

BERIBERI AND OTHER FOOD-DEFICIENCY DISEASES IN NEWFOUNDLAND AND LABRADOR.

BY W. R. AYKROYD, M.D., (T.C.D.),

*Beit Memorial Research Fellow; formerly House Surgeon at the General Hospital,
St John's, Newfoundland.*

(From the Lister Institute, London.)

(With 4 Charts.)

THE occurrence of beriberi among the people of Newfoundland and Labrador was reported by Little (1912 and 1914) and by Appleton (1921). Previously the disease had been noted in North America among fishermen returning from the Newfoundland Banks by Putnam (1890) and by Birge (1891), who reported also its occasional appearance among shore fishermen in New England. About the beginning of the century, beriberi, previously unrecognised or non-existent, became common on the Newfoundland coasts, and it has been endemic there ever since. In the last decade it has become less frequent and may be on the verge of disappearance. This brief history of the disease is based on information supplied by doctors long resident in the country and on inspection of hospital records.

The following short clinical description of beriberi occurring on a white flour staple will show its identity with the tropical, rice-eaters' disease.

ONSET.

The onset in men is usually gradual, but a small proportion of cases gives a clear history of a chill, a feverish cold, a wetting, or severe exposure directly previous to the appearance of symptoms. In women 40 to 50 per cent. of cases are associated with pregnancy, and often develop suddenly after labour.

In the great majority of cases (roughly 80 per cent.) the first symptom complained of is weakness in the legs, usually accompanied by numbness and paraesthesia, a condition well described by patients who say they feel as if they were wading up to the knees in water. Sometimes an aching pain, usually in the calves, but occasionally in other muscles, such as those of the shoulder girdle, first attracts the patient's attention. Very rarely, unusual nerves are affected at the outset, such as the optic, the oculo-motor, or the *nervi erigentes*. Oedema in the feet or calves may be the first evidence of the disease and shortness of breath with a sense of constriction across the chest and epigastrium is sometimes an early symptom. In a few cases the onset of the disease is associated with vomiting, pain in the stomach, constipation, and loss of

appetite; most cases will confess, if questioned, to some abdominal discomfort and constipation in the opening stages. The majority, when seen early, present a variety of such symptoms.

A FULLY DEVELOPED CASE.

The patient is, as a rule, fairly well nourished, though confessing to some loss of weight, and has not much feeling of illness. The temperature is normal. The abdomen may be a little distended, and constipation is the rule.

The heart is accelerated (90–110) and usually dilated—to the left rather than to the right, in my experience—with muffled sounds and foetal rhythm. The blood pressure is below normal.

The legs show evidence of severe peripheral neuritis. Knee jerks are accentuated or lost, depending on the duration of the disease. The calf muscles show the most marked atrophy, and tenderness, which may sometimes be elicited in every skeletal muscle of the body, is here the most exquisite. Tenderness does *not* follow the course of the nerve trunks. Pain in the legs may be so severe as to necessitate morphia. Areas of anaesthesia vary, the most commonly affected being that over the peronei muscles.

The arms are usually affected by the neuritis, though less severely than the legs. The hand-grip is weak, and there is tenderness and wasting in the muscles, wasting of the thenar and hypo-thenar eminences being often marked. Areas of anaesthesia are variable in their distribution.

In severe cases wasting occurs in other muscles of the body, *e.g.* the abdominal muscles. Anaesthesia may sometimes be noted round the mouth and on the chest and abdomen. A few patients complain of dimness of vision.

Of cases admitted to St Anthony's Hospital, North Newfoundland, since 1912, 29 per cent. showed some oedema or gave a history of its occurrence before admission, swelling of the feet and calves in the evening having been noticed before the patient betook himself to bed. The completely waterlogged beriberic is rare.

The blood picture is unaffected for a slight anaemia. Differential leucocyte counts show no abnormality. The urine is free from albumen and casts.

PROGNOSIS.

The prognosis depends on the treatment. Death is rare, though by no means unknown. The following was the recorded death-rate from beriberi in Newfoundland during the years 1912–26.

1912 ...	11	1917 ...	0	1922 ...	3
1913 ...	15	1918 ...	1	1923 ...	1
1914 ...	20	1919 ...	1	1924 ...	2
1915 ...	14	1920 ...	1	1925 ...	0
1916 ...	18	1921 ...	0	1926 ...	0

These figures indicate a low death-rate for a fairly common disease in a population of 250,000. The risk of sudden death in mild convalescent cases is negligible.

Each case presents a different severity of nerve involvement, on which depends to some extent the period of disablement. The prognosis depends far more on the dietary treatment available for the patient. The average case admitted to hospital and given whole-wheat bread, milk, eggs, beans, peas, and cabbages, is usually discharged in six to eight weeks almost fit for work: others, left to drag along at home without supervision and really adequate dietary treatment, may remain semi-paralysed from six months to two years. In severe cases not energetically treated, foot and wrist drop may cause permanent disablement. Other muscle groups may remain atrophied, and the "chronic beriberi paralytic" is not unknown in Newfoundland. Localised impairment of tactile sense is sometimes permanent. Some shortness of breath may persist. Knee jerks return.

Recurrence is common, patients often giving a history of four to eight previous attacks. The significance of this will be discussed later.

ETIOLOGY

Relation of diet to the disease.

Little, in 1912, suggested that the cause of beriberi in Newfoundland and Labrador was the liability of the people, at certain times of the year, to "come down to a diet of bread and tea," the bread being made from fine white flour. He stated that the condition could usually be improved in a few weeks by a diet including whole-meal bread, fresh meat, and beans, an observation confirmed by all with experience in treating the disease. Acting on Little's suggestions, Ohler (1914) produced polyneuritis in poultry by the feeding of white flour bread, made with or without yeast, an experiment sometimes involuntarily performed in Newfoundland, where hens, reduced in winter and spring to household leavings, may become "leery" and die. Ohler found that hens on a diet of whole-meal bread remained healthy.

Little's observations left no doubt of the association of beriberi in Newfoundland with a diet which contains little fresh meat or vegetables, and in which bread made of white flour bulks largely. The peculiar social and climatic circumstances which, on occasion, reduce the inhabitants to such a diet, require a little explanation.

The cod-fishery is the main industry in Newfoundland and Labrador, and up to a few years ago, before certain mining and lumbering developments occurred, only the coast-line was inhabited. The people live round the entire coast-line in small communities, each with a population of about 40 to 200, the economic basis for the smallness and dispersion of the villages being the fact that good "cod-trap" berths, though found everywhere, are not numerous at any particular spot, and the more scattered the hunters the more game and seals. These small villages (outports) are in the winter and spring somewhat isolated, particularly in the north, where navigation is closed from January to June. The south coast remains open all the year round.

By custom and necessity, in most outlying parts of Newfoundland, food supplies and other stores for winter and spring are laid in during November or December, to last till replenishment in the following May or June. The amount and variety of the stores acquired before winter by the poorer families will usually depend on the success of the summer fishing season.

