and whom they admire in so many ways.

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Conditions and Research into Human Nutrition in Finland during the War Years

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The largest single section of the population of Finland is composed of farmers and farm labourers. During the earlier part of the war the nutritional condition of all sections of the population remained comparatively high but, in 1941, the situation became steadily worse, due chiefly to lack of labour, decline in the fertility of the fields, interruption of commercial connexions and the surrender of a large amount of territory. The rural population has, notwithstanding, fared comparatively well as far as food is concerned, the farmers because, as producers, their rations were sufficient, and the remainder of the country dwellers because their buying power was high enough to procure unrationed and black-market goods. The urban population, on the other hand, was obliged largely to do without such additions. This was especially true of the big families of industrial workers, and of officials and intellectual workers, who experienced a severe crisis due to their fixed income.

Rations and Nutritional State of Finland in War Time

The rations for the most important foodstuffs in Finland during the Second World War are shown in Table 1.

The figures in the table clearly show that there has been a change in the people's food, the diet now being rather one-sided and consisting mainly of cereals and potatoes, animal proteins such as meat, fish and dairy products forming an alarmingly small part of the diet. As a result the protein balance, caloric value and palatability of the food have remained very unsatisfactory. The Finnish food industry has tried its best by research to improve the culinary value of the diet, and new preparations have been devised, partly from rationed products in the raw state, and partly from the waste and by-products of the dairy, fruit and meat industries, from yeast, and from accessory substances of no direct nutritive value, such as aromatic materials, spices and even cellulosic ethers, which are absorbed by the organism. In this way a certain amount of variety has been attained. Most of these war-time products will, of course, be displaced by more normal products but, in all probability, some of them will survive.

The scientific work of A. I. Virtanen, the Nobel Prize winner in chemistry, has been very important for human nutrition in Finland during the war. The application of his research into the fixation of nitrogen by leguminous plants and the preservation of these protein-rich plants as silage by the A.I.V. method offers great possibilities for re-establishing Finland as a self-supporting country in respect to foodstuffs. But, as Virtanen has himself stated, the renewal of the agricultural system is a slow process, due to the extreme conservatism of the farmers. This explains why agricultural reform, even during the war years, did not bring about a greater increase in our agricultural production. This is regrettable also because the application of Virtanen's system would have guaranteed a far higher conservation of vitamin A. Extensive research

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work on the nutrition of the Finnish people showed that the supply of vitamins A, C and D constitutes the most essential practical problem (Virtanen, 1938).

TABLE 1

RATIONS PER HEAD PER ANNUM OF THE CHIEF TYPES OF FOOD IN THE YEARS 1941–45 FOR VARIOUS CATEGORIES OF CONSUMER IN FINLAND

Type of food	Category of consumers	Rations in kg. per annum 1941	1942	1943	1944	1945
Cereals ..	Children 0 to 3 years ..	72	58·2	54	54	54·6
	,, 4 to 9 ,, ..	72	72	72	72	72·6
	,, 10 to 12 ,, ..	79·5	76·5	87·75	90	87·6
	,, 13 to 16 ,, ..	79·5	94·5	105·75	108	102·6
	Persons doing intellectual or light work	79·5	76·5	87·55	90	87·6
	Persons doing moderately heavy manual labour	79·5	94·5	105·75	108	102·6
	Persons doing heavy manual labour	131	128·5	141·9	144	132·6
	Persons doing very heavy manual labour	179·6	166·1	171·6	162	150·6
	The self-supporting:					
	Men	205	180	174	180	166
	Women	168	180	174	180	166
	Children 0 to 7 years	126	135	114	120	112
Fats	Children 0 to 17 years	10·825	7·1	8·55	9	9·5
	Persons doing intellectual or light work	9·250	4·7	6	6	6·5
	Persons doing moderately heavy manual labour	9·250	5·9	7·65	9	9·5
	Persons doing heavy and very heavy manual labour	11·550	7·1	8·55	9	9·5
	The self-supporting	13·5	7·4	8·55	9	9
Milk	Children 0 to 1 year ..	365	365	365	332·5	328·5
	,, 1 to 2 years ..	365	365	365	326·5	328·5
	,, 2 to 17 ,, (in 1944 3 to 18 years)	219	219	219	219·6	219
	Adults	102·3*	73	97·5	103·7	82·2
	The self-supporting:					
	Children 0 to 17 years	365	365	365	366	365
	Adults	340·6	219	317	347·7	255·5
Meat and meat products (beef)	Children and persons doing intellectual or light work	14·3	6·6	6·7	18·2	7·6
	Persons doing heavy manual labour	19·8	11·1	9·3	23·8	11·3
	Persons doing very heavy manual labour	19·8	12·9	11·9	27·0	11·3
	The self-supporting	30	30	25·5	25·5	25·5
Sugar and syrup	Fundamental ration (holders of sugar card 1942)	14	11·75	7·5	6·75	6
	Holders of tobacco card since 1942	—	11·0	4·5	3·75	3
	Children 0 to 6 months ..	1·5 kg. per month				
	,, 6 to 12 ,, ..	0·75 kg. per month				

* Cream 8 to 10 per cent. only in cities for adults, at present 100 ml. milk and 50 ml. cream per day.

A survey was made by P. E. Simola, of the Department of Medical Chemistry at the University of Helsinki, of the conditions of human nutrition in Finland during the war. He found that, in the existing abnormal times, the ration of energy foods, notably grain and fats, was so scanty that it was often difficult to supply energy, especially because the unrationed supplementary source, the potato, also was at times limited. The disparity between the supply of calories and the requirements was

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especially great in the heavy-labour class. The situation was the most difficult in the spring of 1942, when there was a lack of potatoes in the more densely populated areas, and turnips had to be brought in to replace them. At that time there was a general loss of weight, amounting to about 10 per cent. among adults. A few serious cases of malnutrition occurred, but fortunately these were exceptional (Simola, 1942).

The supply of animal proteins was very poor, due to the scarcity of meat and milk. Oedema appeared in exceptional cases, and was due, in addition to the lack of calories, chiefly to the scarcity of animal proteins. Clear cases of malnutrition due to lack of proteins were, however, not generally observed. On an average, the plasma-protein values were at a normal level.

The decrease in milk production during the war noticeably reduced the supply of calcium but, even in the present-day diet, the minimum need of calcium is probably satisfied. No signs of a lack of calcium have as yet appeared. The war-time diet did not essentially affect the condition of the teeth. It would appear, on the contrary, that the scarcity of sugar actually reduced the frequency of caries.

There was some tendency during pregnancy to an anaemia, which reacted favourably to treatment with iron. This tendency would, however, appear to have been due to some other factor than lack of iron for, according to theoretical calculations, the iron content of the war-time diet should have been sufficient (Turpeinen, 1944).

The scarcity of dairy products, especially butter, very noticeably reduced the supply of vitamin A but, up to the present, Finland has managed surprisingly well. The concentration of vitamin A in the blood fell below the previous level but only to the extent of about 25 per cent., and the vitamin A content of post-mortem specimens of human liver was rather high.

In normal conditions in Finland the requirements of vitamin B_1 and of nicotinic acid have been satisfactorily supplied, chiefly due to the consumption of whole-grain products. Present conditions have perhaps caused the situation to deteriorate but, on the basis of a series of analyses for vitamin B_1 and nicotinic acid, the situation may be considered fairly satisfactory. The occurrence of dermatitis during the war has apparently been caused more by lack of cleansing materials than of skin-factors of the vitamin B complex (Simola and Saksela, 1941; Pitkänen, 1943; Kinnunen and Rauramo, 1945; Skurnik, 1945).

In Finland the potato is of the greatest importance as a source of vitamin C. The seasonal fluctuations in the vitamin C content of blood, lymph and tissues are due to the decrease in the vitamin C content of potatoes during the winter. In the spring of 1942, when there was a shortage of potatoes, the blood values for vitamin C were unusually low, but definite deficiency phenomena were not at any time observed except in a few rare cases. The frequency of gingivitis during the war was due to factors other than a lack of vitamin C (Saksela, 1940).

The only deficiency disease appearing in Finland with conspicuous symptoms was rickets, the percentage of children affected in certain localities being between 80 and 90. Thanks to the distribution of vitamin preparations, this disease is at present on the decline.

In Finland during the war there has been a somewhat greater tendency to abortion among women, but it cannot definitely be ascertained whether this has been due to lack of vitamin E or to other factors (Rauramo, 1947).

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Food Conditions in Norway during the War, 1939—45

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It is not possible to give detailed information about the food situation in Norway during the war. Figures for imports, exports, production and rationing are available, but there is no record of how the food consumption of the various groups of producers and consumers was affected by the increasing food shortage.

Before the war more than 50 per cent. of the total calories consumed in Norway were imported, including 75 to 80 per cent. of the grain, 50 per cent. of the fat and all the sugar. During the war the importation of these foods for human consumption was reduced on an average to about half the pre-war amount, and, at the same time, the importation of fodder ceased completely. Agricultural production was largely diverted from fodder to foods for human consumption but, in spite of increased acreage, the grain crop decreased from year to year mainly from lack of fertilizers. Fish production decreased also to about 60 per cent. of the pre-war figure.

The Food Situation in Norway during the German Occupation

The food situation in the five years of occupation may be separated into two periods; in the first two and a half years, from the spring of 1940 till the autumn of 1942, it deteriorated rapidly. One item after another disappeared from the market and was consequently rationed. During the first year the rationing included all imported foods, bread, fats, sugar, coffee, cocoa, syrup, and coffee substitute. In the second year all kinds of meat and pork, eggs, milk and dairy products were rationed in the same way and, during the summer of 1942, the rationing was extended to include potatoes and all kinds of fruits and vegetables which by that time had almost completely disappeared from the market.

Preliminary results, from dietary studies which were secretly performed in Oslo among a small group of 30 to 50 families three times a year from 1941 to 1945, illustrate the great change in the diet of consumers during this period of deterioration. The food consumption (Table 1), including black-market trade and other illegal forms of purchase, showed a considerable reduction, mainly of meat, eggs, cream, cheese and fats, and

TABLE 1

AVERAGE CONSUMPTION IN g. PER MAN VALUE DAILY OF DIFFERENT FOODS IN SOME WAR-TIME DIETARY STUDIES AMONG FAMILIES IN OSLO COMPARED WITH THE CORRESPONDING PRE-WAR AND IMMEDIATE POST-WAR FIGURES

Date	No. of families	Food consumption, g. per man value daily																		
		Milk, whole	Milk, skim	Milk, condensed and cream	Cheese	Fish	Meat	Eggs	Fats	Cod liver oil	Flour, meal and groats	Bread	Potatoes	Roots and vegetables	Pulses	Fruit	Sugar and syrup	Fruit juice and jam	Chocolate and cocoa	Coffee
1936–37 ..	50	541	62	41	30	99	158	39	82	0	62	288	269	88	6·3	124	71	28	6	16·8
1941 February to May ..	39	515	137	26	33	147	105	13	62	1·9	125	294	391	81	7·3	11	41	30	4	6·5
August to September	36	604	134	22	18	174	89	17	55	1·2	86	328	463	99	9·6	24	48	26	4	2·2
October to December	32	558	43	4	11	198	58	4	52	2·3	97	309	449	195	6·4	68	43	42	3	1·7
1942 February to March ..	32	360	237	4	10	255	40	3	40	2·8	87	312	369	177	4·5	6	44	51	2	0·2
April to July ..	31	308	273	12	14	301	67	2	50	5·1	123	281	348	170	9·3	8	43	55	2	0
October to December	29	318	139	1	5	290	40	0·3	44	1·6	86	324	645	231	3·1	19	48	31	0·5	0
1943 January to March ..	31	338	161	3	6	384	39	3	46	4·7	109	323	630	115	4·2	5	48	39	1·8	0
May to September ..	39	373	191	2	8	305	24	2	53	0·8	113	321	597	136	5·5	29	50	38	0·1	0
October to December	47	326	63	1	18	272	32	2	44	2·7	111	314	613	235	3·3	10	34	56	0·4	0·1
1944 January to May ..	47	321	115	1	2	339	28	3	50	3·8	113	332	586	112	2·9	8	44	45	0·1	0
May to October ..	43	332	175	2	10	294	27	3	58	1·2	106	376	407	125	3·0	26	38	18	0	0
October to December	42	284	14	0	7	264	41	0·6	46	2·3	108	368	472	223	2·6	7	28	39	0·1	0
1945 February to April ..	41	345	6	0	2	298	38	2	21	5·7	131	336	432	140	4·4	4	45	37	0	0
May to July ..	32	487	127	1	7	208	97	11	73	0	176	354	467	29	10·1	1	39	25	0·8	5

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a heavy increase of fish, potatoes and vegetables. Coffee, tea, cocoa, eggs, cream and fruit almost disappeared. The consumption of meat was reduced to 25 per cent., cheese to 30 per cent., fats, milk and sugar to 50 to 60 per cent. of the pre-war amount. The consumption of fish was increased by 200 per cent. from 100 to 300 g. a day; the potato consumption was doubled from about half a pound to one pound a day. Even the consumption of bread and flour, in spite of the rationing, increased by nearly 30 per cent., 20 per cent. of the bread being derived from "illegal" sources.

After the first period of rapid deterioration the last two and a half years of occupation represented mainly a period of adaptation to the new low level. Even in this period some further deterioration took place, especially towards the end of the war; apart from this and from seasonal variations, the diet remained relatively unchanged unti liberation.

The food condition among food producers was, of course, not the same as among consumers. Even among the consumers the diet varied widely, more liberal rations being given to the priority groups, children, pregnant and nursing women, sick people and heavy workers (Diesen, 1942). The Calorie content of the rations for the normal consumer was in the autumn of 1940 about 1400 a day and was kept nearly constant throughout the war, varying from 1300 to 1500 Calories. During the first period, however, only bread, fats and sugar were rationed, while meat, milk, eggs, and potatoes could be bought freely on the market in addition to the rations; from 1943 onwards the same calorie figure included the ration of almost all foods.

Many Norwegians during the occupation undoubtedly got no food outside the normal rations. In spite of this some preliminary results of the dietary studies mentioned show that the figures for rationed calories do not give a true picture of the calorie value of the diet of the population in general (Table 2). The average Calorie intake of the subjects of the dietary studies already mentioned was before the war about 3400 daily per man value on the Cathcart scale. During the first two years of occupation the Calorie value of the diet decreased to 2800, in one study to 2700, and subsequently remained at about 2800 to 2900. About 300 to 400 of these Calories were derived from black-market sources of some kind, mostly as bread or flour. Immediately after liberation the calorie figure rose above the pre-war level.

The fat content of the diet decreased from about 40 per cent. of the calories before the war to about 22 to 25 per cent., while the protein content increased from about 13 per cent. of the calories to about 14 to 16 per cent. The total daily protein consumption of 100 to 110 g. was nearly the same as before the war. The calcium content, after first falling to 1·1 from 1·6 g. daily, was for the greater part of the occupation on the same level as before the war, due to fortification of bread and flour with calcium salts. The iron content of the diet was kept nearly unchanged at about 20 mg. daily, while the phosphorus content was increased to 2·2 to 2·6 from 1·9 g. a day. No calculations have been made for the vitamin content of the pre-war diet. The average consumption of vitamins A, B_1, C and D in some of the war-time dietary studies are given in Table 2. The wide variations in the vitamin A intake were due to variations in the amount of cod liver oil. The high values for

TABLE 2

Nutritive Values of the Food Consumed per Man Value per Day Found in Some War-time Dietary Studies among Families in Oslo, Compared with the Corresponding Pre-war and Immediate Post-war Values

Date	No. of families	Animal protein g.	Total protein g.	Fat g.	Carbo-hydrate g.	Calories	Ca g.	P g.	Fe mg.	Vitamin A I.U.	Vitamin B_1 I.U.	Vitamin C mg.	Vitamin D I.U.
1936–37 ..	50	74	115	159	395	3475	1·6	1·9	17	—	—	—	—
Feb. to March, 1942 ..	32	62	101	74	406	2699	1·1	2·3	19	5237	743	68	872
April to July, 1942 ..	31	70	114	84	416	2876	1·1	2·4	23	9045	734	51	1461
Jan. to March, 1943 ..	31	70	114	81	452	2993	1·4	2·6	22	6895	777	67	1431
May to Sept., 1943 ..	39	62	106	84	463	3025	1·5	2·5	22	3697	778	84	1965
Oct. to Dec., 1943 ..	47	60	105	70	457	2872	1·6	2·4	20	5374	719	144	838
Jan. to May, 1944 ..	47	60	100	78	463	2960	1·4	2·4	20	6258	720	98	1307
May to Oct., 1944 ..	43	58	100	89	435	2945	1·5	2·5	18	5118	726	61	1474
Oct. to Dec., 1944 ..	42	48	99	74	426	2761	1·3	2·2	22	5074	700	99	1052
Feb. to April, 1945 ..	41	53	95	64	441	2726	1·2	2·3	18	8081	684	110	1537
May to July, 1945 ..	32	60	112	138	499	3677	1·5	2·5	20	3753	680	30	781

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vitamin D intake were due partly to cod liver oil and partly to herring. The intake of all the vitamins mentioned was probably higher during the war than in normal times, with the possible exception of vitamin A in some of the studies.

Some results not yet published of studies of factory workers in Oslo in the years 1943–45, made by Professor A. Strøm of the Institute of Hygiene seemed also to show high figures for calorie consumption. In January and June, 1943, the average Calorie consumption per man value per day on the Cathcart scale in one study was 3046 and 3206, respectively. In May and November, 1944, the respective average figures were 2905 and 2565. In a second series of studies among Oslo factory workers, the values were 2750 in November and December, 1942, 2708 in October and November, 1943, and 2603 in the spring of 1944. A study of families in the south in November and December, 1943, showed a figure of 2913 for a small city, and of 2708 for a country district.

Nutritional State of the Norwegian People during the German Occupation

In spite of the relatively high calorie consumption revealed by these studies in contrast with the official figures given for the rations, and in spite of the relatively high protein, mineral and vitamin content of the food, the health of the population was affected. There was a general loss of weight among the groups, mainly factory workers and staff, weighed at regular intervals during the war (Strøm, 1946). This loss of weight was found among adults in all age groups, generally increasing with increasing age. It amounted in various unpublished studies to on the average 5 kg. for men, and a little less for women. This general loss, which affected nearly all adults at least in the cities, must be ascribed to calorie underfeeding. Most people complained also of different subjective symptoms attributable to the same cause. In February, 1943, of the adults of the families which took part in one of the dietary studies in Oslo, about 95 per cent. complained of a constant feeling of hunger after, as well as before, meals. Hunger for fat was very prominent. Eighty per cent. complained of being tired and weak with reduced working capacity, 90 per cent. felt cold, 60 per cent. complained of sleepiness, and 50 per cent. of nycturia. The same symptoms were found in a larger group of factory workers examined in the spring of 1942.

The growth of the children was retarded. The average height of the schoolchildren in Oslo in all age groups has been steadily increasing since 1920, due mainly to better feeding. From 1943 this increase ceased and there was even a decrease in the average height compared with the pre-war figures (Stoltenberg, 1944). The greatest decrease was in 12-year-old girls and 13-year-old boys, probably because of the great food requirements of these age groups. The average weight of schoolchildren showed an even larger decrease in all age groups. The percentage of children under the normal range of weight, which before the war was nearly constant at about 14 to 16, increased to 24·6 in 1944. At the same time the Chief Medical Officer for Schools in Oslo reported that the children were on the whole paler and weaker, with less subcutaneous fat and with poor muscular development. This deterioration was undoubtedly due to the general under-feeding.

On the other hand, not a single case of deficiency disease was observed

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and, in some respects, the health of the schoolchildren even improved during the war. The frequency of dental caries decreased from about 90 foci per 100 permanent teeth before the war to 70 in 1943 and to about 40 in 1944 (Gythfeldt, 1946, 1, 2; Collett, 1946; Toverud, 1945). The percentage of children with adenoids and hypertrophic tonsils decreased from 11 before the war to 3·2 in 1943, a decrease attributed to the disappearance of overfeeding to which importance is attached in the aetiology of adenoids and hypertrophic tonsils.

Probably as a result of the lowered food standard, the general morbidity among factory workers and personnel in Oslo increased from year to year during the war, absences rising from 8 to 10 days per head per year in 1939 to 17 to 20 in 1944.

A heavy increase in the frequency of most infectious diseases was recorded. The epidemic index increased from 100 before the war to 640·8 in 1943. Remarkable was the increase in lobar and broncho-pneumonia, the number of cases of both types notified increasing by more than 100 per cent. Gastro-intestinal diseases, too, increased considerably, especially gastric ulcer, gastritis, colitis and gastro-enteritis.

The tuberculosis morbidity continued its pre-war decline into the first year of war, and reached its lowest value in 1940. After 1942, however, there was a considerable increase in the number of notifications, and in 1945 the figure was 32 per cent. above the 1940 level. Mortality figures are unfortunately not yet available except for Oslo where, after a decrease during the first year, they increased by 21 per cent. from 1942 to 1944. Dahl and Backer (1945) showed that the increases in morbidity and mortality from tuberculosis in Oslo were not due to increased spread of infection. The number of new infections was, according to extensive surveys, lower than before the war.

None of the classical vitamin deficiency diseases was detected with increased frequency. Only oedema, attributed to some kind of dietary deficiency, occurred in a great number of cases, especially during the summer and autumn of 1942 (Kobro, 1945). Several types of oedema have been described. One type with nycturia, weakness and dyspnoea occurred among adult men and women of all ages. In another type which was seen among young women, obesity and amenorrhoea were observed in addition to oedema and nycturia. In a third type oedema was combined with polyneuritis.

Vitamin Studies

From the Institute of Hygiene of Oslo University some investigations of the occurrence of subclinical vitamin A deficiency were reported by Hovind (1945) and Lindberg (1946, 1, 2) using the method of Edmund and Clemmesen (1937) as well as with the biophotometer. In one of the groups examined all persons had taken at least 5 g. cod liver oil daily for at least two months previously while, in another group, none of the persons had taken cod liver oil or whole milk for at least six months before the test. There was a marked difference between the two groups, and it was concluded that the percentage of cases of vitamin A insufficiency was in the second group at least 24 in the autumn of 1943, 16 in the spring of 1944, and 26 in the spring of 1945 (Lindberg, 1946, 1, 2).

The vitamin A content of the liver in 113 cases of sudden death in

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healthy persons was examined by Ødegård (1945) and Lindberg (1946, 1, 2). The average value in the first series in 1943–44 was 347 I.U. per g. liver and, in the second series in 1944–45, 250. In the autumn of 1945, 21 additional cases showed an average value of 416. These average values compare well with those found by other authors in normal times. The individual variations were considerable, and the results are therefore not inconsistent with the conclusion drawn from the observations of dark adaptation that a large part of the adult population not using cod liver oil suffered from an insufficiency of vitamin A.

No reports of scurvy or of subclinical vitamin C deficiency were received. Hagtvedt (1945) examined in 1940–42 the ascorbic acid content of the blood serum of about 700 healthy persons. Marked seasonal variations were observed with a minimum value of 0·16 mg. per cent. in June, and a maximum of 0·93 in August and September. The variations reflected mainly the ascorbic acid content of the potatoes which were the most important source of vitamin C in the diet.

The frequency of rickets among infants and children in Oslo was reduced during the war. Toverud (1946) reported that in 1939 about 16 per cent. of the children examined in one of the children's clinics in Oslo had symptoms of rickets. During the war this figure sank, in 1942, to 1 to 2 per cent., and subsequently remained at this level. All children got a daily ration of cod liver oil during the war.

Haemoglobin Surveys

The haemoglobin content and the number of red cells of healthy persons were examined in 1943 by Lange and Palmer (1946). In comparison with the results of a previous survey, they concluded that the average percentage of haemoglobin of men had sunk from 115 in 1934 to 104 in 1943, and of women from 102 in 1934 to 95 in 1943; that is a reduction of 10 per cent. in men, and 7 in women. The number of red cells per cu.mm. was found to be in men 4·5 million against 5·4 million in 1934, and in women 4·0 million against 4·5 million in 1934; that is a reduction of 20 per cent. in men, and 12 per cent. in women. The colour index was correspondingly 1·18 in 1943 against 1·09 in 1934.

No definite reason was found for the lower haemoglobin values and the higher index in investigations in 1943. The only difference between the two investigations seemed to be that the latter had been performed during a period of food shortage. As the colour index was higher than the normal, and the red cells on an average large with increased haemoglobin content, it was concluded that the decrease in haemoglobin content was not due to iron deficiency. For the same reason the decrease was probably not due to hydraemia. The investigations were repeated in October, 1945, when the food situation had improved considerably, with increased consumption of milk and meat. The number of red cells had by then increased by about 10 per cent. from 4·24 to 4·64 million, and the haemoglobin content had increased to 107 per cent. Relatively low haemoglobin values have been found in several other investigations. Among factory workers in 1944–45 H. Natvig (unpublished) found an average of 106 per cent. for men, and 95 per cent. for women.

Kaada (1946) found in 1944 an average of 108 per cent. for 2000 men, and 94 per cent. for 1000 women during the examination of Norwegian refugees immediately upon their arrival in Sweden. In comparison with pre-war values he concluded that there was a decrease of about 5 per cent. Similar results have been reached in other studies.

Nutritional Conditions in the Concentration Camps

So far, the nutrition of the general population only has been considered. Far worse conditions prevailed in the German concentration camps (Aas, 1946, 1; Rasmussen, 1945). From Grini camp in Norway, with about 6000 prisoners, Aas (1946, 2) has recently reported the results of investigations he made as a prisoner in the camp in the years 1943–45. The diet contained daily about 1900 Calories with 55 to 60 g. protein, 27 g. fat, 0·3 g. calcium, 1·5 g. phosphorus, 450 I.U. vitamin B_1, 115 mg. vitamin C, and 2800 I.U. vitamin A. More than 50 per cent. of the prisoners had oedema, together with fatigue, weakness and polyneuritic symptoms. The value for serum protein in about 500 prisoners averaged 6·2 to 6·5 per cent. Oedema was successfully treated with additional vitamin B_1, cod liver oil and fish. Full restoration was generally achieved in 1 or 2 weeks, the serum protein showing an increase of about 1·5 per cent. During the last year, by smuggling food into the camp, the average calorie content of the diet was increased by about 10 per cent. and, at this time, the incidence of oedema was only about 15 to 20 per cent. The calorie content of the diet was, however, even so not sufficient, and the average loss of weight among 550 prisoners was 9·5 kg.

In summing up, it can be said that, apart from these experiences, hunger or famine did not occur in Norway during the war, and no great number of cases of deficiency disease was observed.

On the other hand, the marked reduction in quantity as well as in quality of the food had a serious effect on the health of the population. The Calorie content of about 2800 per man value per day, observed in several dietary studies during the occupation, was obviously far from sufficient to secure the health of the people and the proper development of the children.

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Nutrition and Nutritional Research in Sweden in the Years of War, 1939–45

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Survey of War-time Food Consumption in Towns in Sweden

From the first quarter of 1940 successive statistical investigations were organized of the consumption in 500 households.

Table 1 shows the supply of certain nutrients for the first quarter of 1940, and for the succeeding 21 surveys up to and including the second quarter of 1945. From the figures shown there, it is clear that the Swedish food situation was on the whole satisfactory. The supply only of vitamin A was more or less regularly below the desired level. It must, however, be remembered that the scatter about the mean is considerable. Even in normal conditions no small number of the families was getting a diet unsatisfactory in one or more respects, and even a slight lowering of the food standard meant a rather considerable increase in this group.

TABLE 1

THE SUPPLY OF NUTRIENTS IN SWEDEN DURING THE WAR YEARS, 1940–45, EXPRESSED AS A PERCENTAGE OF THE SUPPLY IN THE FIRST QUARTER OF 1940

Year	Calories	Protein	Fat	Carbohydrate	Calcium	Phosphorus	Iron	Vitamin A	Vitamin B_1	Ascorbic acid
1940 1st quarter	100	100	100	100	100	100	100	100	100	100
2nd ,,	101	101	—	—	104	103	99	94	96	64
3rd ,,	99	101	—	—	104	104	104	148	105	112
4th ,,	102	106	—	—	101	106	109	127	—	92
1941 1st quarter	98	103	88	107	105	106	109	97	106	99
2nd ,,	95	99	83	102	99	100	102	85	100	71
3rd ,,	94	97	80	100	102	122	107	135	105	107
4th ,,	86	91	73	94	91	91	93	85	83	90
1942 1st quarter	96	96	80	105	100	99	103	81	118	95
2nd ,,	93	96	75	104	105	104	97	77	104	89
3rd ,,	95	97	76	106	113	104	94	127	106	130
4th ,,	92	94	74	103	104	99	100	109	102	105
1943 1st quarter	97	102	75	110	114	103	100	102	103	105
2nd ,,	96	127	79	105	140	134	134	102	137	125
3rd ,,	96	103	86	110	155	109	109	92	113	134
4th ,,	99	105	86	105	118	110	116	82	114	201
1944 1st quarter	101	105	88	107	116	122	111	103	112	107
2nd ,,	100	103	95	103	113	106	107	81	111	89
3rd ,,	99	101	94	101	115	105	103	108	108	105
4th ,,	100	103	92	104	113	104	106	101	107	95
1945 1st quarter	99	104	89	105	112	103	106	87	105	88
2nd ,,	98	105	86	102	112	109	119	83	131	68

During the war the calorie supply did not undergo any considerable changes. At the end of 1942, when it was lowest, it was 92 per cent. of the value at the beginning of 1940. Nor did the supplies of protein and carbohydrate undergo any major changes, due to the fact that milk and potatoes were never rationed. The consumption of milk, of which the fat content was standardized at 3 per cent. by law, increased markedly. The consumption of meat diminished and, at the turn of the year 1942–43, it was about three-quarters of the peace-time consumption. With the

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increased consumption of milk which, during the war, rose from about 0·65 l. per consumption unit per day to nearly 0·9 l., there was a corresponding rise in the supply of calcium. The supply of iron remained unchanged or even increased, due partly to the increased extraction of wheat, and partly to the fact that latterly iron was being added to the flour. The same applies to the supply of vitamin B_1, riboflavin and nicotinic acid. The supply of ascorbic acid showed great variations, in part seasonally conditioned and in part connected with the importation of fruit from the south, especially oranges. The supply of vitamin A also was subject to seasonal variation, and was much affected by the extent to which the necessary raw materials were available for the vitaminization of margarine. After the importation of fish liver oils had become extremely difficult, carotene extracted from carrots grown in Sweden was used.

The changes in the consumption are reflected in the distribution of the calories among the groups of foodstuffs, as shown in Table 2. As was to be expected, there was a change from animal to vegetable foods. Whereas in 1940, 42·4 per cent. of the calories came from animal foods, this figure fell in 1942, when conditions were worst, to 37·3 per cent. Among vegetables there was a noticeable increase in the consumption of root vegetables, including potatoes.