Supplies for winter and spring consist mainly of imported food. The Newfoundlander is primarily a fisherman, and a farmer only in his spare time. It is possible to raise potatoes, cabbages and other vegetables in all parts of the island, but often the amount of vegetables grown during summer and autumn is insufficient to last through the six lean months. Cows, sheep or goats, with poultry, are kept by many families, but there may be considerable difficulty in cutting enough hay to provide winter nourishment for the cattle and goats, which are expensive to feed on imported grain, and few of these give much milk during the spring. Similarly, underfed poultry do not start to lay till the snow leaves the ground. Poor families may be found who, having neither gardens nor livestock, are entirely dependent during winter and spring on whatever supplies of imported food their catch of fish may enable them to buy, or on supplies granted on credit. Such families were far more common a few years ago.

On the Atlantic coast of Labrador, for several reasons, agriculture is practically non-existent, and livestock almost unknown. Here the inhabitants who, during the summer, fish from coastal harbours, migrate during the winter up the bays, where it is warmer and timber and game are to be had. On the coast-line itself, poor soil and bleak weather make it difficult to grow anything, and by the time the people move inland it is too late for gardening. Travelling is by small motor boat, which would render the transportation of cattle difficult. Apart from this, the savage "husky" dog, three-quarters wolf, necessary for travel and dragging timber in winter time, is incompatible, unless penned in summer, with all forms of livestock. Penning is nominally compulsory, but the law is disregarded, and there is no one to enforce it. On the Straits coast of Labrador conditions for agriculture are climatically more favourable, but it is not much practised. Further west, in Quebec, the French Canadian is primarily an agriculturist.

In Newfoundland and Labrador it is during the later spring months that food shortage is likely to be most pressing. In the summer, fresh fish is plentiful; usually there is game to be had in the autumn, while supplies are freshly bought for the winter. One would expect deficiency disease to show a corresponding seasonal incidence. Chart 1 shows the percentage monthly admission of beriberi cases to St Anthony Hospital, North Newfoundland, for the years 1912-28.

This hospital, which is managed by the International Grenfell Association, is the only hospital in a large area in the North of Newfoundland, and admissions may be taken as an index of serious disease in that area, for almost all serious cases of illness from the surrounding bays find their way there. It will

be seen from the chart that the majority of cases of beriberi were admitted in April, May and June, well known on the coast to be the beriberi season.

Many patients have an annual recurrence in the late spring months. Some accept a little weakness of the legs and shortness of breath in spring as part of the nature of things.

Table I gives the actual amount of food per head bought or otherwise acquired for use in the winter and spring of 1928-9 by families in which one or more cases of beriberi developed during the spring of 1929. These stores were bought in November or December. The information was acquired by direct questioning. It was found that both husband and wife had usually a

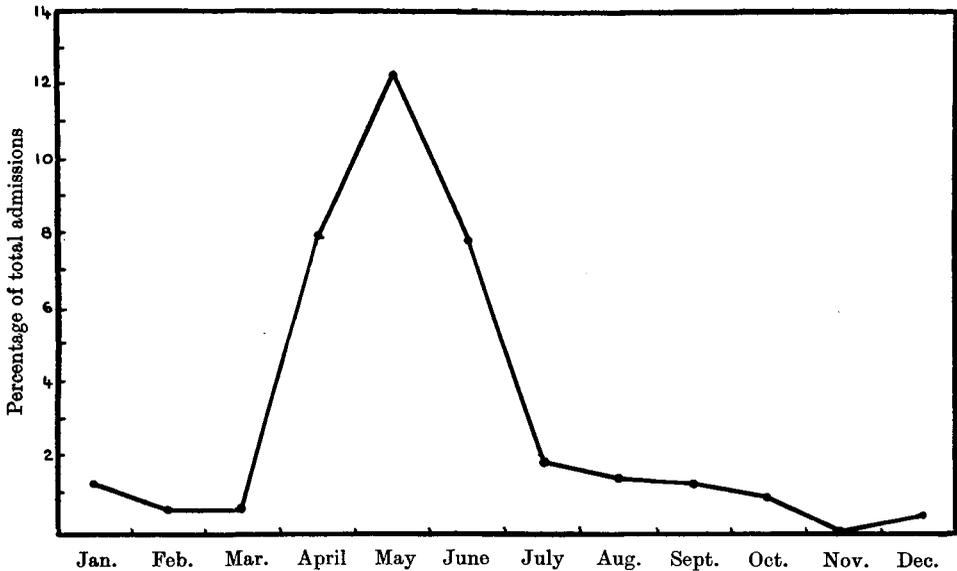


Chart 1. Percentage monthly admissions for beriberi to St Anthony Hospital, North Newfoundland, 1912-28.

clear recollection of so important a matter as six months' food supply. For the construction of the table, children under 10 were reckoned a half and infants under 1 year ignored.

Stores are usually bought for a minimum of about six months and may not be replenished for a longer period. Calorie estimations per diem for six months are thus very rough, and are inserted to show that supplies are in most cases sufficient to cover fuel requirements for that period. When winter stores are purchased, an indefinite amount, small among the poorer families, remains of stores bought during the summer.

None of these households had any fresh or canned milk, or eggs. It is the custom for each family to lay aside in September about a barrel (200 lb.) of "partridge berries" (cranberry), and 60-70 lb. of "bake-apples" (cloud-berry) for use during the winter and spring. These are plucked by the women and

Table I. Food supplies per head for a period of approximately six months (November-December to May-June) (seven months for Labrador Families 2, 3 and 13) in families in which one or more cases of beriberi occurred. North Newfoundland and Labrador, 1929.

Foodstuffs	Family												
	1	2	3	4	5	6	7	8	9	10	11	12	13
White flour and biscuits (lb.)	200	229	196	175	300	160	150	196	394	213	265	205	220
Salt beef and pork (lb.)	15	None	10	12	50	50	15	56	30	33	100	28	5
Salt fish (cod) (lb.)	50	74	None	28	56	56	30	48	56	25	28	16	56
Fresh meat	Plenty for 1 month (wild duck)	None	None	Seal meat for 1 month	Game once a week	Game once a week	None	Two sheep (frozen)	Game once a week	None
Potatoes (lb.)	...	None	None	50	None	None	80	57	100	66	None	None	None
Turnips (lb.)	...	None	None	None	None	None	22	84	None	None	None	51	None
Cabbages	...	None	None	None	None	None	Once a week (3-4 months)	Once a week (3-4 months)	None	None	None	Once a week (2-3 months)	None
Margarine (lb.)	...	6	10	8	11	10	9	20	11	5	33	7	6
Molasses (gal.)	...	2½	3½	5	6	5	2½	3	4	4	3	3	3
Sugar (lb.)	...	None	None	None	34	10	None	16	None	25	25	7	None
Beans (lb.)	...	5	None	4	4	8	6	9	None	5	7	6	None
Peas (lb.)	...	5	None	6	6	8	None	9	None	7	7	6	None
Calories (approx.) per diem	2801	2522	1976	2661	3667	2861	2399	3866	4714	3025	5525	2750	2479

Table II. Food supplies per head for a period of approximately six months (November-December to May-June) in twelve families remaining free from beriberi. Lowest dietary level in families free from beriberi. North Newfoundland.

Foodstuffs	Family											
	1	2	3	4	5	6	7	8	9	10	11	12
White flour and biscuits (lb.)	196	280	200	112	294	168	230	220	215	213	182	270
Salt beef and pork (lb.)	20	25	27	66	50	25	23	50	100	27	18	40
Salt fish (cod) (lb.)	24	50	24	75	37	26	25	28	112	37	20	34
Fresh meat	...	Occasionally	None	3 times a week (3-4 mths)	1 mth's good supply	Occasionally	None	Occasionally	Occasionally	Occasionally	Twice a week (3-4 mths)	Once a week (3-4 mths)
Potatoes (lb.)	...	170	100	None	400	200	220	800	260	260	200	240
Turnips (lb.)	...	None	26	None	100	None	None	25	66	None	None	200
Cabbages	...	None	Lasted 3-4 mths (twice a week)	None	Twice a week (3-4 mths)	Twice a week (3-4 mths)	Lasted 1 mth	Lasted 2 mths	Lasted 3-4 mths	Lasted 3-4 mths	1 mth's supply	Once a week (3-4 mths)
Margarine (lb.)	...	14	5	16	19	13	7	15	25	13	9	30
Molasses (gal.)	...	3	7½	3	None	11	4	1	2	2	2	3
Sugar (lb.)	...	None	None	None	56	None	None	20	74	14	18	40
Beans (lb.)	...	5	8	None	20	4	3½	10	7	8	4	20
Peas (lb.)	...	2	2½	13	20	5	2½	10	7	8	4	20
Eggs	...	None	Occasionally	None	None	None	None	None	None	None	None	Occasionally
Milk (tins)	...	None	None	4	None	None	None	None	6	None	None	3
Calories (approx.) per diem	2590	3431	2637	2709	5511	2579	3152	5080	4980	3687	2943	4977

children, and are available for all. They keep through winter and spring without much deterioration and, being eaten fresh, or lightly stewed, presumably supply a certain amount of antiscorbutic. In addition to the foodstuffs tabulated, most poor families buy a few pounds of rice and some raisins for festive occasions. Tea is almost never lacking and often drunk in enormous quantities, apparently at any hour of the day or night. Dried yeast is used in baking.

In making the above table, the supply of fresh meat was the hardest to assess. I am satisfied, however, that the estimations given represent roughly the amount eaten, and that no family in the table had an abundant or continuous supply.

It will be seen that several families had an insufficient supply of calories. The circumstances of the coast lead to a close association between beriberi and semi-starvation.

In five cases of beriberi it was impossible to get quantitative details of winter stores, but the dietary level was similar to that set out in Table I—that is to say, the patient came practically down to “bread and tea,” with a scanty supply of extras.

Disappearance of beriberi on more varied diets.

The question arose whether the population was generally on the dietary level of Table I with individuals here and there succumbing to beriberi, perhaps as the result of some exciting cause. It proved almost impossible to find Newfoundland and Labrador families *free from beriberi* who had as small supplies of extras to add to white bread as those in Table I. It is quite possible that a few such families might be found by prolonged search over wide areas, but there is no considerable number of them. In other words, beriberi does not appear indiscriminately here and there in a population suffering generally from vitamin depletion, but is confined to the poorest and most ill-nourished of that population.

I enquired widely among hospital patients (mostly surgical) and among the people in their homes for details of the previous winter's stores, bought or otherwise obtained. In the majority of cases a few questions showed that the supplies were adequate in quantity and quality, and no further note was taken. The diets set out in Table II represent the lowest dietaries, from the point of view of variety, which were discovered in families free from beriberi. They are given with the idea that they may represent roughly the point at which human dietaries, on a basis of refined wheat flour, become sufficiently varied to protect against beriberi.

The families in Table II had a slightly more varied dietary than those included in Table I, amongst whom beriberi appeared. If they were short in one article of food, another is in fair abundance. If the supply of fresh meat is scanty, vegetables are available, or *vice versa*. It is particularly noticeable

that they had a fair supply of potatoes which, according to the habit of the coast, would have been the next thing for the families in Table I to consider buying had a little more money or credit been available. Eggs and milk are still lacking, except in the case of a few families able to afford a little tinned milk for occasional use. These families had berries in similar quantity to those in Table I, and small supplies of rice and raisins.

Families 1 and 2 in Table II, at a very low nutritional level, though they did not suffer from beriberi in the spring of 1929, showed other evidences of deficiency disease. In Family 1, the wife, aged 46, had had eighteen children, of whom nine died in infancy at the breast. In August, 1929, she was admitted to St Anthony Hospital for pregnancy. After 3 weeks in hospital on a good diet she was delivered of a still-born child. Discharged in fairly good condition, two weeks later, she developed, within a few days of returning home, what were, in my opinion, unmistakable evidences of beriberi, having weakness in the legs, tenderness and pain in the calves, numbness in the feet, and absent knee jerks. This type of "latent" beriberi introduces a complicating factor. In the same family the husband showed the scar of a large corneal ulcer which had developed following influenza a year previously.

In Family 2, also on a very poor diet, the husband had been night-blind during winter and spring, while the wife was in a condition of chronic ill-health, complaining of indigestion, constipation and lassitude.

The remainder were free from obvious deficiency disease. Housing and manner of life were the same in the two groups.

Labrador diets.

Beriberi has always been less common on the Labrador coasts than in North Newfoundland, in spite of the greater scarcity of vegetables in the former country and of a severer degree of poverty. This may be explained by the greater abundance of game on the Labrador coasts. Labrador families are common who, having nothing for the winter beyond white flour, molasses and tea, with a very little salt meat, salt fish and margarine, are able to kill plenty of fresh meat during the winter and spring. Such families keep fairly healthy. In the case of birds, liver and heart are usually eaten.

Table III. *Food supplies per head, other than fresh meat, to last for a period of approximately seven months, bought or otherwise acquired by four Labrador families remaining free from beriberi.*

Foodstuffs	Family			
	1	2	3	4
White flour and biscuits (lb.) ...	123	113	198	148
Salt beef and pork (lb.) ...	26	28	None	None
Salt fish (lb.) ...	22	40	76	28
Margarine (lb.) ...	8½	4	9	7½
Molasses (gal.) ...	3	1	3½	3½
With tea and a barrel or more of berries (200-300 lb.) per family in addition.				
Calories (approx.) per diem ...	1798	1541	2481	1696

Among the poorest families the amount of food purchased, supplemented by salt cod-fish, is often insufficient to provide adequate calories for the seven months of winter and spring. The food supplies bought by Families 1, 2 and 4 (Table III), which are typical of many, would represent only about 1650 calories per day, though slightly more prosperous families may have enough flour, salt meat, etc., to ensure at least an adequate supply of calories. For the poorest families an abundance of fresh meat, about 5 lb. per week (1 lb. = 1350 calories) is thus necessary for minimum fuel requirements. Actually, game was plentiful during the winter and spring of 1928-9, and these families had a good supply. In practice, periods of deprivation alternate with periods of abundance, the latter following the capture of a deer or seal. A single lucky shot into a flight of wild duck not uncommonly brings down 20 to 30 birds.