TABLE 2

THE PERCENTAGE OF CALORIES CONTRIBUTED TO THE DIET BY DIFFERENT GROUPS OF FOOD IN THE WAR YEARS, 1940–45

Food group	Percentage of calories contributed in various years					
	1940	1941	1942	1943	1944	1945, first half
Dairy products	22·6	22·9	21·3	23·8	25·8	24·0
Margarine and fats ..	5·9	3·5	5·8	5·1	4·4	6·2
Eggs	1·4	1·1	0·6	0·6	0·9	1·2
Meat	10·5	9·9	6·7	8·0	9·8	8·3
Fish	2·0	2·2	2·9	2·5	1·9	2·3
Total	42·4	39·6	37·3	40·0	42·7	42·0
Cereals	31·3	33·3	31·3	31·8	31·1	32·2
Roots	8·2	9·7	12·1	11·1	10·1	9·8
Vegetables	0·8	0·9	1·2	1·1	1·1	0·6
Fruits	5·2	5·0	5·1	4·8	4·4	4·3
Sugar and coffee	11·9	11·6	13·0	11·3	10·7	11·1
Total	57·4	60·5	62·7	60·0	57·4	58·0

The most important foods were rationed throughout the whole war, and still are in 1946. The rations consisted of a basic ration with extra rations for persons doing heavy work, for pregnant and nursing women, for certain categories of children and young people, and so forth. Further, the poorer sections of the population were given a better chance of procuring important foods through the allowance of discounts. On the whole, the price control functioned satisfactorily. There was no black-market traffic of any importance with foodstuffs except eggs. The basic rations had, of course, to vary according to the supplies available.

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During the last quarter of 1942 these were, per week: bread, flour and oatmeal 1306 g., meat and bacon 210 g., household fat including butter, margarine and oils 268 g., sugar 602 g., cheese 35 g., eggs 39 g., coffee 33 g. or tea 13 g. Cocoa was unobtainable.

Health of the People in Sweden in the War Years

In connexion with the investigation of food consumption, medical examinations of the persons participating were made in the first and last quarters of 1942 and in the second quarter of 1943. The results of these examinations may be seen in Table 3. It was not possible to observe any injurious effect on the state of health of the people examined, but the poorest and largest families, where the first symptoms of under-nourishment might have been expected, were not sufficiently represented.

TABLE 3

FREQUENCY OF OCCURRENCE OF SOME SYMPTOMS AT THE MEDICAL EXAMINATIONS MADE IN THE YEARS, 1942 AND 1943, IN CONNEXION WITH SURVEYS OF FOOD CONSUMPTION

Year	Total number examined	Number with weight low, relative to height		Frequent catarrh of respiratory passages		Haemoglobin value low		Acute rickets		Dry skin, keratosis	
		No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
	Children										
1942 1st quarter ..	922	121	13·1	241	26·1	181	19·6	9	1·0	137	14·9
1942 4th ,, ..	1028	148	14·4	141	13·7	106	10·3	8	0·8	69	6·7
1943 2nd ,, ..	1031	156	15·1	139	13·5	113	11·0	10	1·0	114	11·1
	Adults										
1942 1st quarter ..	546	57	10·4	97	17·8	90	16·5	—	—	18	3·3
1942 4th ,, ..	606	47	7·8	50	8·3	84	13·9	—	—	12	2·0
1943 2nd ,, ..	589	43	7·3	53	9·0	52	8·8	—	—	54	9·2

The results of these medical examinations are, however, indirectly confirmed by the statistics of mortality. As may be seen from Table 4,

TABLE 4

DEATH RATES FROM SOME DISEASES IN SWEDEN IN THE YEARS, 1926–44

Year	Death rate per thousand	Death rate for infants under one year per cent.	Death rate from tuberculosis per thousand	Death rate from infectious diseases per thousand
1926–30	12·08	5·76	1·32	0·34
1931–35	11·64	5·01	1·08	0·25
1936–40	11·69	4·19	0·81	0·18
1941	11·26	3·70	0·75	0·22
1942	9·91	2·93	0·68	0·06
1943*	10·14	2·86	0·68	—
1944*	10·85	3·01	0·68	—

* Preliminary figures.

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the death rate continued to fall during the war, and in 1942 the lowest death rate so far recorded in Sweden of 9·9 per 1000 inhabitants was reached. The frequency also of deaths from pulmonary tuberculosis and epidemic diseases continued to fall. A striking reduction occurred in the number of deaths from diabetes; during the years 1932–40 the rate per annum varied between 655 and 749, but fell in 1941 to 628 and in 1942 to 437. Later figures are not yet available.

Food Consumption of Households in the Country in Sweden in the War Years

The consumption of foodstuffs and nutritive factors in households in the country was followed by surveys similar to those described for towns, but they were made only once every six months, beginning at the end of 1940. The results appear in Table 5. The most striking changes were a not inconsiderable reduction in the supply of calories for agricultural workers, due chiefly to a reduced consumption of fat, and the marked seasonal variations in the supply of vitamin A and ascorbic acid.

TABLE 5

Index Figures for Changes in the Nutritive Value of the Diet Expressed as the Percentage of the Mean for the Fourth Quarter of 1940 and the Second Quarter of 1941

Period	Calories	Fat	Iron	Vitamin A	Ascorbic acid
			Small farmers		
4th quarter, 1940	102	102	101	123	114
2nd " 1941	98	98	99	77	85
4th " "	95	89	96	106	126
2nd " 1942	92	90	94	64	94
4th " "	88	85	88	110	126
2nd " 1943	93	93	100	72	96
4th " "	95	94	100	122	140
2nd " 1944	95	101	99	71	98
4th " "	95	99	101	114	120
2nd " 1945	96	101	108	75	81
			Landworkers		
4th quarter, 1940	103	103	101	120	116
2nd " 1941	97	97	99	79	84
4th " "	91	87	95	106	131
2nd " 1942	91	91	96	68	90
4th " "	91	83	99	109	140
2nd " 1943	92	89	98	72	96
4th " "	92	89	101	105	130
2nd " 1944	94	100	99	78	93
4th " "	90	94	96	101	109
2nd " 1945	87	91	100	71	75

Special Investigations

Food Consumption of Heavy Workers and their Families

Some special investigations were made of the food conditions of particular groups of the population. Boalt and Zotterman (1943) investigated the food of 19 lumbermen and 10 rolling-mill workers in the west of Sweden. All the foodstuffs and dishes consumed were weighed for a period of 14 days. The supply of nutrients was calculated with the help of average analyses of the composition of the foodstuffs consumed. The lumbermen, on an average, consumed 5900 Calories a day, of which 26·5 per cent. were derived from fat. This result agrees well with a similar calculation made by Tigerstedt between 1890 and 1900. The intake of Calories was in that case 6200, of which no less than 42·7 per cent. came from fat. On an average, Boalt and Zotterman's lumbermen received daily 175g. protein, 168g. fat, 882 g. carbohydrate, 1·9 g. calcium, 33 mg. iron, 2950 I.U. vitamin A, 2·7 mg. vitamin B_1 and 51 mg. ascorbic acid. For the rolling-mill workers the corresponding figures were 3960 Calories, 123 g. protein, 123 g. fat, 565 g. carbohydrate, 1·7 g. calcium, 23 mg. iron, 2750 I.U. vitamin A, 2·0 mg. vitamin B_1, and 56 mg. ascorbic acid. Thus, in this case also the supply of vitamin A was far below the desirable level. Only in three cases did it reach the figure of 4000 I.U. for the lumbermen.

In the same way Boalt and Zotterman (1944) studied the food supply of 52 households and a lumbermens' mess. In 17 households the husband was a lumberman, in 20 a rolling-mill worker, and in 15 a clerk. The total number of persons was 212, including 76 men, 59 women, and 77 children under the age of 15 years. The lumbermen had the highest energy intake with 4600 Calories. They were followed by the rolling-mill workers with 3800 and the clerks with 2600. The values for the women were strikingly low, 2500 for the wives of lumbermen and 2200 for the wives of rolling-mill workers and clerks. The energy consumption of the children rose in the main in proportion to their ages. On the basis of this investigation, the authors drew up a scale of consumption units differing from the usual one chiefly in its higher coefficients for children and lower ones for women.

In a third investigation (Boalt and Zotterman, 1946) at an ironworks, covering 75 men, women and children, in households, and 105 workers with work of varying degrees of heaviness, the results agreed, on the whole, with the earlier figures. Those who performed the heaviest work consumed about 4150 Calories a day.

Food Habits of Swedish Schoolchildren

Levin (1946) carried out a social-hygiene investigation on schoolchildren in south Sweden. The children, of whom about 97 per cent. were aged from 9 to 13 years, were made to give written answers to questions about various matters, including their diets. The standards of food and housing revealed by the children can be taken to correspond to those of the adults. There were more than 8000 children, the numbers of boys and girls being about equal. The questions about diet were so couched that it was possible to estimate the consumption of the more important foodstuffs. It thus appeared that 63·7 per cent. drank more than half a litre of milk daily; 76·0 per cent. ate at least four potatoes; 45·3 per cent. consumed vegetables once a week and 29·8 per cent. ate them twice; fruit was eaten daily by 46·4 per cent.; bacon was eaten once a week by 28·7 per cent. and twice a week by 37·0 per cent.; herrings were eaten once a week by 53·5 per cent., and other fish by 51·3 per cent. One-third of the children did not drink coffee, one-third drank one cup a day, 22·5 per cent. drank two cups, and 0·5 per cent. drank at least six cups a day. This investigation did not show that lack of any particular food was of importance in connexion with sickness or death from tuberculosis, although it was not possible entirely to exclude some effect of a low consumption of milk or vegetables. The author recommends effective propaganda for better standards of housing and diet as an important aspect of an intensified campaign against tuberculosis.

Miscellaneous Observations

Certain special inquiries were made in connexion with the investigations on consumption. One of them was concerned with the home-preserving of fruit and berries. Whortleberries, blueberries and apples constituted more than half of all home-made preserves. In another study the importance of baking in the home was investigated. A survey was made also of shopping habits, with the idea of making them less haphazard. Special inquiries referred to the food conditions in large Stockholm families in receipt of poor relief, and in large families living in subsidized dwellings. The meal conditions in certain large industries were given special attention. Other investigations were made on dehydrated foods and on the influence of different conditions of preservation, and on the effect of seasonal influences on the content of vitamin A in milk.

Vitamin Standardization

Finally, much work was done in the vitamin laboratory of the State Institute of Public Health by Dr. Brunius on the standardization of the method for estimating vitamin A. For the conversion factor relating the spectrophotometric and biological values, any value between 1200 and 3000 could be obtained by altering the composition of the diet for the experimental rats.

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July 6th, Morning Session:
Chairman, Dr. D. P. Cuthbertson

Nutrition in Poland under the German Occupation

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Unfortunately, in Poland we could not keep pace with the progress made in other countries, because almost all our research centres were closed and their staffs dispersed or imprisoned. All the same, we tried to continue our activities secretly both in collecting experimental data and in disseminating knowledge. The chief aim of these activities was to minimize the detrimental effects of the defective nutrition. For instance, the Social Relief Organization executed, on a large scale, experiments with large doses of vitamin D to prevent and cure rickets. The results were quite satisfactory. Other social organizations tried to save many thousands of political prisoners from deficiency disease by supplying them with synthetic or natural preparations, very often acquired by illegal means; secret laboratories manufactured various vitamin extracts and artificial salt mixtures.

Search for Substitute Foodstuffs

Certain researches were carried out to seek new sources of foodstuffs from raw materials not normally used for this purpose. Such were: (1) utilization of whey; (2) deodorization of beet molasses; (3) extraction of proteins from lupins and seed cakes; (4) conversion of casein as a substitute for egg albumin; (5) utilization of brewer's yeast; (6) utilization of the sediments from the centrifuging of milk as a source of protein for the purpose of acid hydrolysis; (7) preparation of vitamin concentrates of plant origin; (8) substitution of a mixture of potato starch and skim milk for rice.

Various recipes were prepared for the use of such common foodstuffs as potatoes and the cheaper vegetables, and a vigorous propaganda was made for the cultivation of fruits and vegetables in home gardens and plots.

Rations in Poland during the German Occupation

What kind of nutrition did Poland have under the German occupation? This subject is discussed in detail by Dmochowski (1944) in his work, *Food Conditions in Occupied Poland*. According to this author, official food rations in the General Government in 1941 supplied per head daily 1228 Calories, 27 g. protein, 17 g. fats, 226 g. carbohydrates, 95 mg. calcium, 608 mg. phosphorus, and 7 mg. iron.

On the basis of the dietary allowances recommended by the Food and Nutrition Board of the U.S.A. National Research Council (1943), this author calculated to what extent the daily requirements of different nutrients were satisfied in official food rations in 1941, 1942 and 1943. The results of his calculations are set out in Table 1.

In practice, the amount of food obtained was smaller, and for long periods dropped below 800 Calories, being often represented only by rye bread of extremely low quality (Belkowski, 1946). Workers and heavy workers in industry subsequently obtained daily from 1582 to 1982 Calories. Other necessary food articles had to be purchased on the black market which thus contributed much to the maintenance of the public health. It should be added that this unsatisfactory food rationing system functioned only in some of the bigger towns. The population living in smaller places received much less food or almost nothing.

The food rations were a little higher in the western parts of Poland, the so-called Wartheland, which was incorporated into the Reich, but there the black market did not exist and unrationed foodstuffs were difficult to obtain. The rations were higher for the German than for the Polish population.

Much worse was the food situation of the Jews, whose rations were very small. They were also gradually excluded from the black market.

There are several recently published papers on the nutritional conditions in the concentration camps and prisons (Sluzar, 1945; Frydman, 1946). As a whole, the fuel value of food given to the prisoners ranged between 500 and 1000 Calories.

TABLE 1

PERCENTAGE OF THE DAILY NUTRIENTS NEEDED ON THE BASIS OF THE RECOMMENDATIONS OF THE U.S.A. NATIONAL RESEARCH COUNCIL (1943) WHICH WERE SUPPLIED BY THE OFFICIAL FOOD RATIONS IN THE GENERAL GOVERNMENT IN 1941, 1942 AND 1943

Groups of consumers	Calories per cent.	Protein per cent.	Fat per cent.	Calcium per cent.	Iron per cent.	Vitamin A per cent.	Vitamin B_1 per cent.	Vitamin C per cent.
				1941				
Children to 3 years ..	107	80	45	39	73	114	146	81
Children 3 to 10 years ..	60	49	35	24	56	55	85	58
Children above 10 years	35	27	24	7	36	27	53	38
Adults	45	36	34	12	58	17	100	63
Pregnant women ..	49	32	17–34	7	47	15	51	19
Nursing women	41	27	17–34	5	47	12	40	13
				1942				
Children to 3 years ..	95	80	25	39	60	51	159	92
Children 3 to 10 years ..	33	49	20	24	46	25	96	68
Children above 10 years	32	27	14	6	30	12	60	46
Adults	49	44	22	14·9	54	6	131	118
Pregnant women ..	55	39	11–22	8	40	5	66	36
Nursing women.. ..	46	33	11–22	6	40	4	51	24
				1943				
Children to 3 years ..	70	68	30	40	64	31	144	107
Children 3 to 10 years ..	36	31	19	7	48	2	86	72
Children above 10 years	26	23	9	26	40	1	60	82
Adults	43	39	20	11	44	5	104	52
Pregnant women ..	47	34	10–20	6	33	4	52	25
Nursing women	39	29	10–20	4	35	3	41	17

Nutritional State of the People of Poland during the German Occupation

Descriptions of the symptoms of starvation are well known; great loss of weight, diminished resistance to various diseases, diarrhoea, frequent urination at night, nervous disturbances, skin diseases, kidney and liver disturbances and oedema were outstanding symptoms. Some cases of bone decalcification followed by vague rheumatic pains alleviated by treatment with vitamin D, were also noted. Oedema was present in most of the people who came back from the concentration camps and from compulsory labour (Szczygieł, unpublished data). Of the deficiency diseases, scurvy involving the loss of teeth was most common. The most serious consequence of the prolonged underfeeding was tuberculosis and liability to typhus fever and other infections. In one of the Jewish concentration camps three-quarters of the prisoners had oedema (Szczygieł, unpublished data). Their food consisted of very small amounts of bread and watery soup made of barley grits or damaged oat flakes, with huge quantities of sodium chloride. Their physical state was deplorable, but after some changes in the diet all pathological symptoms disappeared within 3 to 4 weeks. The most tragic conditions due to lack of food were described by Professor Hirszfeldowa (1946), who believes that in the Warsaw Ghetto the majority of the infants died from hunger. She says that some Jewish authorities, responsible for the distribution of food, had to withhold it from small children in order to save older ones, but even this did not help the latter. It should be mentioned that a group of Jewish scientists, in spite of their hopeless situation, carried out research work in the Ghetto on the effects of hunger. As one manuscript was saved it will be a great contribution to this subject.

It is estimated that at least one-third of the population simply starved. The food situation did not improve rapidly after liberation, many additional difficulties having arisen from the large-scale migrations of the people to their original or to new homes. Due to the relief action of the United Nations extreme starvation was alleviated, but there is still considerable food shortage, so that in some hospitals even now the patients must have additional food from their families.

It is important to assess the extent to which these food conditions have affected the health of the people as a whole. Up till now we have no exact data on this subject, but we shall collect them. The infant mortality doubled, amounting to some 25 per cent., and we observed a low vitality in newborn children, and numerous cases of spontaneous abortion, especially among women who had been for a long time in a concentration camp (Szczygieł, unpublished data). Investigations were made on the physical development of children in comparison with that observed before the war, and we hope to publish the results.

A special committee has been created to work out a plan to mitigate the detrimental effects of war conditions, and the Polish Government takes special care of the infants, children and pregnant women (Skokowska-Rudolfowa, 1946). Attention is paid to the nutrition of workers, and the service of lunches in factory canteens plays a special role, the object being not only to cater for the actual needs in working hours, but also to correct defective feeding at home.

All these problems need time and much effort, and we hope that international co-operation in the field of nutrition will greatly help us in this respect.

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Malnutrition in Java during the Japanese Occupation

Professor A. G. van Veen (Eijkman Institute and Medical School, Batavia, Dutch East Indies)

As I have only just returned from Java, where I was a prisoner, I have had no time to prepare a lecture. Directly after the Japanese invasion most of the numerous Europeans and Eurasians, and a few Chinese, were put into prisons and camps. During the months that followed the rest of the Europeans, the greater part of the Eurasians, and many more Chinese underwent the same fate, not only the men, but also all the women and children.

As the Japanese very soon started to requisition rice, buffaloes and other agricultural products and livestock, the Indonesian population of Java, about 45,000,000 people, mostly peasants, reduced their production of food crops considerably, as happened in many other occupied countries in this and former wars, growing only as much as would supply their own needs. The Japanese took many other measures which were harmful to food production; transport possibilities for staple foods were reduced to nil in many regions, which was especially harmful to the less fertile parts of the island. According to Japanese records, the rice harvest in 1944 was reduced to about two-thirds of that of 1940, and the production of maize, tapioca (cassava-root) and soya beans by more than half. Moreover, infectious diseases, plague, framboesia and malaria, no longer combated, spread very quickly, so that the state of the public health grew worse and worse. In many regions starving people could be seen everywhere, and nutritional oedema was especially widespread. It is, however, quite impossible to give more details or exact information because, at that time, nearly all medical staff and nutrition workers were living in camps and prisons.

Diet in the Civilian Internment Camps

More can be said about the tens of thousands of internees. After some time they were all put on a diet consisting of about 90 g. polished rice and 180 to 200 g. so-called Asia flour. This is a mixture of about 50 to 60 per cent. tapioca, 35 to 30 per cent. whole-maize flour and 15 to 12 per cent. whole soya-bean flour; this mixture, when not more than 1 or 2 months old gives, after treatment with yeast, a very good-looking and palatable bread, but the flour very soon begins to deteriorate and develops an intense bitter and rancid taste, though goodlooking bread can even then be baked with it. There was, in addition, a daily allowance of 20 g. sugar which was very often not issued, 20 g. salt, vegetables mostly of poor quality and not fresh, and sometimes fruit such as bananas, pineapples and mangoes, usually unripe or rotten.

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The quantities of meat, fish, eggs, legumes and fats were very small indeed, almost negligible, especially at the end of 1944 and in 1945. In my camp the daily supply of milk was 50 to 80 l. for 7000 to 10,000 internees; it was reserved for the hospitals. For persons doing hard work there was, in some camps at least, an extra allowance of bread, but in many cases the quantity was not sufficient to meet the extra bodily requirements. There were usually no special articles of food granted for the very numerous hospital patients and sick people; the more or less healthy internees had, therefore, to give up the best part of the camp food, the milk and eggs, the small quantity of really good vegetables and the ripe fruit, to the sick. This demanded much self-sacrifice from the so-called healthy section of the camp inhabitants; at one time there were in my camp, in a total population of about 7000, not less than 1500, of whom 500 were in hospital, who required special diets because of intestinal disturbances, severe deficiency diseases, and so on.

Much was done in many camps by making food yeast, or preparing tempe, a very palatable and easily absorbed soya-bean product prepared by the aid of a fungus, or tahoe (soya-bean curd) or maize malt. The Japanese were not, in general, interested in the efforts of the scientists among the internees to help their ill and starving countrymen in this way, but they did not obstruct. It will be clear that the diet described above, which was not always edible to the extent of 100 per cent., containing only about a 1000 Calories and on the average 17 to 18 g. of protein, had a detrimental influence on the health of the internees. It will be clear also that, although the efforts mentioned above made by internees were of great use to the many sick and underfed, they had relatively little influence on the underfeeding of the whole, as they did not produce more calories, and only better, but not more, protein. Happily, however, most Japanese camp officials were quite willing in their own material interest, to help to smuggle food and money into the camps and prisons, and this was of great help. In one camp it was possible in this way to raise the average diet in the middle of 1945 to about 1600 to 1800 Calories, and 35 to 40 g. of protein, per head daily. In many camps, however, especially in the women's camps, there were no such possibilities.

For the production of dried yeast for food, various sources of nitrogen were used, soya beans, beans of *Vigna sinensis*, kachang idju (*Phaseolus radiatus*), decayed fish, fish paste, rice bran, livers of sick cows, and even ammonia out of urine. In many cases it was necessary also to make the sugar for yeast production. It was possible to prepare in considerable quantities a very good grade of maize malt, which could be used to hydrolyse great quantities of tapioca, ground maize, old Asia flour, sweet potatoes, and so on. It should be added that all sorts of vessels and apparatus had to be constructed by the internees without any facilities from the Japanese. Bakery yeast had to be cultivated, for which the Japanese gave soya-bean flour, and later on only rice polishings. Alcohol was distilled in improvised apparatus, to be used for heating purposes and, with the aid of malt, for the preparation of tonics. Acetic acid was produced with the aid of bacteria, and was used for the extraction of rice bran in order to get concentrates of vitamin B_1. These various expedients could, however, be realized in only a few camps, and not in the women's camps where the food situation and the general treatment were worst.

Occurrence of Deficiency Diseases

Clear-cut deficiencies were seldom seen in spite of the lack of numerous factors in the diet. The main characteristic psychological symptoms, seen in nearly all the camps, were apathy and sleepiness of most of the underfed people, loss of memory and of ability to concentrate, and, in contrast with this, often a very high irritability. In some cases there were complaints of "burning" feet and hands; there was also quite a number of cases of so-called "camp eyes", a kind of partial blindness in which frequently the fundus of the eye was attacked. The aetiology of this last disease is not clear; it may have had something to do with the B vitamins, but in several cases recovery occurred quite spontaneously, even on the poor camp diet. Beriberi was almost never seen, as might be expected on such a low-calorie diet. Polyneuritis was present, also a few cases of real pellagra and very many cases of skin symptoms, often called "pellagroid". These last were usually successfully treated with food yeast. Vitamin C deficiency was observed only in a few cases. The number of all these diseases, or symptoms of diseases, was low compared with the great number of cases of nutritional oedema which, especially in the Bandung Camps, were often accompanied by diarrhoea and dysenteries, though in very many cases no dysentery bacteria or amoebae could be found. Polyuria and nycturia were often seen before the onset of oedema. There were no laboratories so that analytical work could not be done, and there were scarcely any drugs or vitamin preparations except food yeast.

There was one lucky circumstance; before the war broke out quite a number of scientists had had to deal with the problem of food yeast production and also with nutritional oedema and hypoproteinaemia. This helped the work in the camps. It may be added that, once nutritional oedema has set in, it takes a very long time before it absolutely disappears or before the danger is gone of its reappearance after strong muscular exercise or excessive intake of salt, even when there has been prolonged feeding with diets high in calories and in protein. The question of the genesis of nutritional oedema would not, therefore, appear to be as simple as is often supposed; it seems as if the changes in the oedematous tissues are profound, and that the return to the normal state does not take place easily if the oedema has existed for some time.

Recent Nutritional Research in the United States

Professor C. G. King (The Nutrition Foundation, Inc., Chrysler Building, New York, 17, N.Y., U.S.A.)

Few events in recent years have warmed the hearts of American nutrition workers so much as the arrival of Sir John Boyd Orr and members of his staff to direct the work of the Food and Agriculture Organization of the United Nations. His resounding counsel to strengthen scientific research and to cultivate its application for human betterment is welcomed most heartily.

Nutrition scientists feel grateful also that Surgeon-General Thomas

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Parran has been elected President of the World Health Organization of the United Nations, because he has a real appreciation of the value of basic research and its applications in the field of nutrition.

Food Research in the War Period

During the war years in the United States there was a natural tendency to over-emphasize immediate objectives but, as time went on, recognition grew that practical results often came more quickly to a relatively fundamental approach. There was an unprecedented development of team work between academic and practical-minded men.

In the study of military projects, the following may be of interest.

(*a*) For withstanding exposure to high temperature, earlier emphasis on salt requirements gave way to an emphasis upon water intake accompanied by use of more salt in the food.

(*b*) Those working on Army rations were convinced of the importance of supplying some food that was distinctly fresh, and of paying more attention to palatability, variety and blandness of flavour where there is continuous use, and to ease of preparation.

(*c*) Altitude tolerance was increased by about half a mile if meals before and during flight were relatively high in carbohydrate. A special flight feeding manual was prepared for the aviation forces.

(*d*) The discolouration of dehydrated vegetables and fruits was recognized as being due chiefly to a direct carbohydrate-and-amino-acid type reaction, and not to enzymic oxidation; control was, therefore, directed to keeping moisture and temperature low. Striking improvements were achieved in preparing dehydrated sweet potatoes, powdered milk, ice-cream mix and eggs.

(*e*) The armed forces, with other agencies, succeeded in establishing quickly, on islands in the Pacific, farms of 5000 acres for rapid production of fresh foods.

(*f*) The American Red Cross was very active in educating the general public in nutrition and will continue to do this permanently. It worked in close co-ordination with the Public Health Service and the Department of Agriculture.

Many foods were rationed during the war period, with an emphasis upon fair distribution of meats, butter, sugar, fats, fluid milk and canned goods. Distribution was controlled also through Government allocation, price ceilings and subsidies.

Because of many factors, including public education in nutrition and increase of income among large groups, there was an apparent net gain in the general nutritional status of the population which, through lack of well organized nutritional surveys could not, however, be accurately assessed.

Food production was increased by about 30 per cent. despite severe restrictions in manpower and equipment.

Basic Advances in Science

Advances have been fairly rapid toward recognition of new, unstable nutrients, two of which, thus far, are known to be required by experimental animals only, and a third, folic acid, is now known to be essential for man and at least five species of animals (Berry, Spies and Cline, 1945; Berry, Spies and Doan, 1945; Darby and Jones, 1945; Moore, Bierbaum, Welch and Wright, 1945; Spies, Vilter, Koch and Caldwell, 1945; Darby, Jones and Johnson, 1946; Anonymous, 1946, 1, 3; Spies, 1946).

Amino-acids

The human requirement of amino-acids has been studied intensively by Professor W. C. Rose, at the University of Illinois. There will appear shortly a series of papers giving a fairly complete picture of the qualitative and quantitative requirement for each of the eight amino-acids found to be essential. These are: valine, leucine, *iso*leucine, phenylalanine, lysine, methionine, threonine and tryptophane. A great surprise was provided by finding no evidence of a human need for histidine (Rose, Haines, Johnson and Warner, 1943).

Of special interest is the finding that the relative quantities of the amino-acids needed by man are very different from those required by the albino rat. These observations together with others of the needs of guineapigs and chicks form an interesting series of studies in comparative biochemistry, since each of the four animals showed distinct differences from the others.

At least four laboratories have reported that special nutritive value is associated with protein fragments of polypeptide nature, analogous to the "strepogenin" factor studied by Dr. D. W. Woolley at the Rockefeller Institute (Sprince and Woolley, 1945; Womach and Rose, 1946; also Abstracts of Papers, 109th Meeting, American Chemical Society, Atlantic City, N.Y., 1946).

Methods of estimating amino-acids have been revolutionized. Microbiological procedures have been developed in a number of laboratories but especially by Professor M. S. Dunn at the University of California in Los Angeles. With standard cultures of bacteria, Dr. Dunn has devised quantitative methods applicable to almost all the amino-acids. The methods are more sensitive, more specific and far simpler than chemical ones, and are being adopted widely (Dunn, Shankman and Camien, 1945, 1, 2, 3; Anonymous, 1946, 4).

Detailed steps in the synthesis of amino-acids by plant cells have been observed by Professor G. W. Beadle and his associates at Stanford University as part of his classical studies in the biochemistry of genetics (Beadle, 1945, 1, 2). The indole-serine-tryptophane series of reactions, the methionine-to-choline conversion, and the ornithine-urea cycle were studied with strains of *Neurospora* developed by exposure to X-rays. These "tailor-made" organisms can be used with gratifying frequency for analytical purposes in dealing with amino-acids and their derivatives.

Vitamin B_6

Progress has been made with the specific reactions for which vitamin B_6 and its derivatives serve as catalysts. One group of enzymes containing pyridoxal phosphate is active in transaminations and another is concerned with decarboxylation of amino-acids (Gunsalus, Bellamy and Umbreit, 1944; Axelrod, Morgan and Lepkovsky, 1945; Green, Leloir and Nocito, 1945; Gunsalus and Umbreit, 1945; Lichstein, Gunsalus and Umbreit, 1945; Snell, 1945; Gunsalus, Umbreit, Bellamy and Foust, 1945).

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Carbohydrate Metabolism

In the field of intermediate metabolism, Dr. Carl Cori and his associates at Washington University have followed up the earlier success in isolating the enzyme by which glycogen is formed in animal tissue, by isolating additional enzymes which control sugar phosphorylations. Then followed the demonstration that two hormones, insulin and the anterior pituitary hormone, counterbalanced one another in regulating the activity of the specific enzyme which controls formation of glucose-6-phosphate. The pituitary hormone inhibited the enzyme but insulin removed the inhibition. Observations with albino rats, when normal and when rendered diabetic by alloxan poisoning, furnished evidence of the physiological reality of the relationships discovered *in vitro*. These findings seem especially notable in that they furnish a molecular basis for interpreting hormone function (Price, Cori and Colowick, 1945).

Interest has been stimulated in seeking the cause of diabetes in man, and in the further prospect that the disease might be prevented if the aetiology was known at an early stage. It is estimated that in the United States from 0·5 to 1 per cent. of the population has diabetes or a measurable dysfunction of diabetic type.