On the Labrador a bad hunting season, or incapacitation for hunting by age or injury, leads to danger of actual starvation and presumably of beriberi. The cases of beriberi I observed on the Labrador coasts occurred in families who had been able to secure little or no fresh meat. Further north, the Eskimo, living entirely on fish and flesh, does not suffer from beriberi.

Though beriberi is comparatively rare on the Labrador coasts, the very high infantile mortality, the unhealthy, apathetic appearance of children and adults, the prevalence of severe dental caries, suggest both qualitative and quantitative defects in the local dietary.

The most likely explanation of the comparative freedom from beriberi enjoyed by Newfoundland in the last century is the greater abundance of fresh meat, especially deer and seals, available. Old men's stories leave little doubt on this point, every allowance being made for the greenness of distant fields. It is also true that thirty or forty years ago coarser blends of flour were in use.

Relation of diet to seasonal incidence of beriberi.

The observation that a very small raising of the dietary level from the basic bread, with some salt meat and molasses, will check the appearance of beriberi, is confirmed by the seasonal incidence. The admission rate to hospital falls in July and August, when the only addition to the dietary is fresh fish, before the autumn supplies of potatoes, cabbages, and turnips have been harvested. In many poverty stricken families the diet is poor all the year round, but, with occasional exceptions, it is only in the late spring and early summer months, when the diet is at its very lowest, that beriberi appears. At this season, foods such as potatoes, cabbages, beans and peas, of which the beriberi families have scanty supplies, are becoming exhausted. The spring incidence must also depend on the fact that beriberi probably takes some months to develop on the poorest diet (Fraser and Stanton, 1910) and this time of the year is most remote from the seasons in which a more varied diet is available.

Anomalous cases.

Two cases of beriberi were noted on diets above the level of Table I. One, E.N., male, 31, who developed beriberi in May, 1929, was unable to give exact details of stores acquired in November, 1928. He stated he had sufficient supplies of cabbages and turnips for these to appear at meals three times a week, and fresh game twice a week. He had no potatoes, milk or eggs, an average supply of beans and peas, and a poor supply of margarine and salt meat. This case had an active phthisical lesion.

The other case was on a very fair diet. W.C., 48, admitted to hospital on September 10th, 1929, suffering from unquestionable beriberi, which reacted to dietary treatment. This was his fifth attack, the first being in 1910. Previous attacks had occurred in spring.

This man had had plenty of fresh meat during winter and spring (he himself shot 200 ducks). From April onwards he had at least one egg a day. He had potatoes almost every day all through the year, and turnip-greens and dandelions three times a week during July and August. He was eating fresh fish two to three times a week. No milk was available.

The fact that the patient was an old sufferer from the disease may be of importance. Liability to recurrence, however, is completely explicable on economic grounds. This is the only case I have seen occur on a fairly varied diet, and it is the general medical experience of the coasts that such cases are extremely rare.

Fresh fish not invariably protective.

Though the appearance of fresh fish in the diet in July coincides with a marked fall in the seasonal incidence of beriberi, fresh fish will not invariably protect against the disease, since it occasionally occurs on fishing schooners, where the men usually eat fresh cod-fish daily. I have seen a severe outbreak of beriberi occur on a schooner where the men were eating fresh fish, white bread, and little else.

Cases of beriberi in fishing schooners are, however, rare, as is shown by the monthly admission rate to St Anthony Hospital. St Anthony is usually the first port of call in Newfoundland for schooners southward bound from the Labrador fisheries in September and October. The sick on board are usually left at the hospital, and proceed later to their homes by mail steamer. The annual passage of the homebound fishing schooners is not reflected in the beriberi admission rate to the hospital (see Chart 1.)

Beriberi and poverty.

The seasonal and annual incidences of beriberi in Newfoundland, with an investigation of the types of diet on which it does, and does not, occur, tend to show that it is purely a dietary disease. To-day it is rigidly associated with poverty. If a family can afford but a little greater variety of food than the

minimum necessary to keep body and soul together, they will escape beriberi. On the other hand, a good hunting season will save the poorest.

The liability to recurrence is easy to understand in a poverty disease. A man disabled for the fishing season from beriberi will have to exist through the following spring on whatever stores he can obtain on credit, and will be liable to succumb in the following May or June. For economic reasons one attack renders him more liable to the next. In certain families, pure thriftlessness and idleness lead to beriberi again and again.

It is well recognised at St Anthony Hospital that outbreaks of beriberi follow bad fishing years. The establishment of a lumbering centre in a district, giving the men the chance of making a little extra money in the winter, will cause a fall in the incidence. The sudden diminution in the beriberi incidence, which occurred in 1916 and 1917, reflected in the death-rate and apparent in the records of the General Hospital, St Johns, and St Anthony Hospital, coincided with a burst of prosperity due to the high war-time price of cod-fish. At St Anthony Hospital during the years 1914-16, 6.2 per cent. of the total admissions were for beriberi; during the three more prosperous years that followed the percentage admission rate dropped to 1.2.

The association between beriberi and poverty is so close that, in examining a suspected case of beriberi, a very useful short-circuiting question is to ask whether the patient was successful at the previous year's fishing.

Nevertheless, ignorance may occasionally play a part in preventing variety in the diet. Family 2, Table I, for example, with a fair margin of calories, could have afforded to exclude some flour and salt meat in favour of potatoes, turnips, etc. But for most families in the table sufficiency of calories is the first consideration.

Conclusion to be drawn.

Before beriberi appears among a population on a white flour staple the supply of accessory articles of food will be below the lowest European standards. Diets very low in vitamins, according to modern ideas, are able to protect against beriberi.

Age and sex incidence of beriberi.

Chart 2 indicates the age and sex of 174 beriberi cases admitted to St Anthony Hospital during the years 1912-28.

The disease is rare in males before 16 and, while there is a slight preponderance of cases between the ages 16-20, it is found commonly in men up to the age of 45. Cases of infantile beriberi are omitted from the chart.

The highest female admission rate was between 20 and 30. Few female cases were admitted under 21 and none over 50.

The percentage admission of the sexes was: Males, 80 per cent.; Females 20 per cent.

Of the thirty-four female cases, eleven began, or were accentuated to the point of seeking admission to hospital, during lactation. In four of these cases

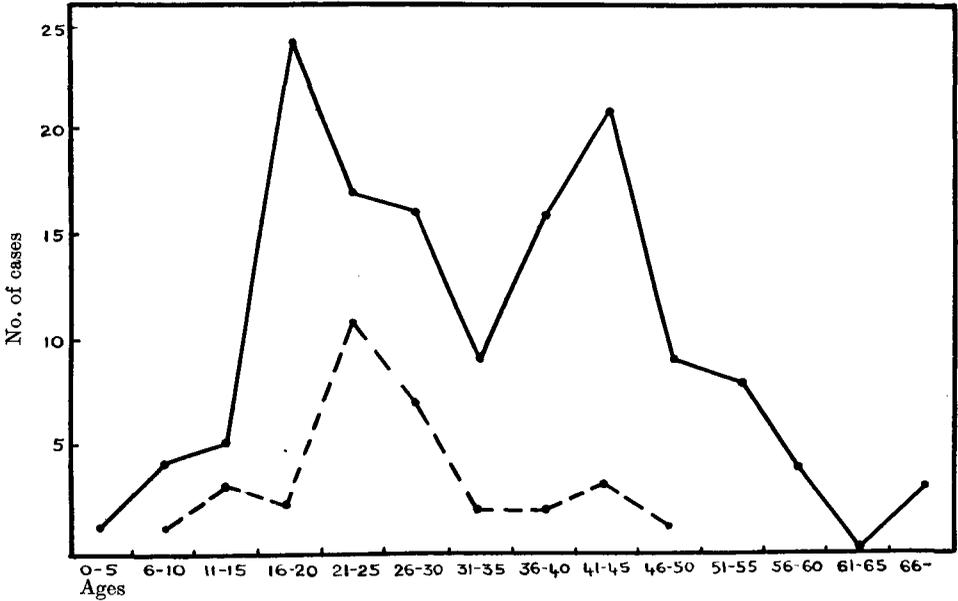


Chart 2. Age and sex incidence of beriberi. Admissions to St Anthony Hospital, 1912-28. Total 174. Males, 140; females, 34.

————— Males. - - - - - Females.

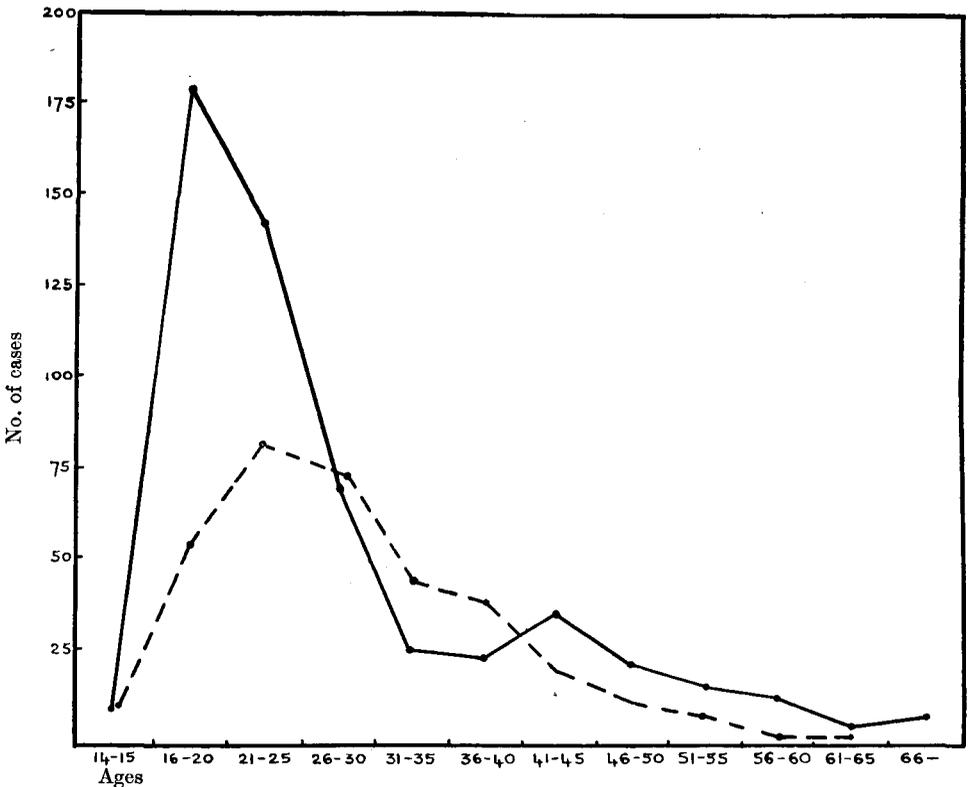


Chart 3. Beriberi outpatients, Japanese Hospital, 1921. Total 876. Males, 527; females, 349.

————— Males. - - - - - Females.

the baby died, at from 3 to 10 weeks old. In three cases the child is noted as sickly; in one case a rapid improvement following dietetic treatment to the mother. In three other cases the child survived, and in one there is no note of the baby's condition.

In four instances beriberi came on during pregnancy. Of thirty-four cases, fifteen (44 per cent.) were thus associated with pregnancy or lactation.

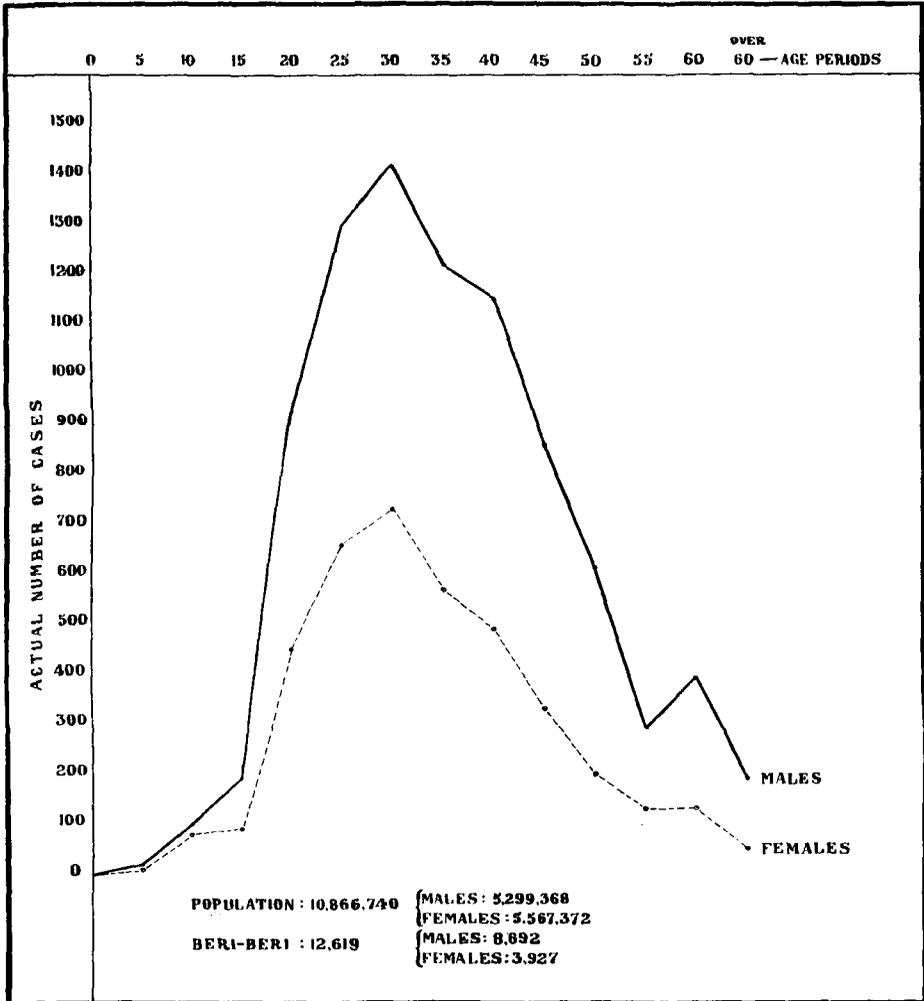


Chart 4. Age and sex incidence of beriberi (Northern Circars, *i.e.* the North-east coastal area of the Madras Presidency).