Degenerative Diseases

Research on degenerative diseases has become of increasing interest to nutrition workers. There has been so much evidence of injury to the liver, kidneys, intestinal tract, heart and blood vessels from studies of malnutrition in experimental animals that it seems reasonable to search more carefully for relationships of this nature in the human population. In this sense, obesity should be included within the scientific category of malnutrition; this point deserves emphasis, and excessive body-weight might well be recognized as evidence that one is "anti-social".

Choline deficiency is receiving attention because of the associated liver and kidney injury in experimental animals. Recently a group at the Alabama Polytechnic Institute has observed a high incidence of tumours in animals subjected to choline deficiencies (Copeland and Salmon, 1946).

Dental Caries

Rejections from military service on the basis of initial physical examination, when the first 2,000,000 men were called, showed a state of dental decay that was shocking to many students of public health in America. Approximately one man in five of those rejected on physical grounds failed because of dental defects. The number rejected was so great that dental standards were practically dismissed. To quote a member of the Surgeon-General's staff, the dental requirement was reduced to the point of "having two jaws".

Dr. P. C. Jeans and his associates at the University of Iowa have been able to demonstrate essentially complete protection against dental caries by providing a good diet. In efforts to identify the nutritional factors of major importance, attention has been focused upon the fluoride content of drinking water. This relatively new factor is probably significant, but it seems unreasonable to attribute to it a unique position. At least eight other nutrients are essential for normal tooth development and for preservation of the supporting tissues, so that the need is for a good all-round diet rather than for a few specific nutrients.

The cotton rat has become a valuable test animal in dental research (Schweigert, Shaw, Phillips and Elvehjem, 1945; Anonymous, 1946, 2; Schweigert, Shaw, Zepplin and Elvehjem, 1946), and considerable emphasis is being placed upon studies with monkeys (Waisman, Rasmussen, Elvehjem and Clark, 1943; Shaw, Elvehjem and Phillips, 1945).

Folic Acid

Interest has been widespread in the isolation, identification, synthesis and clinical use of folic acid. This new member of the vitamin B complex, as isolated from liver, contained a pterin unit conjugated with *p*-aminobenzoic acid and one molecule of glutamic acid. When isolated from the products of fermentation, it contained 3 units of glutamic acid and the product from yeast contained 7 units of glutamic acid. The acid units are linked in a simple peptide chain.

Within a short time after the synthetic compound became available clinical groups at the University of Cincinnati, Vanderbilt University, Washington University and Tulane University demonstrated its value in treating numerous forms of macrocytic anaemia and sprue. Many cases also of pernicious anaemia showed a positive response (Berry, Spies and Cline, 1945; Berry, Spies and Doan, 1945; Darby and Jones, 1945; Moore *et al.*, 1945; Spies *et al.*, 1945; Darby *et al.*, 1946; Anonymous, 1946, 1, 3; Spies, 1946). Spies has reported improvement in human bone marrow within 24 hours after administering the vitamin. Dr. Day at the University of Arkansas, who had earlier studied the factor as vitamin M, has reported rapid recoveries from intestinal infections, leucopenia and anaemia in monkeys.

Human studies, in process of publication, by A. C. Ivy at Northwestern University and by C. G. King at Columbia University, with their respective colleagues, have shown that depletion on diets low in folic acid is very slow.

Interrelationship of Tryptophane and Nicotinic Acid

Dr. C. A. Elvehjem's discovery of a reciprocal relation between tryptophane and nicotinic acid in the protection of dogs against blacktongue, has given a basis for interpreting the relationship of maize to pellagra and affords an explanation of the role of high-quality protein foods such as milk in preventing pellagra, even though they may contain little nicotinic acid (Krehl, Teply and Elvehjem, 1945; Krehl, Sarma, Teply and Elvehjem, 1946; Rosen, Huff and Perlzweig, 1946).

Assessment of Nutritional Status

The clinical problem of identifying the milder forms of malnutrition continues to be a very active field of investigation (U.S.A. National Research Council, 1943; Adamson, Jolliffe, Kruse, Lowry, Moore, Platt, Sebrell, Tice, Tisdall, Wilder and Zamecnik, 1945).

A group at Vanderbilt University has confirmed earlier reports that simple iron deficiency can cause cheilosis and changes in the mouth like the lesions commonly attributed to riboflavin deficiency.

In microchemical studies of blood analysis, the Public Health Research Institute in New York has devised quantitative methods permitting accurate analysis for haemoglobin, plasma protein, vitamin C, vitamin A,

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carotene, phosphatase, riboflavin and iron in blood samples obtained from fingertips or ear lobes; about three drops of blood are sufficient. The possibility of making so many tests on blood samples, that can be taken quickly and without the use of a hypodermic needle, has added an excellent technique for making nutrition surveys. For example, in a recent study of a New York public school, two chemists with one assistant each were able to obtain samples from 80 schoolchildren in about an hour and a half, and had completed most of the analyses just referred to by the third day. The objectivity and reliability of blood analyses for specific nutrients should add much to the confidence felt in the results of nutrition surveys from areas where striking clinical lesions are not observed and where the aetiology of them is uncertain. The Surgeon-General of the Army and the Surgeon-General of the Public Health Service have adopted the technique, suitably adapted, for use in field laboratories (Lowry, 1945; Bessey, Lowry and Brock, 1946; Lowry and Bessey, 1946).

Diet in the Promotion of Health

A handicap in nutrition education is inherent in the difficulty of obtaining sufficient evidence of health impairment that is associated specifically with intermediate degrees of deficiency or excess (Hoobler, 1944). Professor H. C. Sherman at Columbia University has recently made experiments with animals in this field. With his well known diet No. 16, consisting of one part of milk solids and six parts of whole wheat with salt, known to be adequate through 58 generations, he doubled the vitamin A intake and kept all other factors constant. The life span, fertility and regularity of growth of the animals were distinctly improved (Sherman, Campbell, Vdiljak and Yarmolinsky, 1945). Doubling the vitamin A intake a second time afforded additional but less marked gains. The initial level of vitamin A in these experiments was about equivalent to the standard currently accepted in human feeding.

At Harvard University, Dr. Harold Stuart, Mrs. Bertha Burke and their associates have studied for 12 years the relationships between the diet patterns of mothers, their health records, and those of their infants in the first two weeks of life (Burke, Beal, Kirkwood and Stuart, 1943, 1, 2; Burke, Harding and Stuart, 1943). The findings were striking, and showed that the prospect of an infant being essentially in perfect health was many times greater with diets classed as excellent or good than with diets classed as poor or very poor. The risk that an infant would show two or more definite signs of physical impairment was more than six times greater in the poorly nourished group. There was a high incidence of pre-eclampsia among the poorly nourished mothers and almost none among those receiving good diets.

Similar programmes of study have been inaugurated at the University of Colorado, Vanderbilt University, Tulane University and the Mayo Clinic. These studies will be watched with great interest because, if the findings reported above from Boston, and similar findings at Philadelphia and Toronto, can be confirmed in other areas, a great impetus will have been given to the concept of nutritional benefit in a region of physiology not associated with deficiency diseases.

The value of diets providing from 200 to 250 g. protein per day, for promoting convalescence from infectious hepatitis has been of wide interest. The Army and Navy medical groups are agreed that the time of convalescence after liver injury in such cases can be about halved and that the incidence of complete recoveries is increased.

In the Harvard studies just referred to, the one nutrient showing correlation with a superior health record among mothers and infants was protein. However, the high-protein diets probably were characterized broadly by high intakes of other nutrients, particularly of the B vitamins, including those not well identified, and of some minerals, such as iron and copper.

Basic studies of the composition of human milk are under way at the Children's Fund of Michigan by Dr. Icie Macy Hoobler and her associates. The entire September 1945 issue of the *American Journal of Diseases of Children* carries a summary of one major phase of their work together with a closely related paper from Cornell University. It is interesting to note the wide differences recorded for the composition of human and cow's milk. Differences by a multiple of two or more were found for riboflavin, vitamin C, folic acid, nicotinic acid, vitamin A, vitamin B_1, pyridoxin and biotin.

Comment must be made on the service that was rendered by the National Research Council in promulgating the recommended dietary allowances early in the war period. Many investigators, particularly those with little experience in experiments with animals, and others who misunderstood their purpose, were hesitant to accept the levels. The committee men responsible for assembling the data do not feel that the figures represent in any sense final values, but they do feel that they are reasonable values when interpreted in the light of all available evidence.

In looking forward, there is a tendency to emphasize: (1) basic studies of how the nutrients function in living cells, as a guide in medical and agricultural science; (2) long-time studies of human nutrient requirements, on a quantitative basis; (3) special research in nutrition during gestation, lactation, infancy and old age, as contrasted with former emphasis upon growth rates; and (4) investigation of specific aspects of public health in which nutrition may play a dominant but undetected role, as in dental caries, low resistance to infections, and degenerative diseases of the liver, kidneys, heart, vascular system and intestinal tract.

There is encouragement in the growing recognition of nutrition as a field of specialization in schools of medicine and public health. Equally challenging is the task of accomplishing the needed education, so that practice in regard to food will be commensurate with the advance in knowledge of nutrition.

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July 6th, Afternoon Session: Chairman, DR. L. J. HARRIS

Nutrition Problems and Research in Belgium during and since the War

Professor E. J. Bigwood (Faculté de Médecine, 115, Boulevard de Waterloo, Brussels, Belgium)

The Food Problem

During the early period of the Second World War, from 1940 to 1942, the calorie intake of the people of Belgium dropped considerably below the level of physiological requirements, lack of fats and animal protein being the predominant features. Since 1943 up to the present time, the average calorie level has gradually increased. No exact figures are available at present as to the amounts for different population groups. Black-market practices have not yet been ruled out entirely. In urban centres, the official ration of the normal consumer is at present about 1800 Calories, of which 41·3 per cent. is derived from 300 g. of bread. This ration does not include milk which is exceedingly scarce; the consumption of milk is of the order of 120 to 150 ml. per day and per head of the whole population, but it goes chiefly to children, expectant and nursing mothers and sick people. Green leafy vegetables, fish, game and poultry also are not rationed. The fat ration amounts to 32 g., which is about 50 per cent. of the pre-war figure. The increase in calories which has taken place has been obtained chiefly with carbohydrate (Bigwood, 1946).

Before the war consumption of protein amounted to about 75 g. per head daily; this was an average figure for the entire population, and included 28 g. of animal protein. Intake of calcium was low and averaged between 0·5 and 0·6 g. in a diet of 2800 Calories. Home-produced foods supplied only 1500 Calories, a little over one-half of the total figure of 2800. Milk, butter and meat were chiefly home-produced. This situation could be maintained only as long as Belgium found it possible to import about 2 million tons of oil-seeds and feeds in addition to about 1 million tons of breadstuffs.

To-day Belgium's most pressing shortage is of protein and calcium (Bigwood and Demerre, 1945).

The Problem of Protein

The figures already mentioned for the pre-war consumption of protein can be analysed as follows:

Animal protein, 28 g.	Meat	12·0 g.	
	Fish	3·0 g.	
	Milk	7·6 g.	
	Cheese	2·7 g.	
	Eggs	2·7 g.	
Vegetable protein, 47 g.	White bread ..	32·5 g.	(435 g. bread)
	Potatoes	8·5 g.	
	Miscellaneous ..	6·0 g.	

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The animal protein produced at home does not now, most probably, exceed 45 to 50 per cent. of the pre-war supply, so that there is a deficit of about 14 g., which imported meat products have reduced to about 11 g.

In addition, the pre-war figure of 32·5 g. wheat protein has now dropped to about 26·5 g. due to the reduction of the bread ration to 300 g., but this loss is, in turn, partially balanced by a gain of about 4 g. achieved by raising the percentage extraction of flour to 82 to 85 from 70 to 72.

In comparison with the pre-war intake, the total protein deficit thus amounts to about 17 g., 11 g. of animal protein and 6 g. of vegetable protein. Even when the closest possible estimate of game and poultry consumption is included there is still a deficit of about one-fifth. These estimates must be regarded as approximate, but they are the best summary that can be made of the present general situation. It is difficult to see how this substantial deficit can be made up within the next few years, except by fortifying bread with soya flour. If 7 per cent. only of properly processed soya flour were added to wheat flour, 400 g. of bread would supply about 10 g. of high-quality protein and bridge the gap by about 60 per cent. The complementary value of soya protein towards wheat protein makes this combination a very satisfactory one. This is a question of great practical importance and deserves close attention.

The Problem of Calcium

The pre-war daily consumption of calcium was about 0·6 g., of which milk and cheese were responsible for about two-thirds; the 0·4 g. from this source has now been about halved. The total average calcium consumption is, therefore, probably about 0·4 g., and is certainly less than 0·5 g. The Belgian milk problem is one not only of raising the output but also of improving the quality to the consumer. This question was discussed at one of the recent meetings of the Academy of Medicine, by Brull, Bigwood and Marcq (1946), and is being dealt with also by the *Oeuvre Nationale de l'Enfance*.

The State of Nutrition of the Population

Hunger Oedema

During the early part of the war, the dominant form of malnutrition was hunger oedema. The question was studied from different angles by P. Govaerts in Brussels, by L. Brull in Liége and by E. F. Simonart in Louvain. In Brussels University Hospital alone, 159 cases were treated in 1941, 118 in 1942, 38 in 1943, and 4 in 1944. The sudden drop early in 1943 coincided with the distribution of exceptional supplies of herrings from the fisheries along the Belgian North Sea coast. At the same time the country was gradually organizing its black market on a large scale.

Govaerts analysed the condition chiefly from the aspect of metabolic, osmotic and circulatory disturbances. His careful study of 48 cases was published in 1942 (Govaerts and Grégoire, 1941; Govaerts and Lequime, 1942). The protein reserves of all the subjects were severely depleted; their total protein consumption for a long time had not exceeded 25 g., with a diet supplying not more than 1300 Calories. The values for total plasma proteins, determined refractometrically, varied between

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3·7 and 6·0 g. per 100 ml. in 20 subjects out of 48; they fluctuated between 6 and 7 g. in 15 cases and were as high as 7·0 to 8·5 g. in three instances only. The osmotic pressure of the blood plasma which corresponds normally with a column of 35 to 40 cm. of normal saline solution, was below 20 cm. in 15 subjects out of 36, the lowest figure being 12; it varied between 20 and 30 in 18 cases and was as high as 30 to 35 in three instances only. Roughly speaking, the protein level and osmotic pressure were often fairly well related to one another, though in many cases no correlation was found. The osmotic pressure per g. of total protein was usually lower than would have been expected from the total concentration of protein and from the albumin-globulin ratio determined by Howe's method; it varied, for instance, between 22 and 30 cm. in the 15 cases with a plasma protein level of 6 to 7 g. In one case it was only 29 cm. though the concentration of total proteins amounted to 8·1 g. It looks as if, in nutritional oedema, the plasma proteins may be profoundly altered in quality and in their physical state of dispersion. The interesting finding is, therefore, that, in contrast with that in other types of oedema, the osmotic pressure of the blood plasma in nutritional oedema may be definitely below normal even when the protein concentration is normal or slightly subnormal.

In all Govaert's patients the basal metabolic rate was lowered by 10 to 60 per cent. even after resolution of the water retention. Marked bradycardia was the rule. The arterial pressure was low. The venous pressure was frequently normal contrary to what is seen in cardiac oedema; it varied between 5 and 9 cm. in one-third of the cases and exceeded 12 cm. in only about one-fifth of them; it showed a tendency to reach abnormally high levels after muscular exercise. Electrocardiograms showed waves of low voltage and a delay in the QT time. Blood flow was slowed down and the cardiac output was low. Polyuria was pronounced, particularly when the subjects were kept in bed, and nycturia was a common complaint long before oedema appeared. The accumulation of water could be dissipated simply by complete rest in bed, though it recurred soon after leaving hospital unless some adjustment of diet was made.

Brull's findings in Liége were similar, but he believed that prolonged protein deficiency would produce a defect of renal function affecting water and urea output (Brull, Barac, Brakier-Zelkowiecz, Clémens, Crismer, Deltombe, Divry, Dubois, Dumont, Dumont-Ruyters, Lambrechts, Neuprez, Nizet, Op de Beeck, Piersotte and Thomas, 1945). In Louvain Simonart investigated the influence of vitamin B_1 on nutritional oedema. His cases differed from those of Govaerts and Brull: They were severe ones of prolonged oedema among prisoners in the Louvain penitentiary. Neuromuscular symptoms associated with vitamin B_1 deficiency were observed; they included muscular weakness, pains in the limbs, paraesthesia, numbness of the extremities and a tendency to high values for pyruvic acid in the blood. Pyruvic acid was estimated by Straub's method as applied to blood filtrates by G. Delrue and J. de Keyser in 1940, pyruvic acid reacting in strong alkali with salicylic aldehyde to develop a red colour due to oxybenzopyruvic acid. Such high levels of pyruvic acid tended to return to normal under the influence of rest in bed, and to rise after muscular exercise. Simonart claims that administration of crystalline vitamin B_1 alone, in large intravenous doses reaching eventually 100 or 200 mg. daily, would produce a pronounced diuretic effect and the disappearance of the oedema, although his patients had not been put at rest and their diets were unchanged during the treatment. Since the aetiology of nutritional oedema is still very obscure, these various factors in addition to the osmotic factor cannot be neglected altogether (Simonart, 1941, 1942, 1, 2, 1943; Simonart and Devis, 1942).

Other Aspects of the State of Nutrition

Many determinations of body-weight and of growth curves were made in various parts of Belgium during the occupation. Stunted growth was reported, and loss of weight in adults was most pronounced in 1941. Serum-protein levels were reported to be low in 1941–42 in several surveys among subjects with no evidence of oedema. In Liége, however, the value averaged 6·99 g. per cent. among 3000 subjects in 1943 and 1944. In this same area, values for carotene and vitamin A in the blood were found to be normal in Brull's patients. Correct interpretation of such vitamin values is, however, debatable when they occur among people living on diets very low in calories.

At the present time, as has been already stressed, the two main problems are those of protein deficiency, independent of the occurrence of oedema, and of calcium deficiency. As soon as adequate funds are available, it is intended to investigate the situation from these two points of view in large groups of the population. Average levels of plasma protein would be determined in various population groups by Linderstrøm-Lang's specific gravity gradient-tube method. A point which does not seem to be adequately established is the lower limit of normal variation for these values. It is sometimes set at 6 g. per cent., but it seems improbable that this is correct.

Adequate methods of approach to the study of the problem of calcium depletion are scarce. The one which seems most promising is that of P. Beery Mack (private communication) at Philadelphia State College based on determination of the mineral density of bones, with X-ray tracings obtained photometrically against an ivory scale as standard of reference.

It might be mentioned in conclusion that nutritional riboflavin deficiency was not detected among undernourished people in occupied Belgium, as judged from urine analysis, according to J. van den Broecke (1943) in Professor Hoet's laboratory although, according to Hoet, cases of conditioned deficiency seemed to appear occasionally among certain patients.

In Vienna in 1917 and 1918, Riehl reported the appearance of special forms of melanosis which he called "*Kriegsmelanose*" and which he attributed to the war bread (Riehl, 1917). Other clinicians reported similar cases in several German cities at that time. The melanosis appeared chiefly on the face and other exposed parts of the skin and had no effect on the general condition. It was reported in Belgium during and since the present war, and is being investigated. Other findings have been reported in relation to malnutrition in Belgium during the war, including the effect on tuberculosis, but this cannot be considered in so short a summary.

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Observations on Nutrition in France from 1940 to 1945

Dr. J. Trémolières (Department of Nutrition, National Institute of Hygiene, Paris, France)

In 1940, changes in the French diet gave rise to nutritional conditions which provided an interesting experiment.

The matters which will be considered are the food intake as it was observed, and the effect of the changes in it on mortality, on growth and weight increase and on the clinical signs of malnutrition. Biochemical tests for malnutrition will be discussed also.

Actual Consumption of Food in France from 1940 to 1945

With methods based on those described by Bigwood (1939), surveys were made of the quantities of food consumed in Marseilles, in Paris and in rural areas.

Marseilles

In Marseilles surveys were made frequently by the local branch of the National Institute of Hygiene, established previously by the Rockefeller Foundation. The changes in average consumption of food per head daily in Marseilles are shown in Table 1.

Further details of the quantities of food, and of the vitamin content in relation to the various age categories and social strata and in comparison with official rations will be found in Youmans, Chevallier and Kuhlmann (1942), Kuhlmann (1944, 1945) and Trémolières and Alison (1946, 1, 2).

Paris

Up to the time of liberation information as to food consumption in Paris is fragmentary. Table 2 shows estimates for the period preceding the liberation. After the liberation the figures come from surveys made by the Institut d'Hygiène Alimentaire (Trémolières and Alison, 1946, 1, 2).

TABLE 1

AVERAGE DAILY CONSUMPTION OF NUTRIENTS PER HEAD IN MARSEILLES IN THE YEARS 1941–45

Year	Number of individuals observed	Calories	Carbohydrate g.	Fat g.	Protein: Animal g.	Protein: Vegetable g.	Alcohol g.
1941, first half	378	1479	222	32	22	28	16
1942, first half	211	1422	228	28	16	35	8
1943, first half	246	1621	276	26	17	44	6
1945, first half	1172	2120	346	34	15	63	—
1945, second half	875	2210	348	42	22	49	—

TABLE 2

AVERAGE DAILY CONSUMPTION OF NUTRIENTS PER HEAD IN PARIS IN THE YEARS 1941–45

Year	Basis of calculation	Calories	Carbohydrate g.	Fat g.	Protein: Animal g.	Protein: Vegetable g.	Calcium mg.	Vitamin A µg.	Carotenoids µg.	Vitamin B_1 µg.	Riboflavin µg.	Ascorbic acid mg.
1941	estimate	1500	—	40	20	—	—	—	—	—	—	—
1942–44	estimate	1800	—	30	18	—	—	—	—	—	—	—
1945, first half	580 individuals	2205	373	41	24·4	43·6	564	346	3757	1517	1185	91
1945, second half	550 individuals	2276	373	48	27·6	43	674	355	6046	1385	1282	89

Rural Areas

Among rural families with a certain level of expenditure there was a considerable consumption of dairy products, eggs and meat.

Table 3 sums up the data obtained in 1945 for Normandy and the western part of Brittany representing the west, for Seine-et-Marne and the east of Marne representing the east, and for a community in Isère.

The three tables show that, before the liberation, in the large cities the food actually consumed in the years 1940–44 fluctuated between 1500 and 1800 Calories with major deficiencies of about 50 per cent. in animal protein, calcium and vitamin A.

After the liberation there was an improvement; the Calorie level was about 2000 and the deficiency of animal protein fell to 25 per cent.

In rich rural areas the intake in 1945 was about 3000 Calories with 40 g. of animal protein and 800 mg. calcium.

Mortality and Morbidity Rates

The most important features in the mortality rate since 1940 were:

(1) An increase in the large cities; a decrease in rich rural centres;

TABLE 3

AVERAGE DAILY CONSUMPTION OF NUTRIENTS AND FOOD ITEMS IN RURAL REGIONS IN THE WEST AND EAST OF FRANCE AND IN ISÈRE IN 1945

Nutrients and food items	West: 1945, 2nd quarter	East: 1945, 4th quarter	Isère: 1945, 1st quarter
Calories	3146	3031	2763
Carbohydrate, g.	460	451	416
Fat, g.	102	90	64
Animal protein, g.	37	41	45
Vegetable protein, g.	55	57	43
Calcium, mg.	674	1054	975
Vitamin A, μg.	875	717	515
Carotenoids, μg.	2370	2539	7349
Vitamin B_1, μg.	2216	2374	1603
Riboflavin, μg.	1676	2102	1850
Ascorbic acid, mg.	89	114	103
Meat, g.	185	134	114
Fish, g.	4·46	2	1·6
Eggs, g.	21	28	32
Whole milk, g.	245	480	476
Skim milk, g.	34·25	—	—
Cheese, full cream, g.	7	13	43
Cheese, cottage, skim milk, g.	0·97	9	—
Butter, g.	51	23	13
Fats, g.	15·14	18	0·68
Oil, g.	—	—	13
Bread, g.	517	442	338
Cereals, g.	29	43	61
Potatoes, g.	204·9	349	336
Legumes, g.	7·82	192	17
Vegetables, g.	188	29	204
Fruit, g.	106·18	160	72
Sugar and jams, g.	25	34	28
Drinks, g.	611·4	462	371
Alcohol, g.	3·18	—	—
Chocolate, g.	—	—	1
Number of individuals studied	660	282	77

(2) These variations were due chiefly to tuberculosis, without increase of primary infection;

(3) Adults from 20 to 40 and elderly persons above 60 were the groups most affected. Women proved significantly less vulnerable then men;

(4) The mortality rate for children increased to any marked extent only in 1945.

General Mortality

When a comparison is made between the general mortality rates for the years 1935–38 and 1941–43 the increase for the whole of France looks small, only 11·6 per cent., but the picture is different when comparison is made by regions (Chevallier and Moine, 1945). The mortality

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rate rose sharply in urban centres and along the Mediterranean coast while decreasing in rural departments. The following statistics show the percentage changes in a few representative departments:

Bouches-du-Rhône	+ 57	Mayenne	— 10·9
Rhône	+ 29	Sarthe	— 7·8
Seine	+ 24	Orne	— 10·4
Seine-et-Oise	+ 23	Indre	— 11

This pattern of a curve rising where food conditions improved and falling where they deteriorated suggests a close relationship between dietary conditions and the mortality rate.

Mortality Due to Tuberculosis

The same relationship was observed with the death rate due to tuberculosis. The graphs clearly indicate that in the southern part of France groups of all ages were seriously affected, but particularly children under 10 years and adults between 25 and 40 years (Figure 1). Men were significantly more affected than women.

Infant Mortality

The curve rose very little until 1944 but sharply in 1945 (Figure 2). The deaths per 1000 live births in the years 1941–45 were as follows:

1941	73
1942	71
1943	75
1944	77
1945	110

Morbidity Rate of Infectious Diseases

There was an increase for diphtheria, typhoid fever and measles.

Weight and Growth Fluctuations

Great fluctuations of weight and growth rates occurred. They were the object of many investigations chiefly concerned with the pathological or physiological significance of loss of weight (Chevallier and Trémolières, to be published).

Adults in the cities lost about 10 per cent. of weight followed by a slight gain (Figure 3); old and fat men lost more heavily.

Two studies (Laroche and Trémolières, 1942, 1; Bourguignon and Laroche, 1944) tended to show that such loss of weight was often accompanied by troubles of chronaxie.

In adolescence abnormal cases of obesity were seen among girls with frequent amenorrhoea.

Children showed a more obvious relation between growth and adequacy of food intake. The growth curves in Figure 4 illustrate height and weight deficits for boys and girls between 7 and 17 years of age. They show that, while in 1942 in Lyons the retardation of growth seen at puberty was not represented at 15 years, at the end of 1944 this retardation was accompanied by a definite deficit of about 7 cm. in height for boys of 14 years and of 11 cm. for girls of the same age.

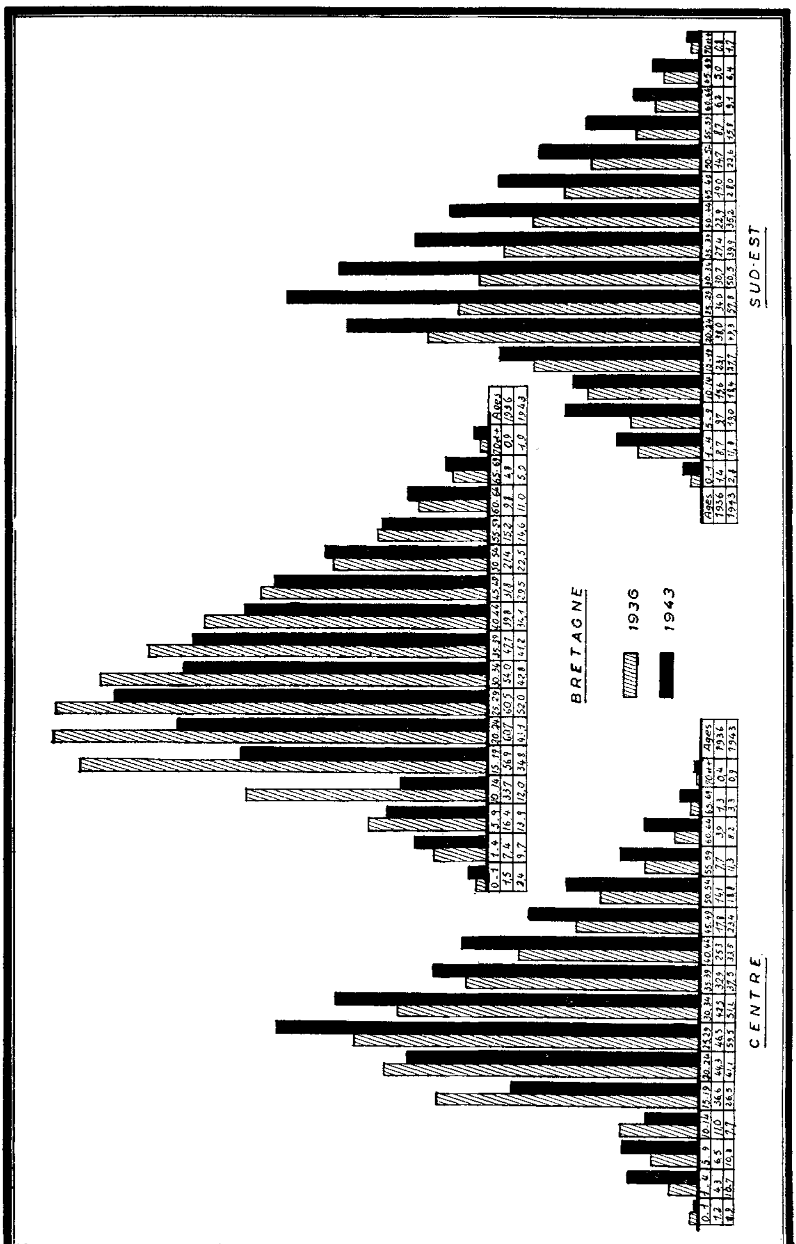

FIGURE 1. DEATHS FROM TUBERCULOSIS PER 100 REGISTERED DEATHS FROM ALL CAUSES IN 1936 AND IN 1943 ACCORDING TO AGE, IN BRITTANY, IN THE CENTRE AND IN THE SOUTH-EAST OF FRANCE.