It is of interest to compare the age and sex incidences of beriberi in Newfoundland with that of the disease in other countries. Chart 3 is constructed from figures giving the beriberi cases applying during 1921 at the Out-patient Department of a Japanese city hospital (Mihami, 1925). The figures are meant to demonstrate the age and sex incidence of beriberi in Japan.

Only cases over 13 were treated. It will be noted, however, that there were few admissions before 16.

Of the female cases forty occurred in the puerperium and four during pregnancy. 10 per cent were thus associated with child-birth.

It will be noticed that the majority of cases occurred in males between the ages of 16 and 25. The incidence among females, as in the Newfoundland group, is at its highest between 20 and 30. The author states that to leave out the cases associated with child-birth does not affect the general female age incidence.

Chart 4 indicates the age and sex incidences of beriberi in the Northern Circars, giving, not hospital admissions, but the actual number of cases. It was very kindly sent me by Colonel McCarrison from the Pasteur Institute, Conoor.

The peak in the male incidence falls later than in the other groups, being at the age of 30. Female cases are slightly more common between 20 and 30, than at other ages.

Examination of charts.

The three charts have certain features in common. They show the greater liability of males to the disease and the immunity of children (omitting infantile beriberi) before puberty. The male preponderance is greatest in Newfoundland.

The age incidence in men shows remarkable differences. The admission rate to St Anthony Hospital in men between 40 and 45 was almost as high as that between 16 and 20, while in the Japanese group five times as many cases were treated at the former age. In the Northern Circars the majority of cases occur in men between 25 and 30. Figures for the three groups were, indeed, collected under widely different conditions, but admissions to St Anthony Hospital give a fair index of the severer type of case occurring in North Newfoundland. Whether the divergences depend on racial or social factors it is impossible to say.

The maximum female incidence occurs in all three localities between 20 and 30, which might be conjectured to depend on an association with child-bearing. The large proportion of pregnant and puerperal cases in the group admitted to St Anthony Hospital might depend, to some extent, on the fact that only the severer cases find their way there. Nevertheless, in the course of ordinary medical work on the coast, I have often received histories of sudden weakness in the legs, etc., during lactation, and incline to the view that in Newfoundland the association between beriberi and pregnancy is close. With regard to the Northern Circars, Colonel McCarrison writes: "that there is any such connection (between beriberi and pregnancy) is not borne out by the chart as most women over the age of 14 in this country are married."

Relative immunity of women.

The relative immunity of women to severe beriberi is striking in Newfoundland. The women of a family group have been known to row their

paralysed protectors 10 miles to the mission hospital after the break up of the ice in spring. In certain parts of the country it is difficult to find any record of female beriberi.

The sex difference does not depend on a dietary factor. All members of the family must eat the same food. There is no room for individual divergence when supplies are at the level of Table I. Similarly, Colonel McCarrison states that in the Northern Circars both sexes must eat the same food. The greater liability of men has been recorded by observers in many countries and cannot be explained by a difference in diet.

One of the possible reasons for the higher incidence of beriberi among Newfoundland men is the man's greater liability to exposure, exhaustion and chills, sometimes precipitating causes of beriberi. The Newfoundlander in the spring is faced by the problem of whether to wear rubber boots and have his feet cold, or skin boots and have his feet wet, while his wife stays indoors. Only a small minority of cases, however, give a definite history of the disease following exposure or chill and this factor is operative only in Newfoundland, while the greater liability of men is universal.

The fact that men do more manual work and have a higher rate of metabolism may be significant in view of various theories that the antineuritic vitamin is quantitatively associated with metabolism. Sprawson (1920) noted that in an epidemic of beriberi among Chinese labourers the incidence was highest among the hardest manual workers (boiler-makers). The recurrent metabolic strain of pregnancy often precipitates an attack in women.

No sex differences have been observed in mammals or birds deficient in the vitamin B complex, or the antineuritic vitamin (B_1)¹ only. Experimental attempts that have been made to correlate vitamin B requirements and the food intake of carbohydrates, fats, or proteins, have been inconclusive and contradictory, so that the greater liability of men cannot at the moment be explained on the basis of their larger food intake. In pellagra the female is more liable.

The immunity of children.

Children after weaning and before puberty are very rarely affected with the nervous lesions of beriberi. Le Roy de Mericourt (1868) remarks that all observers are agreed on the extreme rarity of the disease in children. In Newfoundland this does not depend on a dietary difference since in the spring the children must eat the same food as adults.

The almost complete immunity of children to beriberi has no parallel in experimental vitamin B deficiency. Young animals are extremely sensitive to lack of the antineuritic vitamin (B_1).

¹ In this paper vitamin B_1 means the factor which prevents and cures polyneuritis developing in birds on a diet of polished rice, and is necessary to promote growth and prevent acute nervous symptoms in rats. By vitamin B_2 is meant the factor which promotes growth and cures and prevents dermatitis in rats. Rats sometimes develop a condition closely resembling pellagra in absence of vitamin B_2 which is probably identical with Goldberger's P.P. (pellagra-preventive) factor and the factor which averts "black-tongue" in dogs.

Nutritional oedema in children.

An oedema, without nervous lesions, responding to dietary treatment, occurs occasionally among Newfoundland children and adults. This is presumably the nutritional oedema observed in Calcutta, Central Europe after the war, and elsewhere. Its precise relationship to beriberi is still doubtful.

Infantile beriberi.

It has been mentioned that the babies of women suffering from beriberi may be in poor condition, or die at the breast. I have no data as to the exact condition of such infants. During 1929 I saw the infant of a woman suffering from mild beriberi, which did not differ in appearance from the ordinary mal-nourished child. Removed from the breast it thrived immediately when given cow's milk and three drachms of marmite daily.

Infantile beriberi in children whose mothers show slight, or no symptoms, is recorded by Hirota (1900), Vedder (1913) and Bray (1928). It also occurs in localities where adult beriberi is not a serious problem, as in Naurau (Bray; personal communication). It is a difficult disease to diagnose. According to Vedder (1913), an acute case shows some oedema in the subcutaneous tissues, though this is not marked; often, however, the symptoms do not suggest beriberi as seen in adults. An apparently healthy child at the breast is seized with attacks of vomiting and colic and dies in a few hours. In more chronic cases the symptoms could hardly be differentiated, except by a very experienced observer, from infantile marasmus as seen in the British Isles. Nerve involvement is doubtful. The therapeutic test is the only certain method of diagnosing infantile beriberi, for the infantile disease differs from adult beriberi in its immediate response to treatment by the antineuritic vitamin (B_1), and corresponds in this respect closely to experimental conditions produced in animals by diets devoid of vitamin B_1 .