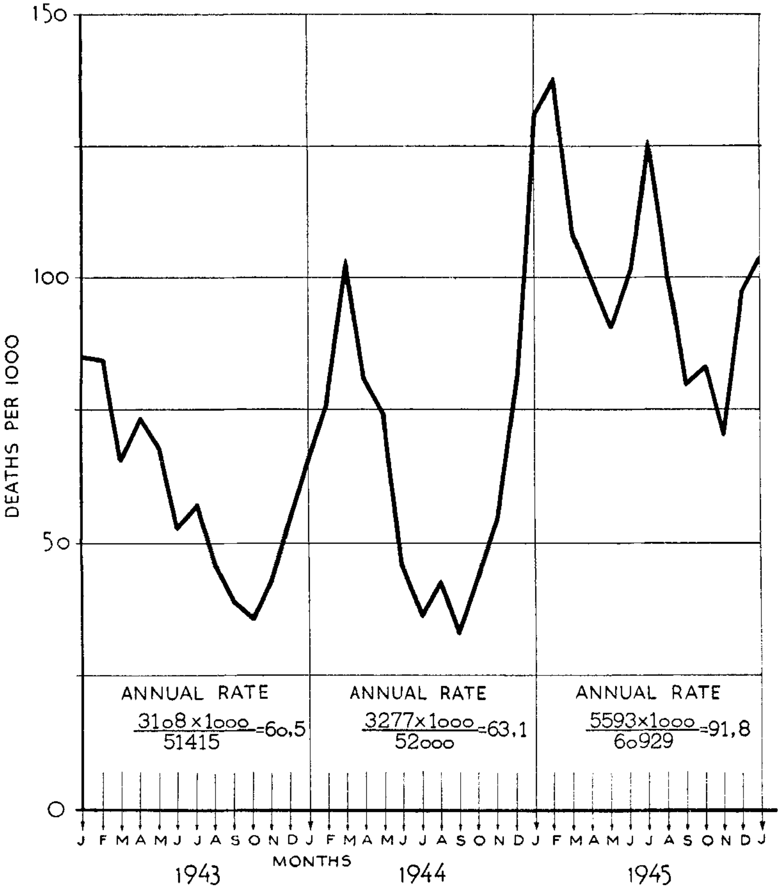

FIGURE 2. DEATHS IN THE FIRST YEAR OF LIFE PER 1000 LIVE BIRTHS FOR THE SEINE DEPARTMENT IN THE YEARS 1943 TO 1945.

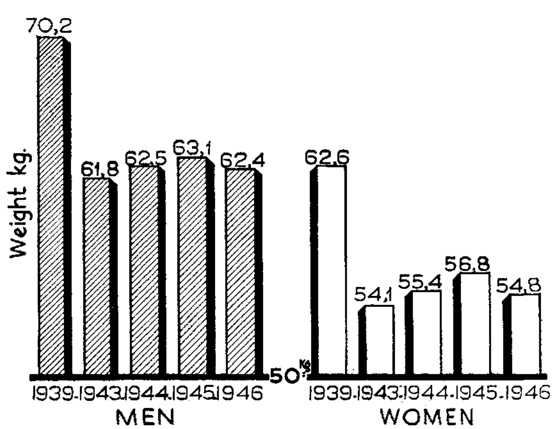

FIGURE 3. CHANGES IN MEAN WEIGHTS OF 6000 WORKERS OF BOTH SEXES IN PARIS, 1939 TO 1946.

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In 1942 a survey (Beyer and Trémolières, 1944) made on 2500 newborn babies in maternity centres of Paris did not show statistically significant differences in height and weight by comparison with pre-war curves. In 1945, however, the average weight of the newborn boy was 60 g. below that in 1942, and of the girl 35 g. below. These differences are statistically significant.

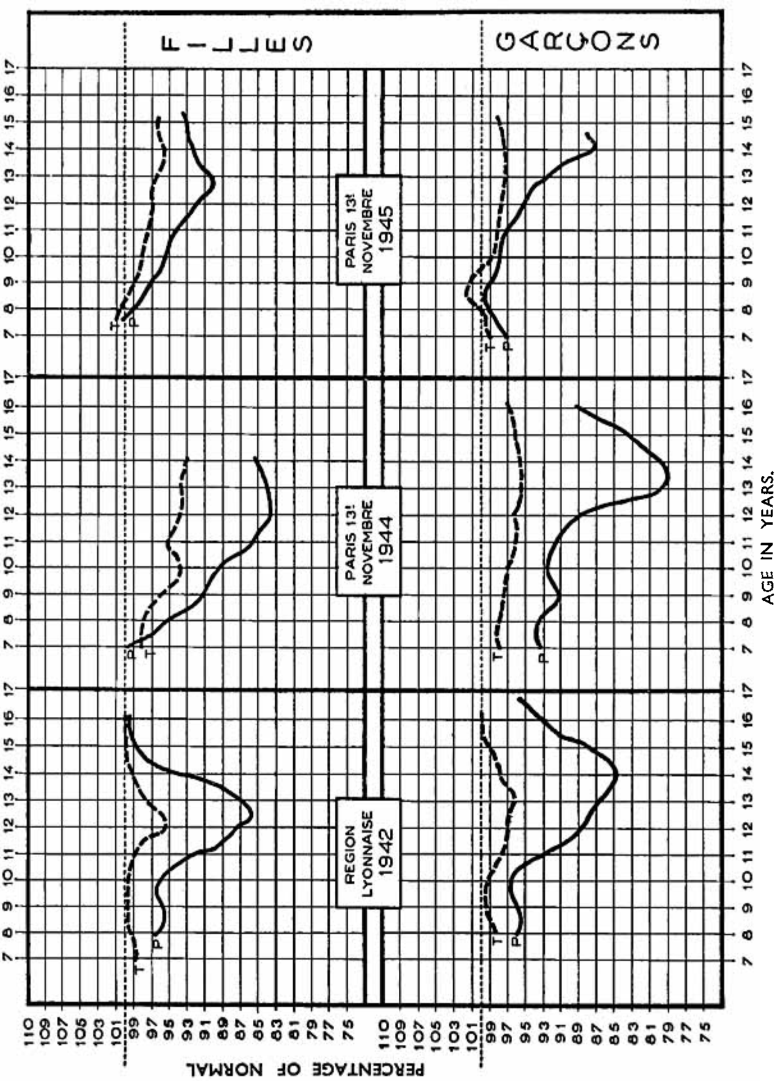

FIGURE 4. PERCENTAGE OF THE NORMAL WEIGHT (P) AND HEIGHT (T) OF BOYS AND GIRLS AGED 7 TO 17 YEARS.

Clinical Signs of Malnutrition

The signs used by Youmans and Sydenstricker as evidence of malnutrition were looked for among the populations of Marseilles and Paris in the surveys made by the National Institute of Hygiene.

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The results of these surveys (Youmans *et al.*, 1942; Kuhlmann, 1944, 1945; Trémolières and Alison, 1946, 1, 2) emphasize the following conclusions:

(1) Striking cases of vitamin deficiency disease were not numerous. The number of cases of scurvy and pellagra did not rise above the normal and never constituted a social disaster;

(2) Vascularization of the cornea and perifollicular hyperkeratosis cannot be considered as valuable tests of vitamin deficiency;

(3) This method of survey is, on the whole, a simple confirmation of a general impression obtained from certain symptoms apparent at a glance in a group of people.

It is concluded that this method of survey was not applicable in the food situation which prevailed in France.

Biochemical Tests for Malnutrition

Vitamin A

In Marseilles there was a progressive diminution of the vitamin A content of the blood serum, measured by the spectrophotometric method of Chevallier (Chevallier, Choron and Matheron, 1938), and this was reflected in the values for the capacity for dark adaptation, measured with the adaptometer of Chevallier and Roux as shown in Figure 5.

The observation of this diminution raises the question of the efficiency of the transformation of carotene into vitamin A, for in Marseilles the carotene intake was almost normal and so was the carotene content of the serum at 200 μg. per 100 ml.

In Paris, on the other hand, the vitamin A content of the serum was fairly constant at about 30 μg. per 100 ml. compared with the pre-war level of 34 μg. (Devron, 1946).

Red Cells and Haemoglobin

In Marseilles a fall was observed in the number of red cells and haemoglobin content of the blood.

Nutritional Oedema

In asylums nutritional oedema was epidemic, almost everyone being affected (Gounelle, Bachet, Sassier and Marche, 1941; Dodel and Delesvaux, 1942; Bachet, 1943). The conditions under which it developed were 4 to 8 months of a diet reduced to 1500 Calories with 18 g. of animal and 35 g. of vegetable protein.

Among civilians the first cases appeared at the end of the winter 1940–41, in large cities among elderly people living alone and among heavy workers. Subsequently the number of cases declined gradually with sporadic reappearances (Laroche, Bompard and Trémolières, 1941, 2; Laroche and Trémolières, 1942, 2; Nicaud, Rouault and Fuchs, 1942; Warembourg, Poiteau and Biserte, 1942; Saridon, 1943).

Clinical Signs of Nutritional Oedema

Besides the ordinary symptoms, diarrhoea and polyuria frequently appeared before the onset of oedema. Bradycardia was constantly present and administration of adrenaline had no effect on the pulse rate.

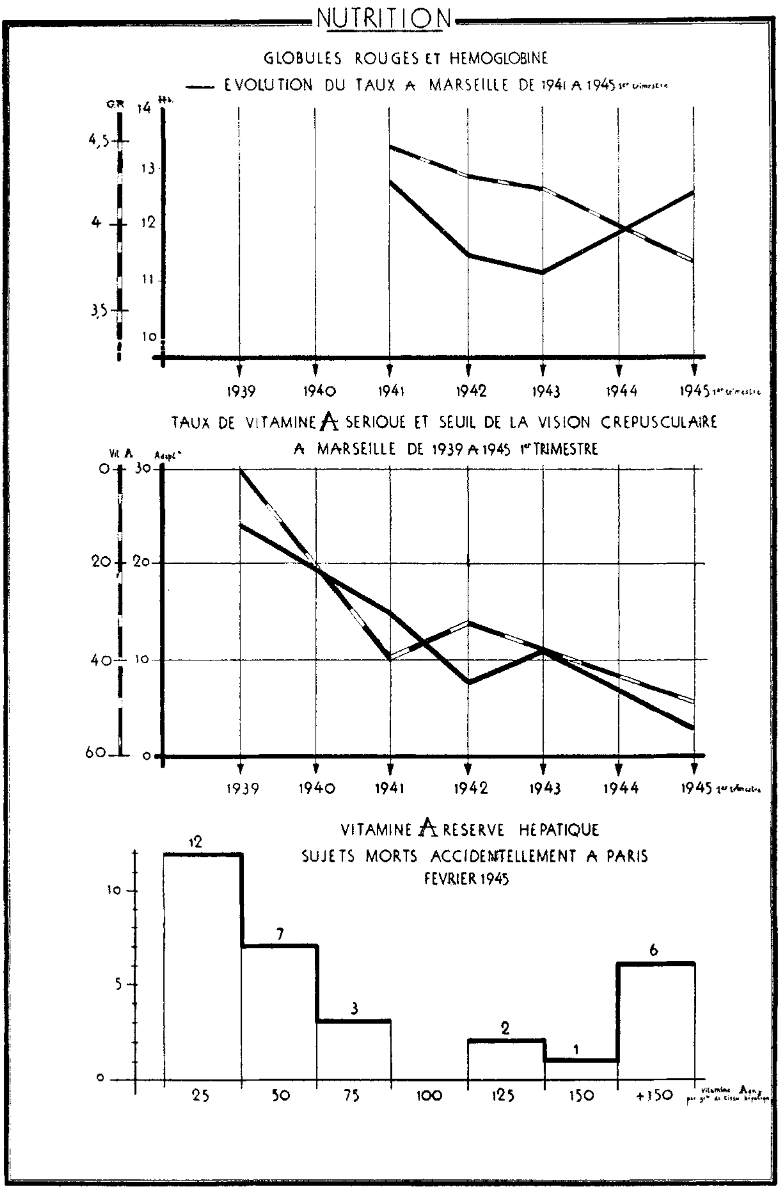

FIGURE 5. (Top) NUMBER OF RED CELLS (MILLIONS) AND AMOUNT OF HAEMOGLOBIN, IN MARSEILLES IN 1941–45; (Middle) SERUM VITAMIN A AND VISUAL THRESHOLD, IN MARSEILLES IN 1939–45; (Bottom) LIVER RESERVES OF VITAMIN A (μg. PER g. LIVER) IN ACCIDENT CASES IN PARIS, FEBRUARY, 1945.

Symptoms frequently seen in association were loss of reflexes, polyneuritis (Laroche *et al.*, 1941, 2) and skin pigmentation (Laroche *et al.*, 1941, 1). Even after the oedema had disappeared it could be caused to appear again on a large scale by administration of oestradiol, testosterone or desoxycorticosterone (Laroche and Trémolières, 1943, 1). Patients with hunger oedema often passed into coma with hypoglycaemia (Gounelle, Marche, Bachet and Digo, 1942; Lhermitte and Sigwald, 1942) but glucose injections did not restore them. Glandular disturbances, exemplified by amenorrhoea, hypotension and pigmentation (Loeper, Varay and Mande, 1942, 1, 2), were frequent.

Biochemical Signs of Nutritional Oedema

It was established that when 10 g. of sodium chloride daily and a high-protein diet were given simultaneously to cases of nutritional oedema apparently recently cured, there would appear, first a serious, fresh oedema and then, after 10 or 20 days, a urinary crisis unless the 10 g. of sodium chloride continued to be given (Fiessinger and Trémolières, 1943).

Anaemia was sometimes present; it was considered by some as a simple blood dilution while others regarded it as pathological. Studies of bone marrow showed a higher percentage of erythroblasts in which modifications of the nucleus were observed. The appearances resembled those described in cirrhosis and certain dysenteries, or in the anaemia of ankylostomiasis. These anaemias were cured as the oedema and hypoproteinaemia disappeared; hence they were called erythroplasmatic (Fiessinger, Tiffeneau and Trémolières, 1943; Giraud and Bert, 1943).

From studies of nitrogen retention in patients suffering from hunger oedema, it was established that it took one to two months to re-establish the nitrogen balance, in spite of treatment with a high protein diet (Laroche and Trémolières, 1943, 2).

Treatment of Nutritional Oedema

Vitamins were generally considered to be ineffective. Milk and rest were considered as the best treatment to secure recuperation (Gounelle, Bachet and Marche, 1942).

Conclusions

The food situation in France since 1940 had certain important effects:

(1) Marked and rapid changes occurred in the general mortality rate, which increased when food conditions were bad and decreased again when they were better, the class most affected being men from 20 to 40 years of age;

(2) There were rapid and serious losses of weight and slackening of the growth rate;

(3) Contrary to expectation there were no very significant clinical signs;

(4) Biochemical tests revealed changes but only after long periods when the food situation was at its worst.

It was, therefore, concluded that when the food conditions are no worse than those described, the most suitable means of assessing the situation are by:

(1) Surveys of food consumption;

(2) Scrutiny of the mortality rates;

(3) Statistical analysis of the weight increase and growth of groups;

(4) Biochemical tests on a scale permitting statistical analysis.

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Nutritional Research in Holland during the War

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To begin with, I have to thank sincerely The Nutrition Society and the British Council for their kind invitation and for their hospitality, which made it possible to meet here nutritionists from so many countries.

Nutritional research in Holland is carried on in numerous university laboratories, high schools, industrial plants, experimental stations, and so on.

At the end of the first world war the Netherlands Institute of Nutrition was founded by Professor van Leersum, which, after his death, was removed to my Laboratory of Physiological Chemistry. In the beginning of this war nutritional research was stimulated by the foundation of the Section for Nutritional Research of the Dutch Organization for Applied Research, which set up the Central Institute for Nutritional Research in Utrecht, under the direction of Dr. van Eekelen. At the same time, the Board of Nutrition in Holland was founded, a section of which was the Commission for Inquiry into the State of Nutrition and Health of the Dutch People. This section was called the *Puls-Commission* since it held, so to speak, its finger on the pulse of the state of nutrition of the people.

In the first place, the chief war-time foods of Holland, potatoes, bread and dairy products, were investigated.

Investigations of Foodstuffs

Potatoes

Since potatoes are a good food, with a large yield per acre, a great deal of the pasture land was changed into arable land for growing potatoes. From 1940 to 1943 the area cultivated was increased by 66 per cent.

Vitamins. Since potatoes are especially rich in vitamins C and B_1, an extensive research was made in the laboratory of Dr. van Eekelen on the content of vitamin C, and in our Institute on that of vitamin B_1, of nearly a hundred varieties of potato from several different soils. The varieties harvested in early summer contained 30 to 40 mg. vitamin C per 100 g., while in those harvested in September to November only 10 to 20 mg. were found (Reestman, van Eekelen, Fontein and Hendriks, 1943). This is of interest, because in the early summer, when the first new potatoes appear, the reserves of vitamin C of the people are exhausted.

In winter the vitamin C content of potatoes gradually decreases till in spring it is not more than 5 to 10 mg. per 100 g. In co-operation with van Stuyvenberg (1943), therefore, an investigation was made to find conditions of storage under which a larger part of the vitamin C content would be retained. Potatoes were stored at constant temperatures of 3°, 7° and 10° C., in an atmosphere containing 0·5 or 10 per cent. of carbon dioxide, and also under treatment with the plant hormones, naphthylacetic ester or ethylenehydrochloride. The results were disappointing, but the investigations with the plant hormones are being continued.

For vitamin B_1 also a wide range of from 30 to 160 μg. per g. was found between the different samples, according to variety, soil, and so on. The average value was 85 μg. per 100 g. A significant, but not very large, difference irrespective of such factors as soil and manuring was found between some varieties.

Before the war the average consumption of potatoes in Holland was about 500 g. daily; in the war, in some months, it was even larger. On an average, this amount supplies more than 400 μg. of vitamin B_1, which is about 30 per cent. of the total daily intake. Growth experiments with rats showed that potatoes contain not only vitamin B_1 but all the factors of the vitamin B complex also.

Proteins. The statements in the literature on the biological value of potato proteins are conflicting. Groot compared the growth of young rats on a diet containing 8 or 11 per cent. of potato protein with that on the same diet containing 8 or 11 per cent. of casein. Scarcely any difference was found.

Groot further determined quantitatively by micro-methods the amounts in potato proteins of those amino-acids which, according to Rose, are not synthesized in the body (Groot, 1942, 1945, 1, 2, 1946). He obtained the results set out in Table 1.

TABLE 1

PERCENTAGE OF ESSENTIAL AMINO-ACIDS FOUND IN POTATO PROTEIN COMPARED WITH THE AMOUNT IN CASEIN, AND THE PERCENTAGE IN THE DIET OF POTATO PROTEIN AS ONLY PROTEIN NEEDED TO SUPPLY AMOUNTS OF ESSENTIAL AMINO-ACIDS REQUIRED ACCORDING TO ROSE

Amino-acid	Percentage found in potato protein	Percentage present in casein according to literature	Percentage necessary in diet according to Rose	Percentage potato protein necessary in the diet when no other proteins are present
Methionine . .	2·2	3·2	0·6	(27)
Cystine . .	0·7	—	—	—
Cysteine . .	0·1	0·3	—	—
Leucine . .	8·3	9·0	0·9	11
Valine	6·6	7·6	0·7	11
*Iso*leucine . .	4·3	6·8	0·5	12
Arginine . .	4·2	3·2	0·2	5
Histidine . .	1·9	2·5	0·4	21
Lysine	3·1	6·0	1·0	32
Phenylalanine . .	5·1	7·0	0·7	14
Threonine . .	6·0	3·5	0·6	10
Tryptophane . .	2·0	1·5	0·2	10

From these results lysine would appear to be the limiting amino-acid. The low methionine content may perhaps be made good by the cystine. Since peas and beans are fairly rich in lysine, a combination of potatoes with legumes may provide a good mixture of proteins.

All in all, it can be assumed that in war time, when meat, milk and eggs were scarce, potatoes contributed largely to the protein supply of the people of Holland.

Bread

Quantitatively, bread is the chief component of the food in Holland; before the war 36 per cent. of the total calories came from it, and the proportion remained nearly the same during the war.

Special War-time Investigations. With the outbreak of war, all imports were stopped, so that the people had to rely on the products of their own soil, which is better suited to grow rye than wheat. The Government, therefore, controlled all the milling and fixed a mixture of about two-thirds rye and one-third wheat, to which were added, according to the available stock, small quantities of barley or dried potatoes or potato flour and, from this mixture, all bread had to be baked. The question then arose as to the extent to which this "Government flour" had to be extracted. The higher the extraction, the more flour would be available for bread making, but the digestibility would be less, and less bran would be left for cattle feeding. An elaborate research showed that an extraction of 85 per cent. gave the largest output for human consumption, both quantitatively and qualitatively; the extraction of the mixture of two parts of rye with one of wheat to be used for baking bread was accordingly fixed at 85·5 per cent.

Research for the Post-war Situation. The possibility of obtaining a flour, containing a large part of the vitamins and minerals of the wheat, and yet yielding bread more or less white in colour and of good baking quality, was investigated by a sub-committee of the Section for Nutritional Research of the Organization for Applied Research, under the chairmanship of Dr. van Eekelen. Several Dutch institutions took part. A large quantity of Dutch wheat was milled in the usual way, the different fractions were analysed, and, in the Station for Milling and Baking at Wageningen, baking experiments were made with the various flours.

Some of the results are set out in Table 2.

TABLE 2

PERCENTAGE CONTENT OF ASH, PROTEIN, FIBRE, VITAMIN B_1, NICOTINIC ACID AND VITAMIN E IN VARIOUS MILLING FRACTIONS OF THE WHEAT GRAIN

Sample	Limits of extraction of fraction per cent.	Ash per cent.	Protein per cent.	Fibre per cent.	Vitamin B_1 μg. per 100 g.	Nicotinic acid μg. per 100 g.	Vitamin E mg. per 100 g.
b_1	0 to 31·4	0·53	9·0	0·1	170	0·64	1·8
b_2	31·4 to 54·4	0·68	9·1	0·2	130	0·96	1·6
b_3	54·4 to 77	1·34	10·6	0·6	630	2·14	1·8
b_4 to b_9	77 to 80	4·37	18·0	4·0	2500	6·3	9·0
c_1 to c_3	80 to 84	5·77	13·9	9·7	1120	13·0	8·6
c_4 to c_5	84 to 96	7·95	13·3	9·7	750	22·7	2·8
d	0 to 100	2·1	10·6	2·0	500	6·1	2·8

By incorporating the fraction, 77 to 80 per cent., the vitamin content of the flour is greatly increased, without adding much fibre, but, unfortunately, the baking quality is greatly deteriorated. It is hoped, however, that it may be possible to get over this without destroying the nutritive value.

The examination of the milling fractions showed also that the enzymes were not uniformly distributed in the grain. Engel found that the amylase was located chiefly in the layer below the aleurone layer, and the proteinase and esterase in the aleurone layer itself.

Butter

In the last few years the nutritive value of margarine has been enhanced by adding vitamins A and D, and the question arises whether the nutritive value of this vitaminized margarine equals that of butter in all respects. Many years ago we obtained indications that the special nutritive value of butter is not entirely due to its content of vitamins A and D. With J. Boer and A. Kentie we pursued this problem by means of experiments on the growth of young rats. Statistical analysis of our results showed how closely the growth reflects an optimum composition of the diet. A basal diet was chosen containing all the components necessary for growth except the fats and fat-soluble vitamins. To this was added 10 per cent. of butter, or 10 per cent. of other fats with vitamins A and D added. It was soon apparent that butter or, at any rate, summer butter, caused significantly better growth than the vitaminized fats. This growth-promoting action was present in the fatty acid fraction of the butter (Boer and Jansen, 1942; Boer, Jansen, Kentie and Oosterhuis, 1944; Boer, Jansen and Kentie, 1946). When quantities of the methyl esters of fatty acids of summer butter were fractionated by distillation *in vacuo*, the active fraction was found to be that of C_{18}. This fraction still contained unsaturated acids. A Twitchell separation with lead acetate was then performed, and the solid fraction was active. It was fractionated further with mercuric acetate, and the soluble fraction was the active one. By repeating these two fractionations an almost pure substance was obtained with a melting point of 35° C. and an iodine value of 81. It proved to be vaccenic acid which Bertram had isolated from butter, without knowing its physiological activity. About 0·5 per cent. of this acid was obtained from summer butter. When we added 1 per cent. of it to the basal diet with rape oil as fat the rats grew significantly better than those receiving rape oil but not vaccenic acid.

Nutritional Survey : Work of the Puls-Commission

An account of the work of the *Puls-Commission* will be published in full together with the results of the food survey after the liberation. In the first three years of the war, the state of the public health was not good, and the incidence of tuberculosis rose considerably. The vitamin C and vitamin A content of the blood remained almost constant. After the railway strike in September 1944 the situation in the western provinces of Holland was extremely bad; for several weeks no more than 500 or 600 Calories a day were available. More than 20,000 people died of starvation.

The Commission included a dentist, Dr. Lindeboom. She examined, among others, the teeth of children in institutions, and in one found the state of health and of nutrition of the children very bad. This led to big improvements; a dietitian was added to the staff of the institution, so that the food provided was much better and was prepared according to the most modern principles. A year later Dr. Lindeboom examined

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the same children in the same institution, and found that in some cases, where in the previous year the enamel had been soft, it had now become hard.

Through the work of the *Puls-Commission*, several measures were taken by the Government, which probably had a good effect on the health of the people. At the end of the winter, vitamin C was distributed on a large scale to children, expectant mothers and heavy workers. Vitamin D was provided for children under three years of age and for their mothers. When milk had to be rationed, 0·4 per cent. of calcium carbonate was added to the flour for baking bread. By this means the average content of calcium in the rationed food was brought up to 700 mg. daily.

During the second half of the occupation a number of cases of so-called hunger osteopathy, a form of osteomalacia, were seen. They were similar to those seen in Germany and Austria in 1919 and in occupied France during the last war. The objective and subjective symptoms of the disease, and the X-ray findings were typical. Pompen, La Chapelle, Groen and Mercx (1946) have published a monograph on the disease, which they are inclined to attribute to a combined deficiency. Among the factors lacking, vitamin D seemed to be the most important, since most of the cases made a quick recovery when some form of vitamin D was given.

At the same time, there was no significant increase in infantile rickets, due probably to the widespread distribution of vitamin D preparations to infants and children during the war. The occurrence of hunger osteopathy among adults who did not receive the vitamin D supplement, supports the view of those who maintain that vitamin D is an essential nutrient for adults as well as children.

Vitamin Researches

Vitamin A and Carotene

A new method of estimating carotene in plant materials and faeces was worked out by van Eekelen, Engel and Bos (1942), and the absorption of carotene was investigated in experiments with infants (van Zeben, 1945). The conclusion was reached that, in general, the absorption of carotene from foods is very poor, and depends on the mode of preparation, so that the carotene content of foods is not a good measure of their value as source of vitamin A.

Estimation of Vitamin B_1 in Blood

Sinclair (1938) found that 90 per cent. of the vitamin B_1 in blood is in the phosphorylated form, so that the vitamin B_1 content of blood can be measured fairly accurately by determining the co-carboxylase content. The existing methods for estimating vitamin B_1 in blood require large quantities of blood or are not very accurate. Westenbrink and his colleagues have devised a new method by adsorbing the co-carboxylase from the filtered blood with apo-carboxylase, which is obtained by washing yeast with a solution of phosphate free from co-carboxylase, at *p*H 8·6. The adsorption product is carboxylase; the amount of it depends on the amount of the co-ferment originally present in the blood, and can be determined in a Warburg apparatus by measuring the CO_2 liberated by it from sodium pyruvate. For this method 2 ml. blood sufficed and, by using a Cartesian diver as devised by Linderstrøm-Lang, 0·01 ml. is enough (Westenbrink, Steyn Parvé, van der Linden and

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van den Broek, 1943; Steyn Parvé and Westenbrink, 1944; Westenbrink and Willebrands, 1944; Westenbrink and Steyn Parvé, 1945).

Vitamin C in Endurance Tests

At the Institute for Preventive Medicine in Leiden, Hoitink set several subjects to do work on a bicycle ergometer until they were exhausted. The vitamin C content of their blood was about normal, but they were not saturated. After receiving large doses of vitamin C, their capacity to do work was much increased (Hoitink, 1942).

Vitamin E

The method of estimating tocopherol was improved, and the tocopherol content of a number of foods was determined (Emmerie and Engel, 1943). Engel (Engel and Bretschneider, 1943) showed that α-tocopherol prevented sterility and testicular degeneration in male rats.

Trace Elements

Research into the importance of trace elements in nutrition and metabolism is easier for three reasons than work with vitamins: their number is limited; there are reliable micromethods of estimating the majority; and they are stable.

Their tendency to be present everywhere, however, makes their study more troublesome, and it is almost impossible to devise a diet devoid of trace elements, such as would be necessary for feeding experiments with rats. About 15 years ago, Filedt Kok (1933), in our Institute, tried to do this, but he succeeded only in reducing somewhat the content of trace elements. Possibly, in the future, the problem may be solved by using crystalline amino-acids instead of colloidal proteins. To investigate the amount in teeth of fluorine and molybdenum, Hoogland, with the co-operation of Lampe, elaborated micro-methods by which he was able to determine these two elements in a single tooth (Hoogland and Lampe, 1943), but almost no difference was found in this respect between carious and normal teeth.

In order to attack the problem of trace elements from another angle Hoogland worked out micro-methods for estimating copper, manganese, zinc, boron, magnesium and aluminium in foodstuffs. This work is not finished. Some results with flour fractions are shown in Table 3.

TABLE 3

Content of Molybdenum, Copper, Zinc, Manganese, Magnesium and Boron in Various Milling Fractions of the Wheat Grain

Sample	Limits of extraction of fraction per cent.	Molybdenum μg. per 100 g.	Copper mg. per 100 g.	Zinc mg. per 100 g.	Manganese mg. per 100 g.	Magnesium mg. per 100 g.	Boron μg. per 100 g.
b_1	0 to 31·7	13	0·15	0·44	0·57	17	50
b_2	31·7 to 54·4	13	0·16	0·59	0·51	20·5	57
b_3	54·4 to 77	23	0·36	2·2	2·3	74	72
b_4 to b_9	77 to 80	70	1·2	10	11	280	160
c_1 to c_3	80 to 84	70	1·3	13	12	470	160
c_4 to c_5	84 to 96	42	1·3	10	8·5	590	160
d	0 to 100	25	0·5	3·1	2·7	135	80

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Switzerland's Contribution to War-time Food Research

Professor F. Verzár (Physiological Institute, University of Basle, Switzerland)

Switzerland, though not directly involved in the last war, was nevertheless totally surrounded from 1941 onwards and, therefore, depended for her imports on her neighbours. Switzerland is unable to feed her population entirely and depends on a considerable proportion of imports. In 1938, 446 million Swiss francs' worth of food and animal feeding products were imported for a population of 4·2 millions.

War-time Diet in Switzerland

In 1940, the Physiological Society of Switzerland recommended to the Federal Public Health Department that a Federal War Nutrition Commission should be formed. This functions as an advisory committee to the War Nutrition Office. Its first plans were reported by its president, Professor Fleisch, in the bulletin of the Federal Health Office dated 15th January, 1941. A nutrition budget and a nutrition plan were drawn up, and the requirements thus planned were compared with the diets of 1939. The needs were calculated as "nutrition units", one unit representing 2400 Calories for a man of 25 to 35 years and 70 kg. bodyweight.

A production plan was worked out (Wahlen, 1942) and the public was kept constantly informed by the press about it. It was not possible

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until 1944 to carry out the plan completely, but the area of cultivated land increased from 185,479 hectares to 363,855, as against the 504,812 hectares desired. The system of rationing worked well. Potatoes, vegetables and fruit were not rationed.

No detailed report has yet appeared, but it is expected shortly. From available data it can be stated that in the winter of 1944–45 the diet was below the limit for calories, animal protein and fat. For October 1942, according to Wahlen (1943) and Fleisch (1942, 1, 2), the average value of the diet was protein 62 g., fat 52 g. and Calories 2180. In 1944 the values were protein 61 g. and fat 43 g. The percentage deficiencies of this diet were protein about 13, fat 22, carbohydrates 13 and Calories 15, as Fleisch and Petitpierre (1945) pointed out. The supply of minerals and vitamins, however, was better than before the war. Income and number of children no longer determined the supply as in pre-war times. The diet contained vitamin C 82 mg., vitamin A 2900 I.U., vitamin B_1 2·03 mg., nicotinic acid 14·6 mg., calcium 1·29 g., phosphorus 2·03 g. and iron 26·9 mg. The last three values were more than before and above the optimum. The intake of vitamin C was increased, of vitamin B_1 doubled, that of nicotinic acid was optimum. Only vitamin D was insufficient, as was the case also before the war.

On the basis of official figures of the War Food Office, we have calculated the following values for the diet of a medium-heavy worker in December 1944. With the food from his supplementary ration card and from unrationed foodstuffs, such a worker got daily: protein 79 g., fat 57·2 g., carbohydrate 449 g. and Calories 2683 for francs 1·55. At that time the monthly quantities were: of meat 1450 g., milk 14 l., butter 300 g. and eggs 2, together with bread 10,945 g. and potatoes 23,250 g.

State of Health of the Swiss People

The state of health was reported by the authors mentioned above to have been astonishingly good. Roos stated that caries decreased, but statistics are not yet available.

Markoff (1943) reported an increase in 1943 of 30·7 per cent. in the frequency of gastric and duodenal ulcer, while other hospital cases had increased by only 9·5 per cent. This was attributed to psychological strain and overwork rather than to war diet. Mirault-Kretchmar (1945) in a detailed report showed the same increase and noted that 60 per cent. of the cases of 1942–43 were of less than two years' standing. The opinion of Gsell (1945, 1), however, was that the increase was not due to nervous strain, but to changes in diet due to the war, such as the greater amount of cellulose and less refined bread consumed.

Gsell described also cases of anaemia due to lack of iron and of osteomalacia, which recovered well on a single dose of 600,000 I.U. vitamin D. Hunger oedema was seen in Switzerland only among refugees. It was described by Martin and Demole (1943) in Geneva, in refugees from France. As cause, lack of animal protein was mentioned. Gsell (1945, 2) wrote about cases among prisoners in concentration camps, where the intake of protein was 18 g., fat 5 g. and Calories 500, daily. He discussed the possibility of feeding such patients parenterally by intravenous infusion of blood plasma and of amino-acid hydrolysates like Amigen.

Practical Nutritional Studies

The feeding of different groups of the population has been discussed in several papers. Rosen (1945) gave a detailed survey of the war-time nutrition in seven European countries. Demole (1943) wrote about feeding in the army; there were three diets of 3100, 3643 and 4879 Calories; the ratio of calcium to phosphorus was 0·7 and the Williams figure of mg. vitamin B_1 per 1000 non-fat Calories (Williams and Spies, 1938) was 0·833, which is sufficient.

Neuweiler (1943) studied the intake of vitamin B_1 in pregnant and nursing mothers, and found, on the basis of the amount excreted in the urine, that it was still sufficient in 1942.

The question of special foodstuffs under war-time conditions was fully discussed in a special number of the *Schweizerische medizinische Wochenschrift* in 1942, of which a few details might be mentioned. Fleisch and Fischer confirmed the earlier statement of Konchakoff that digestive leucocytosis appears only when cooked foodstuffs have been eaten. The possibility was suggested that this might be a reaction against toxic products.

The value of preserves, especially for their vitamin content under modern methods of preparation, was discussed in papers by Stirnimann, Jung and Zbinden, and was found to be satisfactory. Modern preserved milks were found particularly satisfactory by Fanconi, a paediatrician.

A special discussion arose on the allegedly inferior nutritive value of hardened fats. The opinion was expressed that such a denaturing of natural foodstuffs should not be allowed. The controversy led to the appearance of various papers on the importance of highly unsaturated fatty acids in nutrition.

Gigon (1942) pointed out that it is a mistake to fight against a high sugar consumption in Switzerland. Carbohydrate is provided in an easily digestible form and the necessary accessory factors can be supplied in other ways. He strongly advocated the use of untried foodstuffs and also of better methods of cooking. He opposed calculation of food values by calories as misleading and not related to physiological realities. His efforts to promote the use of yeast as a good source of protein and accessory food factors, about which Somogyi (1943) wrote a valuable monograph, has not, unfortunately, led to any increased production of yeast for human and animal food. Similarly, Moser's (1942) renewed advocacy of greater production of the soya bean as a most valuable source of plant protein has not led to any considerable result.

The question of bread was much debated in the medical societies. Kapp (1944) and Hottinger (1944) discussed the digestibility and palatability of bread, and emphasized that the war-time bread makes great demands on the skill of the bakers.

The relation of bread to absorption of calcium was discussed in reference to the work of McCance and Widdowson by Fromherz and Sutter (1946), who fed rats with 0·31 per cent. of calcium and 0·19 per cent. of phosphorus, and found a retention which was increased by giving vitamin D. They stated that calcium is secreted by the intestine in the insoluble form of tertiary calcium phosphate.

The Federal War Nutrition Commission has proposed to continue in the post-war period semi-brown bread consisting of 80 to 82·5 per cent. refined flour (Fleisch, 1946). It contains 48 per cent. of the minerals, all of the vitamin B_1, 52 per cent. of the nicotinic acid and 22 per cent. of the bran, present in the whole grain.

Theoretical Studies

Most of the research work done was, however, theoretical and only indirectly connected with nutrition.

From work on basal metabolism Ludwig (1945) reported that the values of Harris and Benedict for calculating basal metabolism are about 15 per cent. too low for Swiss men, and proposed a formula to cover the difference. Doetsch and Voegtli (1945) showed that, in contrast with former statements, basal metabolism at an altitude of 1600 m. is not increased, so that the climatic action cannot be explained in this way. They estimated the basal metabolism of a series of persons by four different methods during three months.

Fundamental research on protein metabolism included a study of fractions of blood-plasma proteins by means of electrophoresis and salt precipitation, made by Wuhrmann and his colleagues (Wuhrmann and Leuthardt, 1940; Wuhrmann and Wunderly, 1943), by Leuthardt (1941) and by Gukelberg (1940).

In the metabolism of amino-acids, especially arginine and histidine, Edlbacher discovered important facts (Edlbacher and Viollier, 1943; Edlbacher and Grauer, 1944; Edlbacher and Wiss, 1944, 1, 2, 3; Edlbacher and Schmid, 1945; Edlbacher and Wiss, 1945, 1, 2; Edlbacher, Wiss and Walser, 1946). The formation of glycine and urea was studied by Leuthardt and Glasson (1942, 1, 2) and the oxidation of amino-acids by Karrer, Koenig and Appenzeller (1942) and Karrer and Appenzeller (1943). The influence of lack of tyrosine in the food was demonstrated on rats by Zeller and Schweizer (1946).

The metabolism of the fatty acids was studied by Bernhard (1941), Bernhard, Steinhauser and Bullet (1942) and Bernhard, Steinhauser and Matthey (1944) with deuterium as indicator. Flaschenträger, Cagianut and Meier (1945) showed the production of furan–2:5–dicarboxylic acid in the body, and Markees and co-workers obtained interesting results on the influence of fatty acids on blood sugar and on ketonaemia in connexion with the problem of gluconeogenesis in normal subjects and in diabetics (Markees and Reich, 1940; Markees, 1941, 1945; Markees and Menczer, 1946).

The connexion of carbohydrate with electrolyte metabolism was studied in Verzár's laboratory. It was shown that whenever glycogen was formed, potassium was bound by the cells and liberated again when the carbohydrate was metabolized (Pulver and Verzár, 1940, 1941). Potassium was of central importance for muscular metabolism (Verzár, 1943). It was absorbed by myosin and liberated through the action of acetylcholine.

This led the same group of workers to an explanation of the action of the adrenal cortical hormone. They succeeded in showing *in vitro* that it influenced glycogen phosphorylation, which was much decreased in adrenalectomized animals and restored by giving minute quantities of desoxycorticosterone (Verzár and Somogyi, 1941, 1, 2, 3; Verzár, 1941, 1942; Verzár and Montigel, 1942, 1, 2; Montigel, 1943; Montigel and Verzár, 1943, 1, 2, 3).

Abelin (1941, 1942) and Abelin and Althaus (1942) described the antagonism of the adrenal and thyroid glands in glycogen and potassium metabolism. Carbohydrate metabolism during muscular work was studied also by Martin du Pan (1942) and Keller (1944).

A number of workers studied enzyme action. It is impossible to refer to all this work but that of Zeller should be mentioned on cholinesterase, diamino-oxidase and amino-acid oxidases (Zeller, Stern and Wenk, 1940; Zeller, 1940, 1941; Zeller and Bissegger, 1943; Zeller and Maritz, 1944, 1945; Zeller, Maritz and Iselin, 1945). Birkhäuser (1940), Birkhäuser and Zeller (1940) and Zeller and Birkhäuser (1940) studied cholinesterase in brain tissue, while Frommel's laboratory described its action in connexion with various pharmacological problems (Frommel, Herschberg and Piquet, 1943, 1944; Frommel, 1944, 1, 2). Vannotti's (1945) work on the role of cytochrome in the adaptation to lack of oxygen, and his work with Delachaux (Vannotti and Delachaux, 1941; Delachaux and Ott, 1943), and that of Hemmeter (1944) on iron metabolism, especially the free iron of the blood plasma, in connexion with tissue respiration, must be mentioned.

Finally, Almasy's work (Almasy, 1941, 1, 2, 1942, 1, 2, 1945, 1, 2) on the biochemical significance of ionic concentration gradients must not be omitted.

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A Survey of Vitamin Research in Switzerland during the War, 1939—45

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In Switzerland, generally speaking, the vitamin requirements were supplied by the war-time food, but the amounts of vitamins A, B_1 and B_2 and of nicotinic acid were in July, 1944 about 20 per cent. below the recommended dietary allowances of the U.S.A. National Research Council (1945), as shown below in Table 1.

TABLE 1

AVERAGE DAILY INTAKE OF CERTAIN NUTRIENTS BY ADULTS IN SWITZERLAND IN JULY 1944, IN RELATION TO THE AMOUNTS RECOMMENDED BY THE U.S.A. NATIONAL RESEARCH COUNCIL (1945)

Nutrient	Dietary allowance, average recommended for adults by the U.S.A. National Research Council (1945)	Average daily intake of adults in Switzerland, July, 1944	
		Actual	As percentage of recommended allowance
Vitamin A, I.U. ..	5000	3700	74
Vitamin B_1, mg. ..	1·41	1·11	79
Riboflavin, mg. ..	1·88	1·60	85
Nicotinic acid, mg. ..	14·2	12·0	84
Vitamin C, mg. ..	72·5	97·0	134

No epidemic of vitamin deficiency occurred, but there were sporadic cases, usually of dietary origin. Good results were obtained with certain units of the army and groups of schoolchildren in various cities, including Neuchâtel and Bienne, to whom supplements of vitamin B_1 or C in tablet form were distributed.

The Swiss chemical industry produced vitamins during the whole war, so that important gifts could be made to the International Red Cross for countries affected by malnutrition.

Vitamin A

Importation of fish liver oils ceased completely for part of the war. Ordinary requirements were covered by carotene from vegetables. Night blindness was not detected among schoolchildren in a survey in February, 1942 (Fleisch and Posternak, 1943). A synthesis of vitamin A derivatives was reported by Isler, Kofler, Huber and Ronco (1946).

Vitamin B_1

The formation of vitamin B_1 in the nerves and the role of the vitamin in the transmission of nerve impulses is summarized in the work of von Muralt (1946). Stimulation of the vagus for 5 minutes was found to liberate aneurin in the isolated heart of the frog.

Venous umbilical blood showed a higher content of vitamin B_1 than arterial blood (Neuweiler, 1940). Vitamin B_1 diminished the toxicity of certain derivatives of sulphonamides (Jung, 1940; Fleisch and de Preux, 1943). It had no effect on poisoning with *o*-tricresylphosphate (Staehelin, 1941).

Sporadic outbreaks of beriberi were reported in infants (Freudenberg, 1940), in chronic alcoholics (Maier, 1940; Wernly, 1945) and former inmates of concentration camps (O. Gsell, 1945; Hottinger, 1945).

The principal uses of vitamin B_1 in therapy have been in neuritis and sciatica (Martin, 1944; Naville and Martin, 1940), in cardiac disease during pregnancy (Bickel, 1940, 1), in acrodynia (Glanzmann, 1944, 2) and in X-ray intoxication (de Wattenwyl, 1943, 1, 2; Botsztejn, 1942); for the last purpose 25 mg. daily were given by intramuscular injection.

Riboflavin

Light was found to exercise *in vitro* a photodynamic effect on smooth muscle in presence of riboflavin (Boehm, 1941, 1946). Excessive exercise produced a decrease of the riboflavin content of the liver of rats (Minibeck and Verzár, 1940). The average daily excretion of riboflavin in normal individuals amounted to 473·4 μg., and in pregnant women in the sixth to ninth month to 261·2 μg. (Dubrauszky and Blazso, 1944).

Its role in disturbances of the gastro-intestinal tract, including steatorrhoea (Antognini, 1941), sprue, porphyrinuria (Vannotti, 1941) and coeliac disease (Glanzmann, 1943) has been investigated.

Nicotinic Acid

The level of nicotinic acid at 3·0 μg. per 100 ml. was almost the same in the blood of the mother and of the foetus. The heart and liver of the foetus contained 780 to 3500 μg. per 100 ml. (Neuweiler, 1944, 2). The content in human milk was on the average 174 μg. per cent. (Neuweiler, 1944, 1). Nicotinic acid had an antagonistic action towards the experimental asthma produced by inhalation of aerosols of histamine in guinea-pigs (Halbern and Dainow, 1945).

Nicotinic acid was used with success in coeliac disease and chilblains (Birkhäuser, 1942; Kappert, 1943; Glanzmann, 1944, 1, 3).

Vitamin B_6, Pyridoxin, Adermin

Good effects in two cases of early infantile cerebral sclerosis, "*Krabbe*", known also as Sturge's disease, were reported by Glanzmann (1944, 4).

Pantothenic Acid

The action of the derivatives of pantothenic acid on the growth of the rat was studied by Pfaltz (1942, 1943), and the pathological effects, including loss of weight, acrodynia, achromotrichia, alopecia, bronchitis and rhinitis, in the rat and mouse by Jürgens and Pfaltz (1944).

Overloading of the organism with vitamin C, B_1, riboflavin, nicotinic acid or pantothenic acid left the level of iron and copper in the serum generally unchanged. Only with riboflavin could some decrease of iron in the serum be detected (Neuweiler, 1945).

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Pantothenic acid was used with success in restoring loss of hair (J. L. Gsell, 1944).

Biotin

A method of synthesis was devised and published just before the end of the war (Bourquin, Schnider and Grüssner, 1945; Grüssner, Bourquin and Schnider, 1945; Schnider, Bourquin and Grüssner, 1945). Six vitamins, vitamin B_1, nicotinic acid, biotin, riboflavin, pyridoxin and pantothenic acid, as well as two other unknown substances, were identified as necessary for the development of the American rice-meal beetle, *Tribolium confusum* Duval; biotin could be replaced by synthetic *dl*-biotin, desthiobiotin or pimelic acid (Rosenthal and Reichstein, 1945; Rosenthal and Grob, 1946).

p-*Aminobenzoic Acid*

Oral administration of *p*-aminobenzoic acid diminished the toxicity of a combination of sulphapyridine and papaverine for rats. This effect was not specific (Markees and Demole, 1943). Leucine, histidine and proline had the same effect (Markees, 1943).

Linoleic Acid

Deficiency of unsaturated fatty acids in the food of pregnant rats was found to produce scaly tail in the newly born (Guggenheim and Jürgens, 1944).

Vitamin C

Confirmation of the biological identity of ascorbic acid, synthetic and natural, was published by Hangartner and Gordonoff (1942). Vegetables contained several substances protecting vitamin C (Somogyi, 1944, 1, 2). A method for titrating vitamin C with oxidase from the gourd was developed by Müller (1945). Poisoning with inorganic and organic substances such as lead, bismuth, arsenic, ergotamine and morphine resulted in a deficiency of vitamin C (Frommel, Piquet and Cuénod, 1945, 1, 2, 3). Vitamin C influenced enzymic processes during the synthesis of fatty acids (Sullmann, 1943), and of urea in the liver (Leuthard and Glasson, 1943). It stimulated the growth of fibrocytes in tissue cultures (Gehri, 1944), and played a protective part against experimental anaphylaxis in animals (Frommel and Aron, 1943). Ascorbic acid could be traced in nerve cells of various types, pyramid cells, microglia, oligodendroglia and in cells of regions of the brain. Peripheral nerves gave no histochemical vitamin C reaction (Wolf-Heidegger, 1942). Ascorbic acid was localized in definite parts of the cell, especially in Golgi's apparatus. Giroud and Leblond's histological test possessed sufficient specificity for practical histological purposes, provided that the necessary precautions were taken (Wolf-Heidegger and Waldmann, 1942). The loss of vitamin C in milk, vegetables and fruit by cooking in different kinds of cooking utensils was determined by titration. The loss was greatest in badly lined copper pots (Fleisch, 1942). Synthetic vitamin C prevented dietary deficiency in the army (Demole, 1940), counteracted the vitamin insufficiency produced by physical exertion (Delachaux, 1945), was used with success in whooping-cough (Glanzmann and Meier, 1945; Fanconi, 1945,1, 2) and in cutaneous eruptions following sulphonamide therapy (Bickel, 1940, 2).

Vitamin D

There was no increase in rickets. Large, single doses of vitamin D were used prophylactically and therapeutically (Freudenberg, 1943).

Vitamin E

A fluorimetric method of estimation was worked out and the concentration of tocopherol in the blood of human beings and animals was determined (Kofler, 1942, 1943, 1945). Human adrenal glands and fat deposits contained from 2 to 15 mg. of tocopherol per 100 g. (Abderhalden, 1945, 1). Brain and skeletal muscles of the human foetus did not contain tocopherol (Abderhalden, 1945, 2). *dl*-α-Tocopheryl prevented paralysis (Demole, 1942), cured uterine lesions (Demole, 1941) and diminished creatinuria in rats deprived of vitamin E (Verzár, 1939). Vitamin E cured experimental *retinitis pigmentosa* in the rabbit (Babel, 1944).

Prophylactic or early therapeutic doses of *dl*-α-tocopheryl acetate prevented or diminished the creatinuria of the rabbit after poisoning by *o*-tricresylphosphate (Bloch and Hottinger, 1943) and supressed the creatinuria produced in children by administration of creatine or thyroxine (Chrétien, 1944). On the clinical side we have to report improvement in one case of progressive muscular sclerosis (Monnier and Donzallaz, 1941), and one case of progressive muscular atrophy (Marcel, 1944).

Vitamin K

The physiological and clinical literature of vitamin K has been summarized in a work by Koller (1941). The liver function was examined by means of the vitamin K test.

Physiological hypoprothrombinaemia in the newborn and the effect obtained on administering vitamin K could be studied with the help of a micromethod needing only 0·13 ml. of capillary blood (Fiechter, 1940). The inactivity of vitamin K in three cases of idiopathic hypoprothrombinaemia in children was described by Hauser (1946).

Vitamins and Cancer

Vitamins B_1 and C were found to increase the discolouration of toluidine blue in cultures of fibrocytes (Gehri, 1943); they were unable to modify alterations of the nucleus produced by the action of benzpyrene (von Möllendorf, 1941, 1942, 1943).

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Danish Experiments on the Nutrition of Domestic Animals during the Years of War

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According to the statements prepared by the Agricultural Council of Denmark (Landbrugsraadet, 1946, 1) oilcakes supplied before the war about 9 per cent. of the available quantity of energy while they contained about 22 per cent. of the available quantity of protein. The amount of maize, wheat and rye imported, was so large that almost the whole quantity of Denmark's grain crop of 3,226,000,000 feed units* was available for the feeding of animals. Consequently, the outbreak of the war and, above all, the German occupation in April 1940, created difficulties in the feeding of Danish domestic animals. A reduction of the different stocks became necessary. Poultry suffered most as this stock was halved, but the number of pigs was greatly reduced. On the other hand, all possible efforts were made to preserve cattle since it would take many years to renew this stock, and besides, milk and dairy products were, in many ways, the basis of the production of other domestic animals. As is known, Danish bacon production is largely based on the use of skim milk.

Cattle

Denmark has probably preserved her stock of cattle better than any other of the occupied countries for, since the liberation, she has been able to export considerable quantities of animal foodstuffs. During the first week of June, 1946, butter exports were only 3 per cent., while exports of eggs were 30 per cent., and of bacon and pork 50 per cent., below those for the corresponding week in 1939 (Landbrugsraadet, 1939, 1946, 2). This difference may be explained by the favourable conditions for milk production in the summer of 1946.

*A feed unit = 1 kg. of barley or 0·7 starch equivalent.

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Effects of Protein Shortage

Apart from the very heavy reduction in the quantities of feeding-stuffs available, caused by the occupation, the 22 per cent. reduction in protein added to the difficulties in the production of milk. It was, therefore, natural and necessary that the experimental activity in the winter of 1939–40 led to an inquiry into the expected effects of the reduced quantities of protein. Experiments were started in which the Danish standard norm of 60 g. of digestible true protein per kg. of 4 per cent. fat-corrected milk was compared with reduced quantities of from 40 to 45 g., and in one case with as little as 32 g., of digestible true protein, while at the same time the amount of energy was increased by about 10 per cent.

The result (Forsøgslaboratoriet, 1940) was that the difference in yield was very slight, provided the quantity of protein did not fall below 40 g. per kg. 4 per cent. milk. Larsen (1941) therefore proposed the following protein norms for a cow weighing 500 kg.: 150 g. of digestible true protein for maintenance and production, 40 g. digestible true protein per kg. 4 per cent. milk. He advised, at the same time, the increase of the amount of energy by 10 per cent., in the hope that in this way protein would be used only for the actual synthetic processes in the organism.

Urea

It was reported from Germany, in the autumn of 1940, that urea could replace protein, particularly in ruminants. Professor Møllgaard undertook to carry out some provisional experiments which were started in the winter of 1940–41 by the Department of Cattle Feeding and Management at three farms with three experimental groups in each farm. A normal group of cows received 60 g. of digestible true protein per kg. of 4 per cent. milk. A "restricted" group received from 35 to 40 g. and a urea group received from 35 to 40 g. plus urea nitrogen corresponding to 20 g. of true protein, it being assumed that urea nitrogen was utilized to the extent of 50 per cent.

In none of these experiments did the urea group give more milk than the "restricted" group, and always decidedly less than the normal group (Forsøgslaboratoriet, 1941, 1). The experiment was repeated during the following winter of 1941–42 with four groups of cows. The fourth group received, besides urea, a bacterial culture supposed to encourage fermentation in the rumen, thereby leading to full utilization of urea. The result was no better than during the first year, the urea group gave no more milk than the "restricted" one (Forsøgslaboratoriet, 1942). The experiment was repeated once more with the same result as that of the four preceding experiments (Forsøgslaboratoriet, 1944, 1), and after that the use of urea came to an end in Denmark. From 70 to 80 tons of feeding-stuff mixed with it was used as fertilizer by gardeners in the suburbs of Copenhagen.

Though the results were so poor in Denmark, Norway and Sweden fared better with urea. The difference is probably explained by the presence of a considerable quantity of beet, usually from 5 to 6 kg. of dry matter in the normal Danish feed ration. Since beet contains large quantities of non-protein nitrogen in the form of amides, some of which are no more complex than urea, all the basic material needed for the

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bacterial synthesis of protein in the rumen is already supplied in the diet and added urea has no effect.

Other Substitute Feeds

We therefore had to resort to other expedients. It may sound strange that skim milk, so important as human food, was used as fodder for the milch cows. When its value was investigated in group experiments it appeared that the economical limit was between 10 and 15 kg. per cow daily. If larger quantities were given, they were not fully utilized (Forsøgslaboratoriet, 1941, 2).

Shortly after the occupation meat-and-bone meal came into use as a feed for milch cows; formerly it had been a highly appreciated additional feed for bacon pigs and hens. Milch cows learnt to eat it, and, during the last years of the war, this feed was rationed at 25 to 30 kg. per cow annually. Even though the quantities were not large, the protein was of high biological value, and the cows received at the same time calcium phosphate, a compound of which they were in great need. That the consequences of the war-time scarcity of phosphorus did not become more serious than they actually were, was, no doubt, largely due to the meat-and-bone meal ration.

Professor Bendixen's interesting and useful findings of the deficiency of cobalt in certain parts of Jutland should be mentioned in this connexion (Bendixen and Pedersen, 1945). It led to pronounced unthriftiness in young cattle and was common among calves and heifers. Old inhabitants recalled that similar symptoms had been known in the past century before imported feeding-stuffs became common.

Bendixen and Pedersen showed that the disease could be cured by giving the animals very small quantities of cobalt, and this cure became very popular and of great economic value in the affected districts. Time will show whether the use of cobalt will prove superfluous when imported feeding-stuffs are again used.

Mustard Meal

The results of a few experiments with mustard meal as the main source of protein for milch cows were not very favourable, but the use of mixed concentrates to secure a high biological value of the protein promises well for the future (Forsøgslaboratoriet, 1944, 3).

Silage

Before the war Danish farmers were already learning the value of beetroot tops (Steensberg, 1933). During the years of war these were generally used and many farmers learned that efficiently ensiled beet tops are a more valuable feed than the beets themselves. The higher protein content of the tops was of particular value, and the carotene content should always secure the tops a prominent position as a winter feed for milch cows. To obtain fodder of high quality the tops should be clean when gathered. At digestion trials carried out with milch cattle it was found that 74 per cent. of organic matter was digested in clean beet-top silage, but only 64 per cent. when the silage was dirty. In the former case scarcely 7 kg. per feed unit was used, in the latter well over 11 kg. (Steensberg and Winther, 1942).

The deficiency of protein also caused Denmark to consider the old problem of crude protein and true protein as measures of protein value. Mrs. Thorbek (1945), in collaboration with Professor Møllgaard, devised a new method, still in the experimental stage, of determining the quantity of polypeptides and free amino-acids besides the actual protein ingredients in the feeds. Regulations hitherto in force regarding the feeding of cows supplying special milk for infants prohibited the use of silage. The exigencies of the war made it necessary in many cases to use silage in order to maintain the milk production at all. In an effort to solve this contradiction both paediatricians and the Experimental Laboratory investigated the question; we fed the cows and the doctors the children. So far the results have shown no ill effects from the silage (Forsøgslaboratoriet, 1944, 2). On the contrary, it was shown that such milk was even better than milk produced without this feed so rich in carotene.

The milk from three groups of cows was examined by Lund (1945) in the course of two winters and an intervening summer. One of these groups was given from 12 to 14 kg. of lucerne silage daily per cow, the others got only beets, hay, straw and concentrates. While the carotene and vitamin A contents of the milk from the three groups were the same in the summer, about 40 I.U. per g. of butterfat, the cows from the two groups which received no silage had only from 10 to 12 I.U. per g. of butterfat at the end of March, while the cows which were fed on silage still had, at that time, from 25 to 30 I.U.

Feeding of Calves and Heifers

Comprehensive feeding experiments with calves and heifers have been carried out at the Experimental Laboratory since 1928. These experiments were continued during the first years of the war but were abandoned later. The work has now been resumed (Steensberg, 1940; Steensberg and Østergaard, 1945).

Experiments with Bulls

The feeding of breeding bulls has become of great interest since artificial insemination is widely used in Denmark, about one-fifth of the breeding cows being inseminated in this manner. Experiments on the influence of feeding on the quality of the semen were carried out last year under the leadership of Professors Hansen Larsen and Ed. Sørensen (Larsen and Sørensen, 1944).

Pigs and Poultry

In spite of the reduction in the number of Danish pigs their feeding has been intensively investigated, particularly the use of beets. A strain of fodder sugar-beets with a content of dry matter of from 17 to 21 per cent. has proved very well suited as a pig feed and, on the basis of experiments undertaken by Jespersen (1945) and Petersen (1946), practical feeds have been devised consisting of 30 to 40 per cent. of beets.

In the absence of yellow maize Jespersen (1941) carried out experiments with home-grown feeds of high carotene content, especially artificially dried lucerne and silage; both proved very suitable, the lucerne meal being more expensive but easier to use.

With poultry grain was also partly replaced by coarse feed, mainly boiled potatoes. According to Baelum (1940) it was possible to give

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hens 70 g. of boiled potatoes and 40 g. skim milk daily, in this way saving considerable quantities of grain and other concentrates.

Pedersen (1940) studied rickets in pigs, particularly in relation to the content of phytic acid and phytase in the feed. This work gave rise to an animated discussion. As a result Møllgaard (1943, 1945) carried out a number of experiments on the absorption of calcium and phosphorus.

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Animal Nutrition during the War Years in Finland

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General

The Second World War brought severe hardships to Finland. Although the country was involved in war since 1939, the major part was saved from the thorough devastation usually connected with front-line military operations. However, a general decline in agricultural production was one of the indirect consequences of the war and, as it resulted in a defeat, the difficulties are expected to last for a comparatively long time.

The interruption of foreign trade by the blockade restricted the import of fertilizers (phosphates) and concentrates. Thus, the general fertility of the fields was reduced by about 30 per cent. and this alone has considerably lowered the crops of fodder plants. Other factors contributing to the shortage were the surrender of territories, including 11 per cent. of the cultivated area of Finland, and alterations in the trend of farm production. It has been necessary to concentrate especially on the production of grain for direct human consumption. Under these conditions, the crops of hay and oats, the main fodder plants of Finland, have now decreased to about 50 per cent. of the normal pre-war level. The number of cows was reduced by about 20 per cent. and that of pigs by over 50 per cent. These reductions, together with the almost complete lack of imported concentrates, soya and maize, have continuously lowered animal production. From the point of view of the health of the population, the decrease in milk production of nearly 50 per cent. has become the most vital problem. Moreoever, milk production has so far shown no signs of the increase which can already be observed in the production of pork, eggs and wool.