In Newfoundland and Labrador the existence of infantile beriberi, except in the infants of women themselves suffering from this disease, has never been suspected. Since female beriberi is rare, beriberi in infants whose mothers are actually suffering from the disease is a rare condition, and can have little effect on the infantile mortality. But there, as in the Philippines, where infantile beriberi was first systematically investigated, the mortality among the breast-fed babies of mal-nourished women is high. The average infantile mortality for the colony from 1905-26 was 131.3 per 1000 births—high for a rural population. At a small, very poor, settlement on the Labrador coasts, it was elicited that of sixty-seven children born to the twelve families there, twenty-two had died under 2 years of age (32.8 per cent. mortality).

One woman (42) stated that she had had twelve children born alive, of whom seven had died suddenly in infancy at about 2 months old. She said they mostly "went black and died in convulsions."

Another, aged 45, who presented at one period in 1929 symptoms of beriberi, said that of eighteen children born alive, nine had died suddenly at the

breast in early infancy. Similar, if less tragic, histories are given in the poor settlements all along the coast, suggesting that vitamin deficiency is responsible for a considerable amount of infantile mortality among the Newfoundland poor. It is difficult, in small scattered communities, definitely to prove the existence of a condition identifiable only by a therapeutic test.

Beriberi and vitamin B₁.

In some instances beriberi in Newfoundland and Labrador develops on a regime consisting practically of bread made from refined wheat flour (*e.g.* Families 2, 3 and 6, Table I) but it may occur on diets containing a proportion of salt meat and cod-fish (about 20–30 per cent. by weight of the total stores). Birds on highly milled wheat flour develop polyneuritis (Ohler, 1914). The vitamin B₁ value of salt cod-fish and salt beef and pork muscle is not at the moment established.

It is reasonable to suppose that the disease occurring on a wheat staple is identical with oriental and tropical beriberi associated with polished rice. In the case of wheat flour the question of "spoiling," which has long been a red herring to investigators of the rice-eaters' disease, does not seem important. Under the climatic conditions of the coast, flour seems to keep well for six months or more, and complaints of deterioration are rare. Every family in the remoter parts of Newfoundland, including those in districts where beriberi is rarely seen, is supplied once or twice a year with the same standard type of white flour from St John's.

The diets which lead up to beriberi in Newfoundland show other deficiencies apart from lack of vitamin B₁. Those recorded in Table I are deficient also in vitamin A and inorganic salts, especially calcium. Salt meat and cod-fish probably contain vitamin B₂, but when the diet sinks to white bread almost alone it is lacking in this vitamin also. Diets associated with beriberi in India show similar all round deficiencies (McCarrison, 1928).

Laboratory work has shown that absence of vitamin B₁ leads to collapse and death more rapidly than the absence of any other single food factor. Beriberi occurring on a diet of white flour or polished rice with negligible extras, may be looked on as mainly due to vitamin B₁ deficiency, if this is regarded as the pre-potent deficiency in a generally inadequate diet.

The occurrence of beriberi on diets mainly composed of milled cereal other than rice affords further proof of the truth of the vitamin deficiency theory of its origin. Moreover, investigation reveals the fact that it disappears when the cereal is supplemented by foods shown by experimental work on birds to be rich in vitamin B₁. Thus, potatoes and fresh meat, substances shown by Chick and Hume (1917, 1) and Cooper (1913) to contain a fair amount of vitamin B₁, protect against the disease (Tables II and III). Little (1912) made the observation that whole-wheat flour, accidentally acquired from a wreck by a Newfoundland district in which deficiency disease was rife, appeared to obliterate beriberi. A diet of whole-wheat bread, eggs, cabbages, beans and

peas, which are good sources of vitamin B₁, will cause fairly rapid improvement in a developed case.

But, since the disease usually occurs on a diet generally wretched, for practical clinical purposes a case of beriberi is better treated on a good all-round diet containing vitamin B₁, than by individual substances rich in vitamin B₁, such as yeast or wheat-germ. It is my experience that cases do better on a good abundant mixed diet, and this is to be expected from the general deficiency of the diet on which the disease usually develops. It is, perhaps, for this reason that, according to Musgrave and Cromwell (1926), tikitiki, an alcoholic extract of rice-polishings, specific in infantile beriberi and a strong source of vitamin B₁, has "proved a failure" in the adult disease.

Since Goldberger and his colleagues have clearly demonstrated that pellagra is associated with deficiency of a particular food-factor, it is of interest to record that no case of pellagra has ever been admitted to St Anthony Hospital. Appleton (1921) noted a single case on the Straits of Belle Isle; otherwise the disease is unrecorded in Newfoundland.

Investigations on pellagra in the U.S.A. by Siler, Garrison and MacNeal (1913), brought to light the fact that pellagra may occur when the diet contains little maize and much wheat flour, so that presumably the latter does not contain the P.P. (pellagra-preventive) factor. It was shown by Aykroyd and Roscoe (1929) that wheat and maize endosperm are equally deficient in vitamin B₂, which corresponds closely to the Goldberger's P.P. factor.

Thus, though meat and fish probably contain more vitamin B₂ than vitamin B₁, a diet of "bread and tea" is as deficient in the antipellagra vitamin (B₂) as in the antiberiberi vitamin (B₁). Such a diet, nevertheless, produces beriberi in man, and not pellagra, and similarly in rats a total vitamin B deficiency never produces "rat pellagra," but usually rapid death with or without acute nervous symptoms.

Experimentally, therefore, pellagra-like symptoms appear only when sufficient antineuritic vitamin (B₁) is provided, and it is possible that pellagra occurs in man only under similar special conditions. The wretched diets which Goldberger (1920) found associated with pellagra in cotton milling districts of Carolina appear to have contained fairly abundant vitamin B₁ in the form of potatoes and beans, while the worst Newfoundland diets are deficient in both the B vitamins. Nevertheless, dietary regimes do occur in Newfoundland which, on the theory just stated, should lead to pellagra, if pellagra is regarded as solely due to vitamin B₂ deficiency. It is noteworthy that maize is rarely eaten in Newfoundland.

WET AND DRY BERIBERI.

Newfoundland beriberi is predominantly of the dry type. About one-quarter of cases show mild and transient oedema, but severe waterlogging is very rare. The theory that wet beriberi is beriberi plus oedema of the same type as that which occurs alone in "famine oedema," is plausible. Oedemã is

found at times in close association with all the deficiency diseases, and has been thought to be due to lack of one of the dietary fundamentals other than vitamins, such as fat or protein. Kohman (1920) produced oedema in rats by deficiency of the latter. The rarity of severe oedema in Newfoundland beriberi would fit in fairly well with the theory that the oedema of wet beriberi is due to shortage of protein. Salt meat and fish supply good protein to some cases of beriberi, and the protein content of white flour is a good deal higher than that of milled rice. Beriberi, developing on the latter cereal, seems more frequently to be of the "wet" variety.

PREVENTION OF BERIBERI.