The A.I.V. Process

From the very beginning of the war-time hardships in 1939, Finland had at least solved the problem of preserving domestic fresh fodder with the minimum loss of nutritive value. The method had been developed ten years earlier by A. I. Virtanen, and has since been known as the A.I.V. process. It had also been adapted to agricultural practice in several countries, particularly in Finland and Sweden. The biochemical principle of the method, the lowering of the reaction of fresh fodder to a *p*H of between 4 and 3 by addition of diluted mineral acids to the raw material, has proved valid in every respect. The extensive research carried out by Virtanen and his collaborators (Virtanen, 1938, 1941, 1942; Aikkinen, 1938) has covered a wide field of study beginning with the fundamental syntheses of proteins in leguminous plants, the chief material for making A.I.V. silage, including the technical and economic details of the process, the feeding of animals on the acid silage, and, finally, emphasizing the significance of the high quality products, especially milk rich in vitamin A, gained by feeding cattle with A.I.V. fodder.

The application of the A.I.V. process by the Finnish farmers is still very far from its maximum. Shortage of men became, during the war, probably the most important factor limiting the utilization of this method, which has, however, proved to be the only safe way to replace the ordinary concentrates and to satisfy fully the demand for proteins and vitamins during the winter feeding period of over eight months. The Government and the agricultural organizations have now started an extensive campaign in order to popularize the method, particularly on smaller farms.

Fodder Cellulose

For various reasons discussed above, there was a shortage of feed units, *i.e.*, of energy supply for animals. Since the export of wood cellulose was cut off by the blockade, a part of this large-scale Finnish industry could be utilized for animal production. It has been calculated that the feeding of cattle and horses on wood cellulose, particularly in 1942, saved the country from an impending danger of irreparable losses through mass slaughter. Numerous controlled feeding experiments, as well as very extensive practical work on farms, have shown that shredded cellulose is a concentrated and useful feed for ruminants and horses. Being an almost chemically pure carbohydrate, it had, of course, to be adequately supplemented with proteins, minerals and vitamins in the feeding. Thus it gave the best results when used together with A.I.V. silage, which is very rich in those constituents. In peace time, however, wood cellulose will probably always prove too expensive for feeding purposes.

Research of more general scope and theoretical character was also carried out. The microbiological studies of U. Vartiovaara and collaborators (Vartiovaara and Roine, 1942; Vartiovaara, Roine and Poijärvi, 1944; Vartiovaara, Suomalainen and Arhimo, 1944; Poijärvi, 1944) dealt with the general conditions for cellulose decomposition by intestinal bacteria of herbivorous animals. These investigations were chiefly concerned with pigs, a species which has shown great variation in the ability to digest cellulose. It was hoped that a closer insight into the causes of these individual variations would show new ways of improving the utilization of cellulose in certain cases, *e.g.*, by young animals. With this end in view the behaviour *in vitro* was studied of various enrichment cultures toward different environmental factors.

This work disclosed some new features in the physiology of mesophilic intestinal cellulose bacteria. It resulted also in a simple laboratory method by which the digestibility of different cellulosic preparations could be compared and the results were in agreement with the corresponding but very laborious animal experiments. The enrichment-culture technique was improved to such a degree that the rate of decomposition of cellulose in test-tube experiments nearly equalled that in animals. The lignin content of cellulosic preparations proved to be an important limiting factor in the decomposition of cellulose by intestinal bacteria of the cow, horse and pig.

The most interesting results were obtained in a few preliminary experiments when pigs were fed on cellulose which was inoculated with enrichment cultures of bacteria known to be strong decomposers. Thus, for instance, the ability of two animals to digest cellulose rose during five weeks from 50 to about 90 per cent. of the amounts given. Positive results were obtained also with a larger group of horses in a similar experiment. In some other cases again no effect was discernible. The idea and possibility of rendering the digestion of cellulose more effective by bacterial inoculation thus bears a great resemblance to the classic inoculation of leguminous plants with nitrogen-fixing *Rhizobia*.

Some Finnish nutritionists have already reported work based on our results. It is evident that the requirements and peculiarities of the cellulose-digesting bacterial associations also deserve careful consideration when the fibrous natural feeds like grass, hay and straw, are concerned. Individual variations of animals and the new possibilities of improving their digestive efficiency may deserve attention in the estimation of the nutritive value of that group of feeds. The usefulness of the traditional analysis of feeding-stuffs for this purpose has also been questioned in the recent discussions. Unfortunately, animal inoculation experiments have not been continued in Finland since all cellulose is now needed for more important purposes, and the general conditions for research work are very restricted.

Metabolism in Underfeeding

Among typical war-time problems in animal nutrition the underfeeding of milk cows has been extensively studied in Finland. Kajanoja (1944) in a large series of experiments investigated the milk production of newly calved cows when given rations containing considerably less net energy, or smaller amounts of protein, than should be provided on the basis of the productive capacity of the animals. It was shown that during energy underfeeding, a newly calved cow utilizes very easily and in large amounts the reserve fat of its body in order to maintain the level of milk production. The critical limit in protein underfeeding was not reached until the amount of digestible true protein for milk production fell below 30 g. per kg. of milk produced. Energy underfeeding raised the percentage of fat in milk, protein underfeeding lowered it; neither had any influence on the protein content of milk. The results indicated in general that the milk production of newly calved cows is not a sensitive measure of the changes in the amount of energy and protein in the feeding rations.

Utilization of Non-protein Nitrogen by Ruminants

In addition to his vital experiments on wood cellulose as animal feed (Poijärvi, 1943, 1944, 1945) Poijärvi (1942) published a paper on the utilization of amide nitrogen by ruminants. The author has paid special attention to the methods of earlier investigators. His own experiments included nitrogen balances and post-mortem analyses of wethers fed with rations containing urea. The results showed that urea, under certain conditions, improved the nitrogen balance, even in cases where no synthesis of urea to bacterial protein occurred. It was also found that it was not possible to decide, on the basis of feed- and carcass-analyses alone, whether amide not accounted for had been synthesized into proteins. Being water-soluble, amides can be very rapidly carried off in the liquid portion of the food to the lower parts of the alimentary tract.

Metabolism of Fattening

The investigations of Paloheimo (1944, 1, 2, 1945) were directed, among other things, to a study of fat and lean cows. He was able to ascertain from a large number of carcass analyses that, in the first phases of fattening, the increases of fat and muscle tissue proceed at an equal rate, that visceral and tissue fat increase in a nearly constant proportion, and that in full-grown cows the fat content of bones is independent of the general condition of the animal.

Biochemistry of Milk Formation

Finally, Saarinen (1944, 1945) has published a series of thorough investigations of the biochemistry of milk formation in the cow. His work includes statistically treated analytical data on the composition of blood, plasma and milk. Special notice was taken of the amounts of steroids and phosphatides in the formation of milk fat. His most recent, still unpublished, investigations have dealt with the influence of feeding on the lipid composition of blood and on the production of milk fat.

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Experiences and Research Work in Animal Nutrition in Norway during the War, 1939—45

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Before the war Norway, of all the Scandinavian countries, was the most dependent on imports, particularly of grain and concentrates. The war brought these to an end, and also necessitated the diversion of home-grown feeds formerly used for animals, such as grain, vegetables and potatoes, to human consumption. To meet this shortage of feeds the number of domestic animals was drastically reduced, and research work on animal nutrition concerned itself with the most economical use of the available rations, and the efficiency of substitute feeds.

Substitute Feeds

Wood Cellulose

Of the substitute feeds investigated, cellulose from wood proved to be the most important (Breirem, 1940, 1, 2, 3; Hvidsten, 1941, 1, 1946). We obtained good results in feeding it to beef bulls (Hvidsten, 1941, 2, 1946), dairy cows (Hvidsten, 1940, 2, 1946; Hvidsten and Presthegge, 1941), calves (Ulvesli and Breirem, 1944, 1, 2), sheep (Hvidsten, 1940, 3, 1946) and horses (Hvidsten, 1940, 1, 1945). We estimated that cellulose has about the same net energy as oats, but it seems that the value may be even greater under certain circumstances. Cellulose, however, being a pure carbohydrate, required for digestion an expenditure of 37 g. of digestible protein per kg. of dry matter. To obtain good results it was necessary to feed it together with fodders containing liberal amounts of protein, vitamins and minerals. On account of the scarcity of herring meal we were not able to obtain balanced rations with cellulose for milch cows during the last two or three years of war. It was easier to produce such rations for horses, sheep, young cattle and beef bulls, as the protein requirement of these animals is less.

We commonly used 2 to 3 kg. of cellulose daily for milch cows, but we have tried up to 5 to 6 kg. in experiments. In the feeding of horses we have used up to 5 kg. per day. The cellulose was given to ruminants in sheets, soaked in water, but horses received it finely chopped (Hvidsten, 1941, 3).

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The feeding of cellulose reached great proportions during the war. In the period 1940–45 a total of 740,000 tons of cellulose was sold for fodder. Though this great quantity did not cover more than about one-fifth of the feeding-stuff shortage caused by the war, it was vital in maintaining the stock of herbivorous animals (Breirem, 1945, 1; Hvidsten, 1946).

The digestibility of cellulose for pigs varied according to individual, age, and type of cellulose. The average digestion coefficients for organic matter were 23 to 24 with acid-treated wood cellulose, and 31 to 55 with various other wood celluloses. The highest digestion coefficients were found for straw cellulose, 72 for organic matter and 93 for crude fibre. Group experiments revealed that, with the exception of straw cellulose, cellulose possesses no net energy for pigs. It produced considerable enlargement of the intestine and a low dressing percentage. The gain in weight was small and the animals took a long time to reach bacon weight. Nor did the feeding of cellulose, even straw cellulose, lead to a saving of fodder (Breirem, Husby and Presthegge, 1943).

Experiments with cellulose for foxes also were unsuccessful (Rockmann, 1943).

Straw Pulp

Another feeding-stuff that came to play a fairly important part was straw pulp, which was produced by treating straw with a 1·0 to 1·5 per cent. solution of caustic soda. This method was developed by Beckmann in Germany in 1917. The process was developed in Norway by Hesthamar and Lid (1940, 1941). They constructed concrete plants with electric pumps for the changing and circulating of the lye and for washing (Hesthamar, 1943, 1944). These plants are probably more labour saving than the plants used in England. Our results (Homb, 1945, 1, 2) agree very closely with those of Slade and Watson (1939) in Great Britain. The digestion coefficient of organic matter increased from 42 for the original straw (mainly wheat) to 66 for treated straw. The expenditure of protein in digestion was 7 g. per kg. of dry matter. From group experiments with dairy cows we have computed the net energy at 72 feed units per 100 kg. of dry matter. We found a loss in dry matter of 15 to 20 per cent. With this loss allowed for, 100 kg. of straw yields 50 feed units against 20 feed units in the untreated straw. The straw pulp is a healthy and palatable feed that goes well with A.I.V. silage.

Urea

The possibility of saving protein by using urea as a source of nitrogen was tried in three experiments. Only the results of the first of these have been published (Ulvesli, 1942). In the same experiments we tried various quantities of protein, about 25, 45 and 60 g. of digestible crude protein per kg. of fat-corrected milk, allowing 225 g. of digestible crude protein for maintenance at a weight of 450 kg.

The deficient groups with 25 g. of digestible crude protein per kg. of fat-corrected milk decreased heavily in milk yield and weight and the animals became lean, with rough coats. The appetite also declined.

In two of the three experiments urea gave distinctly positive results. The milk yield was higher and the condition better with urea than with the deficient diet. With 45 g. of digestible crude protein per kg. of fat-corrected milk the condition was good, and the milk yield was slightly higher than that of the urea groups. The highest milk yield was attained in the groups that received 60 g. of digestible crude protein per kg. of fat-corrected milk. Table 1 illustrates results obtained in the last experiments in 1943–44.

TABLE 1

EFFECT OF DIFFERENT LEVELS OF PROTEIN AND OF UREA ON THE MILK YIELD AND WEIGHT OF COWS

Digestible crude protein per kg. of fat-corrected milk g.	Daily yield of fat-corrected milk, corrected for difference in yield in the preliminary period kg.	Daily change in weight g.
60	11·5	+ 55
44	10·8	+ 50
22 + 10 g. urea	10·3	− 40
23	9·3	− 405

In these experiments we used rations of hay, roots, silage, cellulose, herring meal and a little bran and molasses. Consequently the rations contained some sugar, but only traces of starch. Urea was not used in practice during the war, and it is not likely that it will be used in peace time as we have much better protein feeds in herring- and fish-meals.

Other Substitute Feeds

The production of fodder yeast from the sugar in the sulphite lye from the manufacture of cellulose was considered as a means of providing protein. Unfortunately it was not possible to start manufacture. Attempts were made to get a better utilization of fish offal by ensiling. The experiments (Fyrileiv and Helgebostad, 1943; Hoie, unpublished) gave good results, especially when Amasil (formic acid) was used. Silage from fish offals, however, was used only to a small extent, partly because of transport difficulties.

Extensive investigations with other substitute feeds have been carried out. Ringen (1939) studied seaweed and Presthegge (1943) leaves, forest waste such as needles, bark and twigs, hay of *Phragmites communis* cut in winter time, and heather meal. The seasonal variation in the composition of heather was investigated by Ulvesli and Nordbø (1945).

Owing to the lack of labour it was impossible to use these feeds to any great extent during the war. Leaves without twigs have the nutritive value of good hay and the carotene content is high and stable. Forest waste and heather have about the same nutritive value as straw, but may be of some importance as emergency feeds for sheep and goats when sufficient winter fodder is hard to get. Needles and heather are relatively rich in carotene, and heather has a fairly high copper content.

Lichen is of some importance as a substitute feed in the mountain valleys even in normal times. We carried out elaborate experiments with this feed (Presthegge, 1944, 1). There was wide variation in digestibility. On the basis of group experiments with dairy cows and sheep we calculated the net energy at about 45 feed units per 100 kg. of dry matter, *i.e.*, the same as for poor hay. The content of vitamins and minerals in lichen is negligible, and the digestion of this feed involved an expenditure of protein as with cellulose. Lichen is palatable, however, and may be of some value in replacing straw in districts where grain is not cultivated.

Cooked kitchen waste, consisting mainly of potato peel and vegetable waste, proved a useful substitute feed for pigs (Husby, 1941, 1945). On the average the organic matter was digested to the extent of 82 per cent. Up to 60 per cent. of the energy value of the rations could be given in kitchen waste. The firmness of the back fat of the pigs was not as good, however, as with ordinary feeding. It also proved possible to make a good silage from kitchen waste. This may be of interest to smallholders wishing to store kitchen waste. In experiments with laying hens good results were obtained with 60 to 100 g. of it daily (Finne, 1944, 2).

Mineral Deficiencies in Farm Animals

In the years 1938–41 we carried out three experiments on the west coast of Norway on mineral supplements for lambs (Engdal and Ulvesli, 1942). Calcium and phosphorus had no effect but supplements of copper and cobalt resulted in higher live weight gains, higher haemoglobin values and improved health.

At the same time Ender (1942, 1) studied, at the Veterinary College of Norway, the causes of pica in ruminants with licking symptoms. He found that in the interior of Norway this disease occurred in districts with hay poor in phosphorus (below 0·17 per cent. of phosphorus in dry matter). Of the sick animals 93 per cent. were cured by treatment with phosphate. The licking disease in the coastal districts was caused by copper deficiency. The hay in these regions contained on the average only 3·4 mg. of copper per kg. of dry matter against 7·5 mg. in normal hay. According to Ender, deficiency occurs when the copper content is below 4·5 mg. Treatment with copper sulphate cured 82 per cent. of the sick animals.

Later Ender (1944, 1946) showed that cobalt deficiency is also very common in Norway, especially in the coastal districts with sandy soils. In districts where copper treatment had little or no effect, treatment with cobalt cured 90 per cent. of the sick animals (Ender, 1946). In some cases copper and cobalt administered jointly were more effective than cobalt alone. Lack of cobalt seems to be the cause of the Norwegian "dry sickness" with anorexia and extreme emaciation. On the basis of chemical analyses Ender and Tananger (1946) state that hay from affected areas contains less cobalt than normal hay. The beneficial effect of various feeding-stuffs rich in cobalt has been demonstrated. The problems involved in the prevention of copper and cobalt deficiency have been discussed by Breirem (1944, 4, 5).

Ender (1942, 2) studied the aetiology of muscle degeneration ("fish flesh") in lambs, calves and young cattle. This disease is common in the upper valleys of the interior of Norway in the later part of winter. The feeding of yeast and of yeast ash and phosphates had a beneficial effect on the diseased animals, but synthetic aneurin had no effect. It appears that the disease is caused by phosphorus deficiency, as analyses of the hay showed low phosphorus values.

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Slagsvold (1943, 1, 2) is of the opinion that phosphorus deficiency is a very common cause of disease in ruminants in Norway. Owing to the lack of phosphatic fertilizers and of concentrates these diseases have increased during the war.

Vitamin B_1 Deficiency in Foxes

Beriberi in foxes increased during the war owing to feeding difficulties. Ender and Helgebostad showed that many of the feeds used for foxes were poor in vitamin B_1. The minimum vitamin B_1 requirement was set at 0·1 mg. of aneurin hydrochloride daily for pups and 0·6 to 1·2 mg. for nursing vixens.

Ender and Helgebostad (1945) found that various fishes, among them sprats and herrings, contain, when raw, substances that inactivate vitamin B_1. These fish should not be mixed with other feeds until cooked. The factor destroying vitamin B_1, which may be called anti-vitamin B_1, may have caused the beriberi of foxes which were fed large quantities of raw herring and sprats during the war.

Ender and Helgebostad (1944) compared fish and meat in the feeding of foxes as measured by the quality of the pelt. They found that fish-feeding gave good quality, but the finer grades were found among the animals fed with raw meat. The addition of minerals, yeast and pantothenic acid to fish had no perceptible influence on the quality.

Diseases of Nutrition and Lactation in Dairy Cows

The poor nutrition of dairy cows during the war caused a great increase in disease. The spread was investigated by Landbrukets Priscentral (1945), which used information from the Cow Test Association. Cases of sterility increased by a third, and there were three to five times as many cases of acetonaemia, tetany and paresis in milch cows as before the war. While sterility and acetonaemia were most common from January to May, the majority of the tetany cases occurred when the herds were turned out to pasture in May and June. There were also some cases during the stall-feeding period. The following results are quoted from unpublished work by Slagsvold, Ender and Halse on the aetiology of acetonaemia and tetany carried out during 1943–45. With the feeding of maximum quantities of cellulose the daily intake of magnesium was only about 10 g. daily as compared with 25 g. in a normally fed control group. This led to a significant difference in the concentration of magnesium in the blood serum, the mean values being 1·4 mg. per cent. in the cellulose group and 2·4 mg. per cent. in the normal group. Of 12 cows in the former group one was lost from tetany and three showed symptoms of latent tetany. The lowest serum magnesium value, 0·55 mg. per cent., was observed in the cow that died, some days before the onset of tetany while she was still apparently normal. The feeding of cellulose did not cause acetonaemia, and in other experiments we were unable to confirm that the feeding of roots high in sugar had any significant preventive effect on this disease.

Rations short in energy, 20 per cent. below the standard but with sufficient protein, given during the first weeks of the lactation period, had a distinctly unfavourable effect, especially when A.I.V. silage was

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fed. This sort of feeding produced acetonaemia as well as the tetany-paresis syndrome. As far as we know this is the first time that hypomagnesaemic tetany has been produced in cows under strictly controlled feeding conditions. We were able to obtain blood analyses from cows shortly before clinical manifestation of tetanic symptoms. These analyses showed a similarity between our tetany in cows and the tetany of magnesium deficiency described by Kruse, Orent and McCollum (1932). A state of chronic hypomagnesaemia was always observed before the acute tetanic stage of the disease. The calcium level of blood serum, generally normal during the chronic stage of hypomagnesaemia, showed a sharp decline at the onset of tetanic symptoms.

We are of the opinion that energy shortage is one of the causes of the war-time acetonaemia and tetany. In the herd belonging to the Agricultural College of Norway we had no cases of acetonaemia in the last winter before the war, and we had no cases in the first winter after the war ended when the cows were again fed according to energy standards, whereas, during the war, we had up to 3 per cent. of acetonaemia (Breirem, 1943, 1, 2).

The Evaluation of Feeds

As digestibility experiments are of great importance in the evaluation of feeds, Ringen (1940), Hvidsten (1946) and Homb (1946, 1) investigated the methods used in such experiments. The problems concerned were the conservation of faeces, the length of the preliminary and the collection periods, the individual variation, and the error of the digestion coefficients. Further, we compared a ration of hay and a mixed ration of hay and concentrates as basal rations in different experiments with sheep. The mixed rations are to be preferred. In some experiments the digestibility determined for mixed rations was compared with the digestibility calculated on the basis of the digestion coefficients for the separate foods in the rations.

Homb (1946, 1) carried out lignin analyses for about 50 feeds and compared crude fibre and lignin as a basis for the estimation of digestion coefficients.

Results of energy-metabolism experiments with cattle carried out in Europe and the U.S.A. have been recalculated (Breirem, 1944, 2, 3). It was found that the utilization of the metabolizable energy in fattening decreases linearly with the increase of crude fibre content in the dry matter of the rations from about 10 to 30 per cent. The calculation did not confirm the statement of Axelsson (1939) that the metabolizable energy in all feeds is utilized equally well and to its full extent at a "crude fibre optimum" of 18 to 23 per cent. in dry matter. Axelsson's severe criticism of the net energy concept is not well founded as it is based on a misinterpretation of Kellner's experiments.

Breirem *et al.* (1943) showed that group experiments are useful in determining relative values of feeds. The assumption that digestible nutrients are of equal value in different feeds may lead to serious mistakes in many instances.

Breirem and Presthegge (1946) made a table of the composition and nutritive value of Norwegian feeds, based on more than 1200 digestibility experiments with sheep.

Self-sufficiency

Various experiments have been carried out with home-grown feeds. Ulvesli (1941) found that A.I.V. silage of mangold tops is a suitable feed for dairy cows. Statistics show that in 1943–44 90 per cent. of all silage was made by addition of acid as against 21 per cent. in 1939–40 (Landbrukets Priscentral, 1944). Amasil (formic acid) and A.I.V. acid have been compared with respect to losses and digestibility and the latter proved superior (Fyrileiv and Ulvesli, 1945, 1, 2). Group experiments with dairy cows (not published) have, however, given slightly better results for formic acid than for A.I.V. as judged by milk yield, condition and appetite. Chemical neutralization was not used in the A.I.V. treatment. In Norway we intend to use both A.I.V. and formic acid as it is difficult to do without the A.I.V. in the ensiling of protein-rich materials, such as clover. Breirem and Fyrileiv (1946) have studied the value of silage from clean and dirty root tops.

Mountain hay is more digestible than lowland hay (Breirem, 1940, 4). The composition of timothy and clover at different stages of growth has been studied (Hvidsten, not published). Homb (1946, 2) and Eri and Homb (1946) have examined the influence of the season of calving on milk yield, the consumption of different feeds, and the economics of milk production.

Breirem (1941, 1, 1946) has discussed the problem of attaining self-sufficiency with dairy cows during the war.

Potatoes are in Norway regarded as the staple food for bacon production. Elaborate experiments have therefore been carried out to compare the digestibility of raw, boiled and ensiled potatoes for pigs, and the storage of potatoes in cellars and silos has been studied also. In the feeding of breeding sows good results have been obtained with potatoes and A.I.V. silage from chopped root tops (Breirem *et al.*, 1944). Experiments with bacon pigs have shown that 10 to 12 per cent. of the energy value of the ration can be provided by A.I.V. silage of chopped mangold tops (Presthegge, 1944, 2). The quality of the back fat is not as good as with ordinary feeding and the retention of calcium is reduced. This may be due to the oxalic acid in the mangold tops.

Finne (1944, 1, 2) has carried out extensive experiments with potatoes for hens in amounts varying from 125 to 300 g. The egg-laying percentage gradually decreased from 66·3 to 50·7; 125 to 150 g. seems to represent the optimal quantities, but even larger quantities of potatoes are allowable when concentrates are scarce.

Finne (1945) has shown that skim milk is a valuable feed in the rearing of chickens.

Other Problems

Experiments with man, pigs and sheep were done to study the problem of the degree of extraction of flour (Breirem and Nicolaysen, 1942; Breirem and Nordbø, 1941). An extraction of 95 per cent. of wheat and rye gave the maximum yield of calories for human nutrition but this degree of extraction should be regarded as an emergency level; an extraction of 80 to 85 per cent. is preferable.

The efficiency of animals as converters of energy has been calculated Breirem, 1941, 2). Pigs and dairy cows have the highest efficiency.

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As it is possible to use roughages as maintenance feed for dairy cows, concentrates are most efficiently used as production feeds (Breirem, 1941, 2, 1946). Under war conditions with shortage of feeds, milk production should, therefore, be given a certain priority.

The effect of the feeding of the cow on the content of carotene and vitamin A in milk and dairy products, especially butter, has been studied by Hvidsten (1943) and Breirem (1943, 1), and on the quality of butter by Ystgaard (1940, 1, 2).

Hvidsten (1940, 4) investigated the value of the chest-girth measurement as a basis for calculating live weights in cattle.

Breirem (1944, 2) found that the fat percentage of winter milk decreased during the war mainly because of underfeeding. The economic problems involved in increasing the fat content in milk and payment for fat have been dealt with by Breirem (1945, 2, 3).

Haugen (1945) carried out extensive investigations on the variation in the fat percentage of cow's and goat's milk.

Berg and Halse (1945) investigated the phosphatase activity in blood serum of milking cows. They found generally lower values in cows receiving maximum quantities of cellulose than in cows on a more balanced diet. Some samples, taken from cows with acetonaemia and hypomagnesaemic tetany, also showed depressed values.

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A Survey of Swedish Research Work in Animal Nutrition, 1940–45

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After the outbreak of the Second World War the importation of fodders to Sweden was gradually suspended. Only minor quantities could be imported by so-called free-passage ships. Moreover, crops, especially hay, were bad in 1940 and 1941. As a result the total production of milk dropped, in 1942, to 82 per cent. of the pre-war figure, but has since risen rapidly and now equals or exceeds that before the war. The number of poultry and pigs decreased very much during the war and is still below normal.

It was, therefore, natural that, during the war, research work in animal husbandry in Sweden dealt with the urgent practical problems of the day, while more fundamental and detailed investigations were postponed.

Dairy Cattle

Fodder Cellulose

Owing to the shortage of feeds, it was necessary to produce fodder cellulose in large quantities in order to supply energy. The fodder cellulose used during that time was distributed in ground form, which greatly facilitated its use. Both sulphite and sulphate fodder cellulose were used and, with each, five digestibility experiments were carried out on bulls; the results are given in Table 1.

TABLE 1

Results of Digestibility Trials with Bulls of Sulphite and Sulphate Fodder Cellulose

(Nordfeldt, 1942, 1)

	Chemical composition, per cent.							Digestibility coefficients		
Type of cellulose	Dry matter	Crude protein	Ether extract	Nitrogen-free extract	Fibre	Ash	Lignin	Organic matter	Nitrogen-free extract	Fibre
Sulphite fodder cellulose . .	87·5	0·2	0·1	18·2	68·3	0·7	3·2	82·1	60·7	92·2
Sulphate fodder cellulose . .	87·7	0·3	0·7	16·9	69·3	0·5	3·4	81·6	62·4	89·9

There was no difference between sulphite and sulphate cellulose. A variation of the percentage of lignin from 2·4 to 4·4 per cent. did not affect the digestibility. The digestibility of crude protein was negative, and for each kg. of fodder cellulose an average of 21·7 g. of crude protein was lost in the faeces.

Eleven group experiments with two or more groups of 6 to 16 milch cows were also carried out. The nutritive value of fodder cellulose amounted to about 75 to 80 feed units per 100 kg., provided the protein and mineral requirements of the animals were met.

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Bulk

As the supply of concentrates was extremely limited in Sweden during the war, it became urgently necessary to investigate the importance of fodder concentration in the feeding of milch cows. The fodder concentration indicates the number of feed units of a feeding-stuff or ration per 100 kg. of dry matter. When roughage is extensively used, the amount of dry matter often becomes relatively high, even if the concentration of hay and silage is increased by early harvesting and improved conservation. In order to investigate the influence of the concentration, a series of feeding experiments was begun, and up to date two group experiments have been carried out (Jarl, unpublished). Three groups were arranged in each experiment. The concentration was varied by feeding 7, 10 and 13 kg. of hay, respectively, to the three groups in addition to concentrates and succulent fodders. The amount of feed units and digestible protein was the same in all three groups, the amount of dry matter per cow daily being the only variable. The cows yielded daily 15 to 20 kg. of milk. Production decreased with the increase in dry matter.

The effect of grinding on the digestibility of barley and oats was studied with milch cows at the Animal Experiment Station (Jarl, 1946). Crushing for oats, and medium grinding for barley, proved the most satisfactory.

Milk

During recent years experiments in raising heifer calves have been increasingly carried out. One of them was designed to find out whether whole milk could be saved for human consumption (Jarl, unpublished). Friesian and Swedish Red Breed calves were used. The only variable in the experiment was the amount of whole milk; other feeds were given in the same amounts. The results are shown in Table 2.

TABLE 2

EFFECT OF CHANGES IN THE AMOUNT OF WHOLE MILK CONSUMED ON THE WEIGHT OF HEIFER CALVES

MEAN VALUES FOR GROUPS OF EIGHT CALVES

Breed	Group	Total amount of whole milk consumed up to the age of 65 days kg.	Weight at one year of age kg.
Swedish Red	1	266	295
	2	194	295
	3	141	304
Friesian	1	302	333
	2	239	335
	3	148	340

Owing to the reduction by law of the working hours of farm labourers during recent years, it has become the practice in many places to milk the cows only twice a day and to abandon the noon milking. Consequently, it has become common to give calves milk only twice a day. An experiment with Friesian calves showed no disadvantage from feeding twice, as compared with three times, daily (Jarl, unpublished).

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When milk is used for butter making it is usual in Sweden for the farmer to collect the skim milk from the dairy for feeding the stock. In recent years the dairy industry in Sweden has become centralized, small-scale dairy plants being closed and big ones built instead. As a result, the skim milk returned takes longer in transit and, during hot summer days, though pasteurized at the dairy, may turn sour before it is used on the farm. This can be prevented by controlled souring with lactic acid bacteria added after pasteurization. In order to obtain the full effect of this process, the milk should be kept for 24 hours in the dairy at a suitable temperature. Most dairies have no room to store such large quantities of skim milk, and bacteriological investigations have proved that the development of unfavourable bacterial flora can equally well be prevented by the addition of 0·11 per cent. of acetic or formic acid. Feeding experiments with Friesian calves up to seven months of age have shown no difference between fresh milk, milk soured with a lactic acid culture, and milk acidified with formic acid (Jarl, unpublished).

Selective breeding of dairy cattle has resulted in a rise in the percentage of milk fat, and in more rapid growth of calves. These breeding results are contradictory from a physiological point of view, because the quicker the growth, the greater the need for body-building nutrients, such as protein, and the less the need for maintenance nutrients, such as fat. For this reason we started a series of experiments to find out the most suitable percentage of fat in the whole milk fed to calves (Jarl, unpublished). Three groups of eight Swedish Red Breed calves received equal amounts of metabolizable energy from milk containing 3·0, 3·5 and 4·0 per cent. fat. The group receiving 3 per cent. did best though, when the diet of all the calves was changed to skim milk, the differences disappeared. By feeding milk with a relatively low percentage of fat, more butterfat can be spared for human consumption. The effect of a further lowering of the percentage of fat will be investigated in new experiments.

Horses

Fodder Cellulose

During the war fodder cellulose was of great value even for horses. In ten group experiments with them, cellulose was examined in different amounts and in various combinations with other feeds (Edin, Helleday and Nordfeldt, 1941). With 3·0 to 4·5 kg. per animal daily, no detrimental effect on the condition and working capacity of the horses was noticed.

Olsson (1943) carried out a number of digestibility experiments with fodder cellulose. Its organic matter was digested to approximately 80 per cent. but there were definite individual variations. The "negative protein value", *i.e.*, the consumption of protein during the digestion of the fodder cellulose, amounted to about 40 g. per kg. of cellulose. Unlike cattle, horses used part of the fat contained in other feeds when digesting cellulose. This "negative value of fat" amounted to 6 to 9 g. per kg. of cellulose.

A larger series of digestibility experiments not yet completed has proved that horses do not digest feeds rich in crude fibre as well as ruminants (Olsson, unpublished).

Pigs

Fodder Cellulose

During the years 1940–42 Nordfeldt (1942, 1) carried out experiments with common fodder cellulose as a feed for pigs but the digestibility of cellulose was so low and the results so variable that it must be considered unsuitable as a feed for growing bacon pigs.

Kitchen Waste

Nordfeldt (1942, 2) also carried out an extensive series of digestibility trials and feeding tests with dried and fresh kitchen waste as a pig feed. The best result was obtained when not more than 60 per cent. of the energy of the ration was replaced by waste, and the remaining 40 per cent. consisted of grain. The growth and quality of the pork were about the same as those obtained by feeding grain and skim milk.

Whey

Some experiments were also made with fresh or concentrated whey in increasing amounts as a feed for bacon pigs (Edin and Nordfeldt, 1941). In these the views of Bünger (1930) in Germany were confirmed, that the pigs should be fed 1 kg. of fodder grain, and in other respects satisfy their need of nourishment with fresh whey. The method was also tested with fat pigs weighing 80 to 175 kg. Bacon pigs receiving 1 kg. concentrates and the rest in the form of whey, consumed up to 23 kg. of it daily. The weight gain was less than when grain and skim milk were given but the feeding of whey proved more economical on account of its low price.

Fish Offal and Blood

Edin and Nordfeldt (1942) also did a series of experiments with fish offal preserved in various ways, *e.g.*, by addition of A.I.V. acid with and without molasses, and by addition of sodium hydroxide. Fresh blood also was mixed with 13·89 normal A.I.V. acid in the proportion of 100 kg. to 3·5 l. The fish offal proved satisfactory and bacon did not develop fish taint if not more than 0·4 kg. daily was fed and the feeding was stopped 8 weeks before slaughter. Preserved blood gave results as good as those with blood meal; up to 0·5 kg. could be fed daily.

Root Silage

Nordfeldt (1944, 1) found that grain could be replaced in the diet of bacon pigs to the extent of 40 per cent. of the energy of the concentrate ration by a silage prepared from mashed boiled potatoes and pulped fodder beet or turnips in equal proportions or in a 3 to 1 ratio. The results were as good as when grain alone was fed.

Vitamins

Piglets born to sows which during pregnancy received a diet of skim milk and oatmeal, deficient in vitamin A, were weak and many of them died early (Nordfeldt, 1944, 2). The most obvious cause of the early deaths was the higher skin temperature of the affected animals leading to greater loss of heat than in normal sucking-pigs. Conjunctivitis, paralysis of the hind legs and acute scours were prevalent. No vitamin A could be detected in the livers, but the vitamin C content of the blood of the young and of the sows and of the sows' milk was normal. During lactation the sows developed tumours, or haematomas, on parts of the body exposed to pressure against the floor. Nordfeldt found that 34 μg. β-carotene per kg. of bodyweight was sufficient for maintenance of the sows in good health, and for normal development of the foetuses and of the young.

Nordfeldt (1945) also studied the requirements of pigs for vitamins. The feed with a low content of vitamin B_1 supplied 300 I.U. per animal daily as against a calculated content of some 4000 I.U. in a diet consisting of equal parts of barley and oats with 3 l. skim milk daily. The experiments showed that in normal feeding with feeds common in Sweden the need for vitamin B_1 of growing bacon pigs is generally well satisfied. The requirement of vitamin B_1 for pigs more than 7 months old when the percentage of fat in the feed was normal, *i.e.*, 4 to 5 per cent. of the dry matter, was estimated at 4 I.U. per kg. of live weight. In younger pigs the need was greater.

Poultry

Vitamin D

Olsson (1941, 1) worked out a method for determining the amount of vitamin D in fish oils, using chicks as experimental animals. In this method the calcification of the tarsal joints is followed by X-ray photographs. This method is no doubt well known in England, and will not be further discussed here.

From time to time there has been a shortage of cod liver oil in Sweden and for this reason it has become a matter of interest to examine the antirachitic effect of ultra-violet radiations on laying hens. It was found that a mercury vapour lamp of 475 watts (Biosol B) produced, with the body of the hen at a distance of about 1 m. from the burner of the lamp, in one second about the same antirachitic effect as 0·01 μg. of crystalline vitamin D_3 (Olsson, 1942, 1). In tests with growing chicks it was shown that ultra-violet irradiation can replace the entire vitamin D content of their feed (Olsson, 1941, 2).

The vitamin D requirements of ducks and turkeys were also examined (Olsson, 1942, 2). Ducklings needed 0·8 μg. and turkey poults 0·7 to 0·8 μg. of vitamin D per 100 g. of mash at an optimum calcium : phosphorus ratio. For normal growth and calcification goslings of Italian geese needed about 0·3 μg. of vitamin D per 100 g. of feed, whereas those of the Toulouse and other rapidly growing breeds needed at least 0·35 μg. (Olsson, 1946, 1). As in ducks, the calcification of the metatarsal joints was completed at 8 weeks of age. In chickens and turkeys this degree of calcification is not attained until between the ages of 16 and 24 weeks.

Pig-hoof Meal

Feeding experiments with Rhode Island Red and Light Sussex chicks showed that dried pig-hoof meal can replace soya-bean meal and, to a certain extent, fish meal in the concentrate ration. At a 10 per cent. level it produced better growth and feathering than that given by the control ration alone (Olsson, 1945, 1).

Seaweed Meal

Olsson (1945, 2) studied also the effect of seaweed meal (dried kelp meal) on laying hens. The egg production of a group receiving 10 per

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cent. of the meal was about the same as that of a control group. The addition of seaweed meal considerably increased the amount of iodine in the eggs. The yolks of eggs in the control group contained 0·007 mg. of iodine while those of the experimental group had at least ten times as much. The content of iodine in the whites was, however, only doubled.

Kefir Grains

With the centralization of the dairy industry the direct feeding of whey has become more and more difficult and many experiments to find new uses for it have been carried out on cattle, horses, pigs and poultry by the Animal Experiment Station. In one experiment kefir grains grown on whey were given to chicks (Olsson, 1945, 2). The performance of birds receiving 10 per cent. of the dried grains was equal to that of birds with 10 per cent. dried skim milk in their diet, and similarly good results were obtained with fresh grains.

Battery Laying

Battery laying proved more economical than henhouse laying. In a 4 months' experiment the percentage of culls was 8·4 and 14·3 per cent. and the consumption of feed per kg. of eggs 2·78 and 2·99 feed units, respectively. The live weight and general condition of the hens, and the number and quality of the eggs, were the same in both groups (Olsson, 1946, 2).

Rabbits

Vitamin D Requirement

During the severe shortage of meat caused by the war there was a great increase in the number of rabbits. Their vitamin D requirements were the object of an investigation, in which the X-ray method developed by Professor Olsson was used (Jarl, unpublished). The does were put in a dark shed as soon as they became pregnant and remained there with their young until the latter were 12 weeks old. Artificially dried grass was used. In one test the calcium : phosphorus ratio was 1·5 and in another 10·0 and the animals were given graded doses of vitamin D. Though immediately after birth calcification was better in young receiving additional vitamin D, the difference had disappeared by 12 weeks. Under normal conditions, with access to ultra-violet irradiation and to hay, young growing rabbits do not require any added vitamin D.

Crude Fibre

Jarl (1944) carried out some 40 digestibility experiments which showed that rabbits, like pigs, do not utilize well foods rich in fibre. While for cattle the digestibility of a ration may be calculated from the equation $y = 86{\cdot}0 - 0{\cdot}66\, x$, where y is the digestibility coefficient and x the crude fibre content of the dry matter, the equation for rabbits is $y = 93{\cdot}0 - 1{\cdot}48\, x$.

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The Effects of Malnutrition on Domestic Animals during the German Occupation of Belgium

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General

During the occupation of Belgium all domestic animals such as horses, cattle, pigs, rabbits and poultry were officially rationed with food consisting of waste products of meal (husk and residues), shea-nut cake and colza cake.

The rationed food for horses, intended almost exclusively for those in towns, contained approximately the following components: straw, chaff, molasses and about 15 per cent. oats. Dried brewer's yeast was successfully added to the ration at a rate of 200 g. daily per horse. Attempts were made to give synthetic fodder to cattle, without success, although fodder containing molasses and urea, the latter given at a rate of 100 g. daily per animal, did not cause any disturbance. Urea was not found suitable for pigs and poultry.

The large stock of shea-nut cake available at the outbreak of war was successfully used at a rate of 5 per cent. in the fodder of all animals, in spite of the high content of saponin.

Colza cake, owing to its high protein content supposed to be suitable as fodder for cattle, pigs and poultry, was not sufficiently palatable.

The general impression is that in the rationed foodstuffs there was a lack of energy, of vitamins A, B_2, D and E, as well as of animal protein. Mineral foodstuffs were plentiful, but insufficiently assimilated, because of the lack of vitamins.

Poultry

Although the poultry stock was reduced to about 500,000 birds which received official rations, there was much rickets, and other diseases were

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caused by the lack of proper protein, and by unbalanced diets. The authorities tried to supply additional protein from meat meal made from animals which had died, but, though the total protein content of the ration was only about 15 to 18 per cent., the high proportion of animal protein caused a high mortality in young birds from acute nephritis or visceral gout. The laying capacity of adult fowls was not, however, affected by it but there was a mortality of about 20 per cent. among them after the liberation due to either the exclusive diet of home wheat or the use of dry mash infested with meal mites (*Tyroglyphus farinae*).

Rabbits

The great increase in the breeding of rabbits which took place during the occupation was due to the shortage of meat for human consumption. Many breeders were without experience and, consequently, rabbits were fed with all kinds of food, forage and plants. This method of feeding aggravated all forms of infectious and parasitic diseases. Numerous cases of enterotoxaemia and hypocalcaemia occurred, the latter almost always immediately after parturition (birth paresis). Both diseases appeared to be due to the use of potato peelings in feeding.

Dogs

Owing to circumstances, many dogs were killed. With those that had been undernourished, no symptoms of hunger oedema were observed, such as occurred in human beings, but only gradual dehydration together with a decrease of blood proteins.

Pigs

Many cases of anthrax were reported and upon investigation were found to be due to the insufficient sterilization of bone meal. The most important diseases were avitaminoses, especially rickets in young, and even in more mature, pigs, anaphrodisia and non-infectious abortion, which latter might have been cured with vitamin E.

Sheep and Goats

There were numerous cases of osteomalacia, as well as disturbances accompanying pregnancy and parturition, such as pregnancy toxicosis, birth paresis and hypocalcaemia.

Cattle

Great use was made of silage. Because of the lack of molasses, hydrochloric acid was extensively used as an alternative, with the result that many cases of tetany occurred. Formic acid (Amasil, Bayer) was more successfully used. Many cases of grass tetany were observed as a result of manuring with only nitrogenous compounds for want of the other indispensable components.

There were cases of anthrax again caused by insufficiently sterilized bone meal.

At the present moment cases of dystokia in heifers, probably due to undernourishment during calfhood, are particularly numerous.

Horses

Cases of anthrax similar to those in pigs and cattle were observed in horses, and rickets was prevalent in colts. In horses fed exclusively on rationed foodstuffs, various ailments occurred, such as obstruction of the oesophagus caused by too much cut straw, sometimes followed by pneumonia (lung gangrene) through dysphagia, eczema on the legs due to liver disturbances, stomach and intestinal disturbances accompanied by thirst, polyuria, rapid emaciation and heavy perspiring during work; the latter were probably due to lack of protein and excess of molasses. It may be mentioned that the examination of fresh dung revealed the presence of large numbers of *Balantidium coli*, but there is no certainty of this being linked with the further development of disease. At an advanced stage horses went off their legs, though appetite remained. In a number of cases recovery was impossible; in the others convalescence lasted two or three months.

Several endemic cases of botulism were observed in horses; in all these cases the toxin was of type D. It was found that the contamination of forage by botulinus spores occurs before the harvest, through contact with spore-containing soil. The formation of botulinus toxin requires conditions including heat, moisture and anaerobiosis. Heat was often produced by fermentation of molassed fodder or was due to fires. Special care in the harvesting, particularly when the weather is inclement, the boiling of suspect or toxic food, and preventive immunization of the horses by anatoxin, are among the preventive measures that may be taken in districts where botulism is endemic.

Research Work on Animal Nutrition in France during the Years, 1940–45

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The work on animal nutrition conducted in France during the years 1940–45 was influenced by the conditions which prevailed in our country during the German occupation.

The lack of material, and especially the dispersion of the scientists, greatly handicapped research. Some workers were prisoners of war, others were deportees, while many had to abandon their official duties and conceal their identity. The division of France into two zones made general co-operation impossible, and the presence of the Germans was, of course, the greatest difficulty. Instead of preparing statistics on the production of the country, improving the breeds of domestic animals and studying better rationing, our main task was to try to conceal from the Germans the real condition of our livestock and of our food supply. Consequently, no general plan of research work could be established. On the contrary, researches were sporadic and carried out when opportunity offered.

Since there were no imported feeds, and the Germans seized a large proportion of home-grown feeds and of oilcakes, most of the researches in animal nutrition dealt with food substitutes. Many of these "Ersätze" proved disappointing as, for instance, the shea-nut cake, which was

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studied with laboratory animals by Jacquot and Guillemet (1943) and on farm animals by Leroy and Gasnier (1943); its nutritive value was very low and moreover it was toxic. The home-grown oilcake obtained from *Camelina sativa* had a good nutritive value but the available quantity of the seed was so small that it was of no practical use (Matet and Matet, 1945).

Much work was devoted to the recovery of the yeast used in the distillation process. This yeast supplies a large amount of protein which is not very rich in methionine, but it has proved very useful in reducing the scarcity of protein in the diet of domestic animals. It also enabled us to refuse the importation of *Torula* yeast which the Germans wanted to sell to us at a high price as they had no use for it. These yeasts were studied by Simonnet (1944, unpublished), while Jacquot (1942, 1943), Jacquot and Armand (1942, 1), and Jacquot, Armand and Rey (1942) investigated the use of common yeast and of baker's yeast by human beings. They determined the amount of vitamins by biological and chemical methods, and the utilization of proteins by nitrogen balance, and they investigated the best way to introduce the yeasts into the diet.

Another problem which might be of importance even in peace time is the use of tuberin, the globulin of potato. This globulin can be obtained during the process of extraction of potato starch, by precipitation at the iso-electric point. Tuberin has a good biological value although its digestibility is rather low. Its value as a food has been studied on the rat by Jacquot and Armand (1942, 2) and on the pig by Bonnet, Gasnier and Leroy (1945).

Many other by-products, neglected by the Germans, have been tried as foods for animals or man. Casein and lactalbumin have been extensively used in the preparation of cakes which proved very valuable as an extra food for schoolchildren.

One very important problem was the shortage of vitamin A due to the lack of imports. We found the liver of a Mediterranean fish, *le thon rouge* (red tunny fish), a good source of oil rich in vitamin A which easily yielded very potent extracts.

Amongst the various other questions studied was the increase of the nutritive value of some vegetable foods. In this connexion it was found possible to burst the cells of bran by a mechanical process thus increasing the biological value of this food for non-ruminants. Feeding experiments with this bran were carried out on rats, rabbits and pigs (Gasnier, Archambaud and Leroy, 1941; Jacquot, 1941; Leroy and Archambaud, 1941). In 1942, we found it possible to increase the nutritive value of dry beans and soya beans by heating under pressure (Jacquot and Rousier, 1943; Rousier, 1944). This observation is in agreement with the findings of American nutritionists.

In 1942, the Vichy government made an attempt to organize the market of proprietary feeds for domestic animals; scientists were asked to propose official methods for the estimation of the constituents of these feeds. An interesting problem was that of the selection of methods for measurement of vitamins A and D. Numerous investigations were conducted to compare the various methods. For vitamin A, the spectrophotometric method, using Professor André Chevallier's technique, was recommended and it was also suggested that the amount of vitamin A should be expressed in terms of axerophthol. A spectrophotometric method was elaborated also for vitamin D by Vacher. This method proved to be valuable for pure products but unsuitable for foodstuffs. The biological method using the degree of calcification as estimated by radiographic examination with the rachitic rat was recommended. It was not possible, owing to the prevailing conditions, to use the chick method.

Attempts also were made to elaborate better methods for the estimation of some more common constituents of the foods. The determination of crude fibre is still made in our country according to the Weende method, which is neither reliable nor accurate. Guillemet and Jacquot (1943) and Guillemet and Hamel (1945) elaborated a new method based on the property of 70 per cent. formic acid to dissolve starch, sugars and protein and to leave a residue which contains crude fibre and lignin. This method is simpler than the classical one and greatly reduces the amount of undetermined substances in the analysis of foods.

Very soon after the liberation of Paris, the French provisional Government started to reorganize agricultural research. A mission was sent to Great Britain in January, 1945, under the auspices of the French Scientific Mission in Great Britain headed by Louis Rapkine. This mission received a very hearty welcome from the Agricultural Research Council and we spent six weeks visiting the main laboratories and research centres in England and Scotland. Another mission was sent to the U.S.A. A few months later the *Centre National de Coordination des Etudes et Recherches sur la Nutrition et l'Alimentation* was created under the authority of Professor Emile Terroine.

This organization is a part of the National Centre for Scientific Research (C.N.R.S.) of which until recently Professor Joliot-Curie was the Director. This new Centre is empowered to co-ordinate research work on nutrition in seven departments: National Education, Public Health, Agriculture, Navy, War, Aviation, Colonies.

Two Committees of the Centre on bread and milk have already begun work. The first task of the Bread Committee has been to recommend the addition of 1·5 g. of calcium carbonate per kg. of flour, as has already been done in Great Britain. This measure was rendered necessary by the frequency and severity of lesions arising from decalcification. The Committee has also supported the substitution of 10 per cent. soya-bean flour for wheat flour in order to increase the percentage of protein in the bread.

The Milk Committee has set out the programme of its work. The chief problem is the improvement of the quality of milk, especially from the bacteriological point of view, in order to reduce the infant mortality during the summer months. Another important problem is the popularization of milk to promote a larger consumption. In that we are following the example given by the National Milk Scheme of Great Britain.

The basic principles and the practical methods which we have recommended are derived from what we were able to learn in December, 1944, when Sir Jack Drummond received us so kindly at the Ministry of Food and gave us information about the organization of the food administration in Great Britain during the war.

The amount of work involved in the organization of the Centre has prevented Professor Terroine from attending the Conference. He was very sorry and asked us to thank the British Council and The Nutrition Society for having invited the French Delegation and we shall take back to him the invaluable information gathered during the Conference.

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July 8th, Afternoon Session: Chairman, Dr. S. K. Kon

Nutritional Conditions and Research in Animal Nutrition during the Years, 1939–45, in the Netherlands

Professor E. Brouwer (Laboratory of Animal Physiology, Agricultural College, Wageningen, Holland)

Before the war the Netherlands exported considerable quantities of such animal products as butter, cheese, meat, bacon and eggs. But, though the yield per acre of crops of vegetables and feeding-stuffs was one of the highest recorded in any country, the total amount produced was insufficient, and animal production in the Netherlands was dependent not only on imports of fertilizers such as potassium salts and phosphates, but also on that of oilseeds, oilcakes and cereals.

When all these imports stopped at the beginning of the war the stock of concentrates was soon exhausted and the supply of feeding-stuffs almost ceased. Consequently, the numbers of pigs and poultry were seriously reduced; cattle were affected to a lesser extent, though the shortage of concentrates was equally severe for them. The number of young and adult cows was reduced from 2·8 millions to 2·1 millions, that of pigs from 1·6 millions to 0·5 million and that of poultry from 35 to 3·7 millions. Large areas of land were flooded, and the situation was made more difficult by the German order to plough up 20 per cent. of the pasture land. The Germans also ordered the exportation of some animal products to Germany.

The experimental work on animal nutrition during the war was, of course, severely limited and was chiefly concerned with the examination of unusual feeding-stuffs and methods.

Pigs

Pig-feeding experiments were done with starfish meal, raw potatoes, ensiled steamed potato peel, boiled late turnips and turnip tops, and artificially dried grass, artificially dried lucerne, feed casein, mangels, super-heated tankage, lupines and other feeds. Further, hydrolysed straw and ensiled potato leaves were tested with cattle.

Cattle

Non-protein Nitrogen

The supply of oilcakes and cereals being almost exhausted in the first years of the war, there was a great demand for feeds, particularly for those rich in protein, since the shortage of carbohydrates could be partly relieved by mangels and potatoes. In efforts to improve the protein position two feeding trials were performed with non-protein nitrogen, urea and ammonium lactate, at the Agricultural Experiment Station at Hoorn and at the Institute for Modern Animal Nutrition at Hoogland. The experiments with about 100 cows lasted several months (Brouwer, Frens and Stonebrink, 1943).

In our opinion much of the work previously done on these lines was inadequate. In experiments of this kind two control groups are essential, one receiving a normal protein supply and the other sufficiently deprived of protein to decline in condition, live weight and milk production. The experimental group or groups should receive the same protein-deficient ration and, in addition, the non-protein nitrogen under test.

The experiments showed that the feeding standards in use in the Netherlands were on the high side. They are those of Lars Frederiksen and provide 700 g. of crude protein per 1000 kg. of live weight and 70 g. per kg. of fat-corrected, 4 per cent. milk. Loss of weight did not occur until the protein intake was reduced to 70 per cent. of the standard, and a reduction of 60 per cent. was necessary to affect the milk yield.

The loss of live weight and milk yield could only partly be prevented by the giving of non-protein nitrogen. The effect of a given amount of nitrogen in natural foodstuffs was better than twice this amount as urea and ammonium lactate. In our opinion, therefore, urea and other non-protein nitrogen products are only to be recommended in cases of serious protein shortage. The protein content of hay and silage in the Netherlands has, however, increased so much during recent years that a protein shortage as severe as that just mentioned seldom occurs, even in war time.

As might be expected, in poultry feeding urea had no favourable effect (van der Meulen, 1943).

Planning for the Future

The experimental work in the Netherlands was not only concerned with the abnormal circumstances of the war, but was done also partly in preparation for the hard competition of the post-war period. In this connexion I can only mention experiments on calf rearing by Grashuis, the work of de Man on the amino-acids in grass and the extensive statistical analyses of van der Meulen, bearing on the experiments of Forbes and others on mineral metabolism.

Pasture

The dry matter of our pastures frequently contains 25 per cent. and more crude protein, and on such good pasture cows eat considerably more protein than they need. Sjollema (1941, 1, 2, 3, 4, 5) made an intensive study of the different nitrogen fractions in the urine of cows on winter feed and on pasture. He found that the quantity of grass protein eaten is sometimes double the requirement. The health of cows may be affected by such an unbalanced diet.

The Quality of Milk Fat

A problem of fundamental interest to the butter industry is the softness of butter produced on pasture. Attempts to correct this fault have been going on for many years but with little success. It has become known, however, that the consistency depends not only on the feed but is also subject to important individual variations.

During the war the study of these alimentary and individual factors has been continued. The iodine number has been widely used as a measure of the suitability of milk fat for butter production because it measures the unsaturated liquid fatty acids. Some workers believe that the refractometer value is even better for this purpose though on theoretical grounds this seems unlikely. Nevertheless, the refractometer value may be used with great success, and its determination is much easier than that of the iodine value. In my opinion, for accurate research, besides the iodine value, or the refractometer value, the Reichert-Meissl value should not be neglected, as it measures a second group of liquid fatty acids, the volatile ones.

We have considered the usefulness of other measurements, in particular those of linoleic and vaccenic acids. The results of Mulder (1940) and those of van der Burg, Brouwer and Koppejan (1944) show, however, that the fluctuations in the content of linoleic acid are only slight.

Vaccenic acid was discovered by Bertram (1928). It is a fatty acid isomeric with oleic acid with a double bond between the 11th and 12th carbon atoms. It is the first elaidic acid found in nature and is remarkable for being solid. Brouwer and Jonker-Scheffener (1946) showed that butter-fat contains about 4 per cent. of vaccenic acid when the cows are on grass. With two winter rations the amount was only small. Vaccenic acid and the iodine value of butterfat were positively correlated. However, with the same iodine value, the vaccenic acid content of butter produced on the winter rations was distinctly lower than on grass.

Our unpublished experiments indicate that the influence of vaccenic acid on the consistency of butter is probably only slight. Nevertheless, this substance has gained considerable interest through the experiments of Boer, Jansen and Kentie (1946) on its dietetic properties.

Many years ago I expressed the view that the ratio of grass eaten to butterfat produced might be of considerable importance for the iodine value of summer butterfat. As feeding of grass increases the iodine value, both an increase in the amount of grass eaten and a decline in yield should emphasize the effect. When the quantity of grass eaten by cows is roughly proportional to their energy requirement the quotient becomes:

$$Q = \frac{\text{energy requirement}}{\text{butterfat produced.}}$$

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Substituting in the numerator the formula of Lars Frederiksen for the energy requirement, we get, when W = live weight, f = fat percentage, M = daily milk production in kg. and F = daily fat production in g.:

$$Q = \frac{\frac{W}{300} + 1 + \frac{M}{9} + \frac{F}{240}}{F} = \frac{1}{F}\left(\frac{W}{300} + 1\right) + \frac{1}{90\,f} + \frac{1}{240}$$

From this formula it is easily seen that Q rises with decreasing F, and f with decreasing W.

It has been shown by Brouwer (1932, 1, 2) and by Adriani, Tamsma, Vogel and Groot (1946) that the iodine value, or the refractometer value, is influenced in the same way as Q, being on an average higher in animals with lower fat production, lower fat percentage and higher live weight. Adriani *et al.* (1946) studied several other factors and it appears that some of them, *e.g.*, the influence of the age of the cow and the stage of the lactation, may be reduced to the facts just named.

If the pasture is so poor that insufficient food is eaten to maintain metabolic equilibrium, the milk fat is partly produced from the body fat and this causes a serious increase of the iodine value, though the quotient is lowered. Presumably this occurs in practice chiefly in late autumn. It is probable that in this season the long nights and the high water content of the grass cause a diminution of the quantity of dry matter eaten, whilst the metabolic rate and the mobilization of the body fat are stimulated by the low temperature (Brouwer, 1943–44).

There are some indications that hereditary factors also affect individual variations, but these need further examination.

The question of the substance or substances in the grass causing the rise of the iodine or refractometer value of milk fat is not yet definitely solved. Empirically it has repeatedly been shown by myself and others that a positive correlation exists between the crude protein content of the grass and the iodine value of the butterfat, but, as far as I know, it has never been proved that the feeding of excessive amounts of protein produces soft butter. It has been suggested (Brouwer, 1932, 3; Brouwer and Frens, 1937; Brouwer and van Albada, 1943; Brouwer, 1944) that the unsaturated fatty acids of grass having an excessively high iodine value (about 180), are the principal determining factor. Adriani *et al.* (1946) hold that the nitrogen-free extract, calcium and chlorine, are of more importance.

Attempts were made to produce a butterfat with lower iodine value by supplementing pasture with other foodstuffs. The purpose was a double one, for with a feed poor in protein the grass ration would be better balanced. Table 1 shows some of the results.

Copra proved the most effective but it is not certain whether this feed is perfectly harmless.

Sjollema (1943) advises additional foodstuffs for cows and restriction of grazing to 8 hours daily. The economic aspects of this practice are uncertain though it may be beneficial to the cow, and it has been shown (Brouwer, 1932, 3) that it saves grass.

Silage

The making of silage was under constant study. Before the war the dressing of the grassland and the early cutting of the grass for hay, for silage and for artificially dried grass, considerably reduced the quantities of concentrates needed in cattle feeding and, during the war, prevented the milk yield from declining more than it did. Cows yielding daily up to about 16 kg. of milk remained in a fairly good condition with a diet of only

TABLE 1

EFFECT ON THE IODINE VALUE OF MILK OF ADDING VARIOUS FODDERS TO THE RATION (Brouwer, Dijkstra and Frens, 1943)

Fodder	Daily addition per cow kg.	Decrease in iodine value
Oat straw	1 to 1·5	0.6
Molassed beet pulp	1 to 1·5	
Oat straw	1·5	1·0
Molassed beet pulp	1·5	
Oat straw	1	2·0
Molassed beet pulp	2	
Palm kernel meal	2	4·2 to 4·5
Copra	0·5	5·5 to 7·4
Copra	0·25	2·9
Tapioca meal	2	2·5
Mangels	18*	1·5
	2†	
Potatoes	9·5*	4.8
	2·4†	

* Fresh basis. † Dry basis.

hay, grass silage and artificially dried grass. They produced only slightly less milk and butterfat than other cows receiving a ration consisting of hay and 4 to 5 kg. of a concentrate mixture (Dijkstra, 1943, 1). The live weight of the group fed only with grass products declined slightly in comparison with that of the control group. It is possible, however, that the quality of these products could be still further improved.

During the war the restriction of the supply of sugar, molasses and mineral acid for ensiling led to the study of substitutes for these products. Experiments were performed (Dijkstra, 1945) with a silo with press cover (Schmidt system). This sytem, however, was no better than ensiling in an ordinary watertight silo with a layer of soil.

The use of formic acid in ensiling gave fairly good results (de Ruyter de Wildt and Dijkstra, 1943; Dijkstra and de Ruyter de Wildt, 1943; van Riemsdijk, 1942), but this acid did not give the particularly favourable results claimed for it. Careful experiments did not confirm the belief that less of it is needed on a molecular basis than of mineral acids. Formic acid has, however, the advantage that it does not disturb the acid-base balance of the cows. It is, unfortunately, much more expensive than the mineral acids.

With mineral-acid silage the acid-base balance may be maintained by the addition of bases. It has been feared that the digestibility may be lessened when sodium bicarbonate is the base used. Dijkstra (1943, 2), however, showed that it had no such effect.

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Problems of Food Supply and Food Utilization in Switzerland

Dr. A. Schürch (Institute of Animal Nutrition, Federal Institute of Technology, Zürich, Switzerland)

During the war the food resources of Switzerland underwent a considerable change and this directly affected the feeding of farm animals. The land on which crops directly suitable for human nutrition were grown was increased by about 150,000 hectares, and the area of grassland and pastures was consequently reduced. At the same time our imports of concentrates, which before the war amounted to 460 million kg. starch equivalents (541,000 tons) fell in 1944 to 43 million kg. starch equivalents (34,000 tons), while home-grown concentrates, such as barley, oats and industrial by-products, had to be increasingly used for human nutrition.

We were, therefore, faced by the problem of maintaining our stocks, necessary to produce the valuable animal foods essential for the complete and healthy nutrition of the population, without using food supplies suitable for human nutrition. To achieve this we had to reduce the stocks, increase the production of home-grown foodstuffs and ensure the best possible utilization of available fodders. The scientific research

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work of the Swiss agricultural research centres and particularly of the Institute of Animal Nutrition at Zürich was chiefly concerned with the development of these measures.

Reduction of Stocks

The first task, the reduction of our stocks, was partly automatic, but could be guided along certain channels by appropriate rationing of the existing concentrates. First, diseased animals and those with a small productive capacity were disposed of. Then the number was reduced of animals, such as pigs and poultry, needing highly digestible feeding-stuffs and, therefore, competing directly with human beings.

Increase in Home-grown Foods

Our second task of increasing our resources of home-grown nutrients was undertaken by both the specialist for plant production and the animal nutritionist. The former had to improve the quality of fodder crops by encouraging the growing of more productive fodder plants, and the more scientific cultivation of the land.

Silage

The animal nutritionist had the important task of preventing all possible waste in the storage of fodders. Experiments made at our Institute showed that under favourable conditions the percentage losses in starch equivalent in the preservation of grass amounted to 40 with hay cured on the ground, 35 with hay cured on racks, and 10 with grass silage and artificially dried grass. It is obvious from these figures that ensiling and artificial drying can save large quantities of nutrients. These two methods of preservation have the advantage of being independent of the weather, of spacing out the work of the harvest and of making possible the preservation of young plants rich in nutrients, particularly protein.

The increased use of silage led to difficulties in the production of Swiss hard cheese, for which the milk of silage-fed cows is unsuitable. Silage milk in our country usually contains an abnormal amount of butyric acid bacteria which lower the quality of the cheese by causing "blowing". The high count of butyric acid bacteria in the milk is directly related to their great number in silage since these bacteria do not multiply in the digestive system of ruminants. In experiments to produce a silage with the smallest possible number of butyric acid bacteria and satisfactory in other respects, it was found that a pressure varying from 0·5 to 2·5 atmospheres applied to the silo had no effect on the quality of the silage, and that, when the dry matter content of the forage was increased from 14·3 to 31 per cent., an intensification of lactic acid fermentation resulted and the quality of the silage improved.

In further experiments the silage was submerged in water as suggested by van Beynum and Pette (1938) to obtain maximal homogeneity and a dry matter content of only 6 to 7 per cent. This experiment also produced an excellent silage closely resembling green forage. On the other hand, of course, the loss of dry matter in the juice amounted in this case to 20 to 30 per cent., proving this method unsuitable for practical purposes.

This gave us the idea of grinding the green forage very finely in a special

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mill to obtain maximal homogeneity of the silage and, at the same time, to keep the dry matter content of the green material unchanged. In this way a silage of perfect quality was obtained last year in experimental silos, even though over-ripe clover was used without a preserving agent of any kind. There was no increase of butyric acid bacteria in this ground silage. The digestibility for pigs of the organic matter of this silage amounted to 61, as compared with 45, per cent. for chopped silage made from the same original material.

Investigation of the influence of hydrogen ion and lactic acid concentration on the development of the butyric acid bacteria showed that the germicidal action of lactic acid depends on the hydrogen ion concentration. At a *p*H of 6, for instance, 2·5 per cent. total lactic acid was still without effect; on the other hand, at a *p*H of approximately 5 as little as 0·4 to 0·6 per cent. total lactic acid had a bactericidal effect.

These unpublished results indicate the possibility that the count of butyric acid bacteria in milk from silage-fed cows may be sufficiently reduced to make it suitable for the manufacture of Swiss cheese.

Artificial Drying

In the meantime, the construction of silos in cheese-making districts has been prohibited and artificial drying encouraged, since this method also means small nutrient wastage. Our industry, co-operating with our scientific centres, constructed a number of large and small grass-drying installations (Goetz, 1944). These were based either on the drum or the single and double moving belt principle. Unfortunately, the cost of construction and of working these dryers, which are electrically heated throughout, is rather high, so that in this case also we had to look for further improvements which would diminish the cost of the installation and economize energy. Laboratory experiments with infra-red rays for artificial drying gave a product of the same quality as that obtained by electrical heating and saved at least 10 per cent. of energy (Zimmermann, 1946). The use of infra-red rays, however, might prove difficult in large installations. A Swiss industrial firm solved the problem by constructing an experimental dryer, based on new principles, which reduced the energy required for evaporating 1 kg. of water from 800 to 1000 Calories to 300 to 400 Calories. A full-size installation based on this principle will soon be in use.

We also investigated to what extent the net energy of grass, as measured in respiration trials with sheep, was affected by the drying process (Heinzl, 1944). It was found in every case that the drying of green forage caused a loss of net energy, even though the amount of digestible nutrients in the original material was unchanged. This loss amounted in our experiments with unground, dried grass to 16 to 17 per cent. and was due to the increased energy expenditure on mastication.

Tests with albino rats showed that the biological value of lucerne protein decreased progressively as the temperature and drying time increased, and at a temperature of 170° C. and a drying time of 30 minutes this decrease was suddenly accelerated.

Improved Utilization of Food

In a series of respiration experiments we examined how different animals convert the digestible energy of food into the energy of stored fat. Results of experiments with cocks and rabbits showed that, for fat formation, values of the net energy of starch, fat and protein as well as the net efficiency of conversion of these nutrients are in good agreement with the fundamental values found by O. Kellner for adult steers (Schürch, 1946; Bachmann, 1946), with the exception that for cocks the net energy of fat was considerably and unaccountably higher. These experiments with cocks also showed that the energetic actions of the single nutrients behave additively when these nutrients are given as a mixture.

The problem of bulk is closely connected with that of utilization of food. Most of the feeding-stuffs produced and used in Switzerland are very bulky and rich in roughage. These feeding-stuffs are suitable for ruminants and horses but too bulky to be consumed in the necessary quantities by pigs and poultry. Preliminary experiments with rabbits showed that within wide limits the food consumption depended not on mechanical satiation, but upon the intake of digestible nutrients, the physiological satiation (Abgarowicz, 1946). Although the amount of roughage in the food was, in extreme cases, a factor limiting the total food intake, health and the utilization of nutrients remained normal, even when the amount of roughage varied considerably. On the other hand, feeding trials with pigs showed a roughage optimum for the best utilization of food. The capacity and length of the intestine of pigs fed on bulky and on concentrated rations were not significantly different.

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Some Aspects of Work on Animal Nutrition in Poland during the War

Dr. E. Pijanowski (Central School of Rural Economy, Warsaw, Poland)

During the war our research workers carried out limited investigations with a view to obtaining new sources for, and new forms of, human and animal foodstuffs. Our problems may now appear insignificant but they seemed to us very important at the time of the general shortage of human and animal foods.

Milk

Production

The development of the Polish dairy industry largely depends on the rate of reconstruction of livestock and in view of our enormous losses it will take at least five years to reach a sufficiently high level of milk production. The number of milch cows fell from about 7 million to just over 2 million, and the total yearly production of milk, as estimated by the Polish Ministry of Supply and Commerce, amounts now to about 2500 million l. while the pre-war production exceeded 10,000 million l. Of this, only about 30 per cent., *i.e.*, 750 million l., or about 75 l. per head yearly, will be available for the urban consumers, as fluid milk, butter and cheese.

Most of the milk, apart from that consumed in fluid form, is made into butter, the present production of which is about 16,000 tons, a quarter of that before the war. This figure does not include the butter produced on farms, which at the moment probably equals the output of the creameries, but which shows a tendency to decrease as the milk industry recovers.

Quality and Control

During the war the Germans introduced the system of minimum delivery based on the volume of milk so that watering of milk, previously almost absent, became a matter of everyday routine. Fortunately, most of our plants have restored their equipment for fat analysis so that a rapid improvement in the quality of milk may be expected. In 1945, when, owing to the lack of sulphuric acid and amyl alcohol, an exact control for fat of the whole milk delivery was impossible, the following procedure was sometimes adopted: specific gravities were taken of whole milk and of the same milk after it had been separated, and from these the approximate fat content was calculated with the help of Richmond's formula.

Substitute Foodstuffs

The Institute of Fermentative Industries and Agricultural Technology under Professor W. Dąbrowski investigated new sources of feeding-stuffs and the improvement of existing feeds. The late Dr. W. Dominik, Professor of General Chemistry at the Central College of Agriculture in Warsaw, and Dr. J. Bartkiewicz worked out methods of obtaining concentrated bran extracts rich in vitamin B_1 and minerals, and concentrated extracts of ascorbic acid from waste green cabbage leaves from the manufacture of sauerkraut. They also devised a method for the extraction of carotene from the leaves of some vegetables and weeds, and for the making from potato starch and skim milk of a substitute for rice.

Lupines

The problem of removing alkaloids from lupine seeds was investigated by us in collaboration with Dr. J. Rostafinski. We found that in the hulls of yellow lupines the alkaloid content was even lower than in the husked seeds, that the fibre content of the husked seeds was about 60 per cent. of that of the whole seeds, and that the ensiled or fermented lupines partly or wholly lost their alkaloids.

In 1941, a method of removing alkaloids from yellow lupines was worked out, consisting in the extraction of husked seeds with lukewarm water acidified to a pH of 4·2, the point of least solubility of the main lupine protein, conglutin, the acid reaction of the liquid facilitating the extraction of the alkaloids. Two consecutive extractions were always carried out. The extracted seeds, after pressing and drying, contained only one-seventh to one-eighth of the original quantity of alkaloids and the loss of protein amounted to only 10 per cent., whereas the usual extraction with neutral water or with water not brought exactly to pH 4·2 resulted in protein losses of 30 to 45 per cent. This method could not, of course, lower the losses of carbohydrates, 40 to 60 per cent. of which were carried off with the extraction fluids. It was found, however, that these fluids constituted a good nutrient medium for yeast and some strains were grown in this way. The lupines, almost free from alkaloids, showed, after drying to about 10 per cent. moisture, a protein content of 55 to 60 per cent. compared with the 40 to 45 per cent. of the original seeds.

The determination of the approximate iso-electric point of conglutin made possible a method for extracting protein from lupines. Blue lupines were used and the roughly ground seeds were treated with water containing about 0·8 per cent. sodium hydroxide. After 12 hours the liquid containing dissolved proteins was separated and the seeds were again extracted with a weaker solution of alkali. The combined liquids were then acidified to *p*H 4·2 and the precipitated protein collected on a filter, pressed, redissolved in alkali and reprecipitated. The resulting substance contained in the dry form about 90 per cent. nitrogenous substances and 5 to 10 per cent. moisture, and could be used both for human and animal nutrition. In a co-operative factory in Warsaw the lupine protein was obtained in daily amounts of 75 to 100 kg. and subjected to a prolonged acid hydrolysis to convert it into bouillon-like products. The extracted lupine grits were poor in alkaloids, but after pressing and drying still contained about 15 per cent. of nitrogenous substances, and could be used as a fodder for cows. From 100 kg. of blue lupines with 35 to 38 per cent. crude protein some 17 to 19 kg. of fairly pure protein could be obtained. The protein was also suitable for the production of glue. The remaining protein-free liquids could be used as a substrate for the production of food yeast.

Rape-seed Cake

Rape-seed cake was also examined as a source of protein. It was found that most of the seed-cake protein was denatured by heating before the pressing and oil extraction, so that only a quarter to a third of the total protein could be extracted. The final precipitation of protein was done by the addition of calcium chloride rather than by adjusting the *p*H.

Similar experiments with dried non-edible fungi gave disappointing results.

It was also found that purely mechanical sifting of the ground rape-seed cake gave a fraction amounting to about 30 per cent. of the total cake weight but with a higher protein content, 40 as against 30 per cent., and a much lower fibre content due to the removal of most of the husks. This fraction could be used as an addition to bread flour or, after acid hydrolysis, for the production of bouillon-like extracts or as pig fodder. Fractions poorer in protein but richer in fibre could be used for cows.

Milk Centrifuge Sediment

In 1942 the great shortage of protein directed attention to the milk centrifuge sediments which, especially in summer time, are rich in proteins, mostly as precipitated casein, and contain in the moist state about 3 per cent. of total nitrogen. The sediment was treated with equal amounts of sulphuric acid and water, heated to boiling point for 20 to 24 hours, neutralized with calcium carbonate and filtered. The filtrate had a bouillon flavour except for a slight "fishiness", probably due to the choline radical of lecithin contained in the centrifuge sediment.

Of the total nitrogen, 55 to 65 per cent. consisted of amino-acids as indicated by the formol titration. The addition of these hydrolysates to normal pig fodder made it more palatable.

Beet Molasses

In the autumn of 1943 experiments were made on beet molasses to remove the characteristic unpleasant odour. The molasses was slightly diluted with water, the density being reduced to about 50° Balling, treated with 1·5 per cent. activated carbon, heated to 80° C., and filtered after 30 minutes shaking; the same procedure was repeated with 0·8 per cent. carbon. The molasses so treated had to a great extent lost the odour and had a pleasant flavour like malt chocolate. It was better suited for animal fodder and satisfactory results were obtained when it was added to cakes and cream ices, saving about 50 per cent. of the sugar and improving the flavour. It could also be used as a substitute for cocoa and cocoa alcoholic drinks, and in the manufacture of sweets when used with vanilla.

Recent Research in Animal Nutrition in the United States

Professor F. B. Morrison (Cornell University, Ithaca, N.Y., U.S.A.)

Energy Studies

Because of the present critical world-wide shortage of grains and other concentrated human foods and livestock feeds, we are all especially interested in the energy requirements of farm animals.

Extensive co-operative experiments by the United States Department of Agriculture and several state experiment stations have shown that maximum milk production cannot be secured from well-bred dairy cows unless they are fed a fairly liberal allowance of concentrates, in addition to a plentiful supply of good roughage, such as hay, silage or pasturage (Jensen, Klein, Rauchenstein, Woodward and Smith, 1942). However, the law of diminishing returns definitely holds here, just as it does in the effect of fertilizer applications on crop yields. In other words, when the amount of concentrates which is fed annually to a herd of cows is increased, there is a definite tendency for each additional 100 lb. of concentrates to produce slightly less milk than the previous 100 lb. of concentrates supplied.

At present every effort should, therefore, be made by dairymen to meet the nutritive needs of dairy cows as fully as possible, by first feeding an abundance of good roughage. This means plenty of excellent hay or hay and silage during the barn-feeding season, and ample first-rate pasturage during as large a part of the year as is possible. In addition, if maximum milk production is desired, a sufficient amount of concentrates must be fed. The amount needed will depend on the productive capacity of the cows and on the amount and quality of the roughages consumed.

Investigations by several experiment stations have shown that when good cows are fed good roughage alone, such as an abundance of alfalfa hay, without grain or other concentrates, they will during the first year produce only about 70 per cent. as much milk as they would yield when fed the usual amount of concentrates. If this exclusive roughage feeding is continued for successive years, the milk yield will drop to 60, or even 50, per cent. of normal.

We might expect that the chief deficiency in such a ration is a lack of readily available energy. However, in Michigan experiments the addition of starch to alfalfa hay did not result in normal milk production (Huffman and Duncan, 1944). The deficiency was, therefore, a lack of something besides energy. In these experiments and others in Oregon, the production of milk on an exclusive alfalfa-hay ration was decidedly increased when even 2 or 3 lb. of one of several such common concentrates as maize or other grain, soya-bean meal, or cottonseed meal, were added (Byers, Smith and Jones, 1944; Smith, Jones and Haag, 1945).

In Vermont studies it has been found that even dehydrated immature hay cannot fully replace grain and other concentrates for dairy cows. Also, the process of dehydrating hay is usually too expensive for extensive use in the feeding of ruminants, for they can make efficient use of hay cured by ordinary methods.

Of especial interest at this time of grain shortage are the numerous experiments that have been conducted to study methods by which beef and lamb of acceptable quality can be produced with a maximum use of pasturage and other roughage and only minimum amounts of grain.

Much further information concerning the influence of various factors on the use of food energy by animals has been gained in extensive experiments by the Pennsylvania Institute of Animal Nutrition. For example, a liberal fat content in well balanced diets increases the efficiency with which energy is utilized (Forbes and Swift, 1944). Also, within reasonable limits an increase in the protein content of the diet does not appreciably increase the waste of energy through the heat increment (Forbes, Black, Thacker and Swift, 1939). On the other hand, a marked deficiency of certain nutrients may greatly reduce the efficiency with which food energy is used.

Protein Investigations

It has been known for some time that for animals with simple stomachs, including man, dogs, rats, pigs and poultry, the kind or quality of protein in the diet is fully as important as the amount. Recent investigations in New York, Wisconsin and elsewhere have shown that for ruminants old enough to have a well developed rumen, the quality of protein is much less important (Morrison, 1943). For example, in our metabolism experiments with growing lambs at Cornell University, the protein of maize-gluten meal, which is of low quality for non-ruminants, was as efficient as the protein of soya-bean meal or of dried skim milk (Miller and Morrison, 1942; Morrison and Miller, 1942).

To find whether the kind of protein was important for ruminants under practical conditions, the author and associates have conducted experiments with dairy cows, fattening cattle and fattening lambs. In five experiments with dairy cows, each year one group was fed a concentrate mixture supplying protein that would have been of poor quality for non-ruminants (Morrison, Bratton and Salisbury, 1942; Bratton, Salisbury and Morrison, 1943). This was a mixture of maize, oats, maize-gluten feed and maize-gluten meal, with an addition of molasses in two trials. The roughage

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was low in protein. Another group each year was fed the same roughage and a concentrate mixture with better quality protein and also much greater variety.

In two of the experiments the results were in favour of the better-quality protein mixture; in two, however, the production was higher on the low-quality protein mixture; and in the fifth trial there was no difference. Apparently, for dairy cows protein quality is, therefore, of little practical importance when the rations consist of the common concentrates and roughages.

Because of war-time shortages, extensive experiments with pigs and poultry, which require high-quality protein, have been conducted at several stations to find the extent to which plant protein supplements can replace high-quality protein supplements of animal origin, such as milk by-products, fish meal and meat by-products. Fortunately, the quality of protein in well cooked soya-bean meal has been found to approach closely that from animal sources. If care is taken to supply sufficient calcium, phosphorus and certain vitamins, good results with pigs and poultry can be secured on rations in which soya-bean meal is substituted for nearly, though not quite, all of the animal protein.

For poultry, rations supplemented with soya-bean meal have maintained about as high egg production as rations containing animal protein, but the growth rate of chicks and the ability of the eggs to hatch has usually been somewhat lower.

Many experiments have been conducted in California, Washington, New York, Wisconsin and Indiana to determine the amino-acid requirements of poultry or to find the relative efficiency of various protein supplements.

Urea as a Protein Supplement

Since urea can be synthesized commercially from the nitrogen of the air, there has been much interest in determining whether urea can be used as a substitute for the protein supplements usually fed to livestock.

This interest has been stimulated because of the great shortage of protein supplements recently. Urea is of no value to animals with simple stomachs, such as pigs or poultry. However, experiments have shown that it can serve as a partial substitute for protein in the feeding of ruminants. This is because the bacteria which accomplish the digestion occurring in the rumen at the same time convert the urea into complete proteins used in building the bacterial cells. Further on in the digestive tract, the cow or other ruminant digests the bacteria and thereby secures for its own use the complete proteins made by the bacteria.

Experiments in Wisconsin, Massachusetts, Hawaii, Oklahoma, Nebraska and at other stations have proved that for feeding dairy cattle and fattening cattle, urea can be successfully used to replace part of the linseed cake or other protein supplement ordinarily fed. To secure good utilization of the urea, care must be taken to supply readily digestible carbohydrates and to have only a moderate content of real protein in the ration.

In several experiments at Cornell University we have found that growing and fattening lambs show a striking difference from other ruminants. For lambs urea does not satisfactorily replace such protein supplements as linseed cake or soya-bean meal (Morrison and Miller, 1943; Willman, Morrison and Klosterman, 1945).

Amounts of Protein Required by Livestock

Because of the recent great shortage of protein supplements for livestock feeding, a considerable amount of work has been done to determine the minimum amounts of protein which will produce satisfactory results in feeding various classes of livestock, especially dairy cattle, pigs, fattening lambs and poultry. Cornell experiments have shown that dairy cows do not need more than 16 to 18 per cent. of protein in the concentrate or grain mixture if any considerable part of the roughage is from the legumes, such as alfalfa or clovers (Harrison, Savage and Work, 1933). When most of the roughage is from the legumes, 12 to 14 per cent. only of protein in the grain mixture is sufficient.

Illinois experiments have shown that the protein requirements of pigs at early ages are high (Carroll and Burroughs, 1939). For pigs weighing 50 to 75 lb. there should be 18 to 20 per cent. of protein in the ration on the air-dry basis. A smaller percentage is needed as the pigs become older and store more fat and less protein.

In repeated metabolism and feeding experiments at Cornell we have found that for the rapid fattening of lambs, at least 10 to 10·5 per cent. of protein is required in the ration on the air-dry basis (Miller, Morrison and Briggs, 1944; Briggs, 1946; Willman, Morrison and Klosterman, 1945).

Mineral Deficiencies and Mineral Requirements

Serious deficiencies of cobalt have been found during recent years to occur in certain districts of Florida, Michigan, Wisconsin and New Hampshire. Only mere traces of cobalt are required by any animals and only ruminants seem to be affected by a deficiency. It is possible that cobalt may be required for normal bacterial fermentation in the rumen, rather than for any other function.

A deficiency of cobalt is characterized by one or more of the following symptoms: depressed appetite, depraved appetite, constipation, rough hair coats, scaliness of skin, muscular inco-ordination, decreased milk yield, loss of flesh, retarded growth, and sometimes death. When cobalt is supplied, recovery is usually rapid, striking improvement often occurring within five days.

Investigations, especially in New York, have shown that many practical poultry rations provide insufficient manganese for poultry. Traces of this mineral are required to insure good hatching of eggs and it is also one of the factors necessary for the prevention of perosis, or slipped tendon, in chicks. Breeds differ considerably in their requirements. White Leghorn chicks require only 30 parts of manganese per million parts of feed, and rarely suffer from a deficiency. Heavy breeds require about 50 parts per million (Gallup and Norris, 1939). Little is known concerning the manganese requirements of other farm animals. Arkansas studies indicate that they are exceedingly low and are met by any ordinary rations (Johnson, 1944). North Carolina is studying deficiency troubles in cattle which may possibly be due to a lack of manganese.

In certain sections of Florida deficiencies of copper or of copper and iron apparently occur in livestock, in addition to deficiencies of phosphorus and cobalt.

Extensive studies in various states have shown that in the case of cattle, sheep, goats and horses, deficiencies of phosphorus are much more

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apt to occur than lack of calcium. This is because hay, pasturage and other roughage, even non-legume roughage, usually have a fair content of phosphorus. With fattening cattle or fattening lambs which are fed heavily on grain, there may be a lack of calcium unless some of the roughage is legume. Kansas and Oklahoma experiments show that with non-legume roughage a calcium supplement, such as ground limestone, should be fed these animals (Weber, McCampbell, Hughes and Peterson, 1940; Blizzard, 1939).

Experiments have revealed a serious lack of phosphorus in the forage in many districts of the United States. Generally dairy cows that are fed the usual mixture of cereal grains and protein supplements will receive sufficient phosphorus, for the grains contain moderate quantities of phosphorus, and the common protein supplements are fair to rich sources. Decided lack of phosphorus is apt to occur with livestock on pasture which get no concentrates and with dairy cows fed home-grown rations of hay or other roughage with cereal grains. In such cases a phosphorus supplement, such as bone meal, should be provided.

Recent studies have shown that rock phosphate, which has been defluorinated by proper heat treatment and other means, is a safe and satisfactory phosphorus supplement. Ordinary rock phosphate or ordinary superphosphate (acid phosphate) contain too much fluorine to be safely used as a phosphorus supplement in livestock feeding over long periods (Mitchell, 1942).

Much of the phosphorus in cereal grains and in certain protein supplements, such as wheat bran, occurs in the organic form of phytic acid. Recent studies have shown that phytate phosphorus, which is not highly available under certain conditions, is utilized much better when the vitamin D content of the diet is liberal (Krieger and Steenbock, 1940).

Vitamin Requirements

So much research has been conducted recently on the importance of vitamins in animal nutrition that only a few of the many developments can be mentioned.

Extensive studies have been done by the United States Department of Agriculture and several state stations to find the average vitamin A value of butter, to study the effects of various rations and to determine the vitamin A requirements of dairy cattle, beef cattle, pigs and poultry.

South Dakota experiments have proved that dairy cows require vitamin D (Olson, 1938; Wallis, 1944). However, these studies and Vermont work indicate that when cows are fed normal field-cured hay there is no need of supplying a special vitamin D supplement. Minnesota, Pennsylvania and Ohio studies show that unless dairy calves are fed plenty of field-cured hay in winter, there may be a benefit from a vitamin D supplement (Gullickson and Fitch, 1944; Hibbs, Krauss, Monroe and Pounden, 1945; Keyes, Bechdel and Thorp, 1943).

Although preliminary Ohio experiments indicated that the feeding of irradiated yeast to dairy cows before calving would aid in preventing milk fever, later investigations have shown little or no benefit (Krauss, Monroe, Hibbs and Sutton, 1943; Hibbs, 1946).

Ample amounts of vitamin E are supplied in all ordinary rations for dairy cattle, beef cattle, pigs and poultry. In Iowa studies, sheep and goats have reproduced normally in successive gestations on rations so deficient in vitamin E that rats could not reproduce on them (Thomas, Cannon, McNutt and Underbjerg, 1938; Thomas, LaGrange and Culbertson, 1942). However, in our New York experiments conducted over a period of 15 years on the "stiff lamb disease," a muscular dystrophy, it has finally been found that vitamin E prevents and cures the disease (Willman, Loosli, Asdell, Morrison and Olafson, 1945).

In an extensive New York experiment with dairy bulls used heavily in artificial insemination, the addition of wheat germ oil as a vitamin E supplement was not beneficial (Salisbury, 1944).

Various experiments have shown that as soon as the rumen of ruminants functions normally, the various members of the vitamin B complex are synthesized in the course of bacterial fermentations which occur there. There is, therefore, generally no advantage in vitamin B complex supplements, such as yeast, in the feeding of ruminants.

Extensive work on the requirements of poultry for the various B vitamins has shown that they require vitamin B_1, riboflavin, nicotinic acid, pantothenic acid, pyridoxin, choline, folic acid, biotin, inositol and an unknown factor present in animal proteins. Fortunately, however, apart from riboflavin and the animal-protein factor, practical poultry rations supply plenty of most of these factors.

An exceedingly interesting discovery has just been announced by the Bureau of Dairy Industry of the United States Department of Agriculture. This is that the non-fat part of milk contains an unknown substance which greatly improves the nutrition of rats fed a diet supplying all the known vitamins, as well as ample protein and minerals (Hartman and Cary, 1946). This discovery apparently provides another reason for the enrichment of bread with non-fat milk solids.

Vitamin C can apparently be synthesized in ample amounts by all farm animals. Studies in Kansas and Pennsylvania show that when vitamin C is fed to ruminants it is destroyed in the fermentations in the paunch (Whitnah and Riddell, 1937; Knight, Dutcher, Guerrant and Bechdel, 1941).

Because of preliminary results secured in Wisconsin, there has been much interest in finding whether the feeding of vitamin pills to young dairy calves will help prevent calf scours or diarrhoea. However, the results of yet unpublished field experiments with many hundreds of calves in Ohio, Michigan and New York have shown no benefits from such vitamin pills.

Other Investigations

If time permitted, studies on many other subjects should be mentioned, such as: the fat requirements of dairy cows; methods of raising dairy calves on a minimum amount of milk; the effect of thyroprotein, or iodinated casein; the effect of thiourea or of thiouracil; the prevention of mastitis in dairy cows by the rapid milking method; the cause and prevention of ketosis, or acetonaemia, of dairy cows; the prevention of bloat in ruminants; the effect of high temperatures and high humidity on cattle and sheep; the determination of net energy values of feeding-stuffs by means of feeding experiments; the curing of hay by the flue-drying method, and other means of drying hay; methods of making hay-crop silage, or so-called "grass silage", and the nutritive value of such silage.

In closing, I should call attention to the series of reports recently prepared by committees of the National Research Council on the nutritive requirements of the various classes of farm animals, which have been published as special reports of the National Research Council (U.S.A. National Research Council, 1944, 1, 2, 1945, 1, 2, 3).

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Concluding Remarks by the Chairman

Dr. S. K. Kon (National Institute for Research in Dairying, University of Reading): The Officers of The Nutrition Society have, in turn, taken the Chair at the meetings of the Conference, and the rather melancholy honour of winding up its first stage has fallen to me.

We have travelled far and wide in our exploration of nutritional endeavour during the past war and have found a great diversity of experience, and yet a strange unity of purpose. We have watched scientists in sorely tried countries and some under happier conditions give their honest best in the service of their fellow men. We have heard, on the one hand, the great epic of the achievement of the United States, equally triumphant in warlike and peaceful pursuits, and listened with admiration to Drs. King and Morrison telling us most ably about the great surge of nutritional development in America. We had described to us, on the other hand, events of such stark horror in the Ghettos of Poland that Dr. Szczygieł thought it better to leave much untold. We have listened to the sufferings of France, of Belgium, of Holland, of Denmark, of Norway and of Finland, but from each country came also the news of scientific work continued under most trying conditions, of progress in practical things and in fundamentals. We heard the very personal tale, told by Dr. van Veen with the cold detachment of the scientist, of good work done in the appalling conditions of Japanese camps in Java. Our Swedish and Swiss friends spoke of the achievements of their countries, seemingly spared by the war and yet drawn into all the difficulties of war-time economy.

We, on our part, have told our visitors something about what this country has done of late, and we look forward to the pleasure of taking them round our laboratories and showing them our work. We have had many stimulating discussions at the meetings and many fascinating talks round the lunch and tea table.

From all this we derived untold benefit and, as the meetings progressed, there took shape in our minds the thought crystallized on Saturday in Dr. King's resolution and in Dr. Hammond's suggestion, that the good work should continue, and that nutrition workers from all over the world should get together in the flesh as they already are in the spirit, be it under the aegis of the United Nations or, perhaps at first, in an altogether informal way.

Some of us will have the pleasure of seeing our visitors for a few more days; for some today is the day of parting. I believe that I am expressing their feelings when I say to all our friends here on their behalf not goodbye but *au revoir.*

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Statement about the Publication of the Proceedings of The Nutrition Society

This number concludes the separate publication of the Society's Proceedings which will in the future be included in the BRITISH JOURNAL OF NUTRITION.

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