Beriberi in Newfoundland and Labrador is indirectly the result of poverty and the difficulties, due to hard climate, which attend the production and transport of foodstuffs. Its prevention is an economic rather than a medical problem. The number of cases occurring in reasonably well-to-do families has always been negligible. While the better understanding of the cause of beriberi has done little for prevention, it is disappearing at present with the rise in the standard of living.

In connection with Newfoundland beriberi there is no necessity, as perhaps exists in the case of tropical beriberi, for attempting to alter ingrained food habits. The general adoption of whole-wheat flour would improve the health of the people but, since its advocacy for the last 15 years on the part of the Grenfell Association has produced no effect, the possibility of introducing it generally may be put outside the sphere of practical politics. Whole wheat readily deteriorates and good keeping properties, under the circumstances, are of vital importance. Moreover, whole-meal flour would check only one dietary deficiency and it is wiser to aim at a general all round improvement. It is possible that more headway would be made with beriberi in the tropics if administrators would come to regard it, not as a question of polished or unpolished rice, but simply as a problem of poverty. McCarrison (1928) seems to be approaching this view.

Education should encourage the growing of vegetables and the keeping of livestock, and it would be wise if government assistance to the poorest families would sometimes take the form of livestock, seeds, and farming implements. On the East Coast of Labrador, where farming is impossible owing to poor soil, climate, and half-yearly migration, the poorer families should be encouraged and assisted to replace some of the white flour usually bought by potatoes and turnips. These at present are not always available.

OTHER DEFICIENCY DISEASES IN NEWFOUNDLAND AND LABRADOR.

Scurvy.

During the years 1912-28, thirteen cases of severe scurvy were admitted to St Anthony Hospital, the number of beriberi admissions for the same period being 174. Of the scurvy cases, three were male and ten female.

Spongy and hypertrophied gums, probably representing the first degree of scurvy, are fairly common. The comparative rareness of severe scurvy probably depends on the fact that each family, unless prevented by some special circumstances, lays up a store of cranberries for the winter and spring (from 20–40 lb. per head), which are eaten raw or lightly stewed. In the summer and autumn fresh fish and meat are available, both of which are, according to Stefansson (1918), good antiscorbutic agents, at any rate when eaten regularly.

Rickets.

Every grade of severity of rickets may be noted here and there on the coast, but severe types are uncommon. There is a lack of vitamin D in the diet and the calcium, owing to the relative absence of milk and vegetables, and the large amount of flour and fish eaten, is low, while the phosphorus is high.

Rickets, however, has never been a serious problem in North Newfoundland and Labrador, even when dietetic conditions were at their worst. There is plenty of sunlight at all times of the year. On the Labrador coasts, mothers have learnt to prepare cod-liver oil from the fresh livers during the autumn to use as a general tonic for themselves and their families during winter and spring.

Diseases of teeth.

Dental caries is exceedingly widespread and severe, except among those Eskimos who, retaining their traditional habits, live entirely on fresh meat and fish. These are to be found in the remoter parts of Northern Labrador and have excellent teeth. In districts where the Eskimos have learned to rely more on imported cereals for food, a marked deterioration of teeth is evident.

NIGHT-BLINDNESS (FUNCTIONAL HEMERALOPIA).

An interesting condition of functional night-blindness has frequently been recorded among poorly nourished people in various parts of the world. The disease (which is simply a difficulty of adaptation to dim light) occurs in association with a poor diet, is rapidly curable by cod-liver oil, fish, mammalian or bird liver, and is often noted in conjunction with external eye conditions similar to those produced experimentally in vitamin A deficient mammals. For example, Pillat (1929) has recently stated that of ninety Chinese soldiers complaining of night-blindness, forty-nine showed such eye lesions as Bitot's spots, xerosis conjunctivae, and keratomalacia.

Clinical evidence points to lack of vitamin A as the cause of functional night-blindness but the sequence has not yet been fully confirmed by experiment, and is still in some doubt. Vitamin A deficient animals in the laboratory usually show increased susceptibility to mucous membrane infections, xerophthalmia, sublingual abscesses, mastoid disease, and septic lung conditions being observed, while in man night-blindness may occur as a solitary condition in a healthy individual. Vitamin A has been considered anti-infective and little has been made of its possible function in preserving retinal efficiency.

I have previously described (1928) the main features of functional night-blindness occurring among the Newfoundlanders, noting that the dietary level in Newfoundland is often low from the vitamin standpoint, and that cod-liver oil will cure the condition promptly. It was recorded that the Newfoundlanders have learnt to treat themselves for functional night-blindness by fresh liver and cod oil, as have the laity in other parts of the globe. It was suggested that the far greater frequency of the disease among men than women was due to the greater expenditure of visual purple on the part of the former, who are more exposed to sunlight.

While in Newfoundland and Labrador during the summer of 1929, I was able to make some further observations on hemeralopia, the chief point of interest being to discover whether functional night-blindness is beyond doubt due to vitamin A deficiency.

The following cases, among others, were observed:

Case 1.

C.W., aged 45. This man, the captain of a fishing schooner on her way to the Labrador coasts, was brought into the dispensary at St Anthony Hospital just about twilight on June 23rd, complaining of blindness. In a light clear enough to distinguish all objects plainly he could just make out the presence of a white coat.

The patient said he was an old sufferer from night-blindness, having on three previous occasions been night-blind for as long as six months on end. He had learnt, when at sea, to wear dark glasses, which he found protected him from the condition. Before acquiring glasses he had discovered for himself the old seaman's dodge of covering up an eye by day when the sun was bright to ensure one useful eye for the dark.

On the day I saw him he had lent his dark glasses to his daughter, who was suffering from blepharitis. The day had been exceedingly bright and sunny, and the schooner had been at sea from dawn. The previous night there had been no visual disability.

The patient said that, apart from his eyes, he was in the best of health. In appearance he was a strong, healthy, alert, man. His eyes were normal in appearance and reacted to light and accommodation. The gums showed no sign of scurvy. The heart, lungs, and knee jerks were normal. In a well-lit room his vision appeared perfect.

Diet. The diet on the schooner was as follows: white bread, salt meat, margarine, potatoes, beans, peas, and rice. No eggs, butter, milk or cabbages. Fishing had not begun. The patient stated that his son, also on the schooner, was suffering from a "touch of night-blindness."

He was given a bottle of cod-liver oil with instructions to take a tablespoonful morning and evening, and was led out of the hospital by two members of his crew.

Two weeks later I received a letter from the patient saying that he had been able to see normally on the subsequent night (following two doses of cod-liver oil) and that he had not been troubled since. The next day was equally sunny and spent at sea.

Case 2.

V.C., male, aged 13. Seen at Bateau, Labrador, on July 15th. This boy, when first seen, had been suffering from night-blindness about a fortnight. His mother was worried in case the boy should meet with an accident, since on one occasion after dark he had almost walked off a fishing stage into the sea.

The boy said he could see nothing out of doors at night except stars and lights. Indoors, in a lighted room he noticed nothing wrong. Without prompting, he volunteered the statement that bright sunlight had "started" the condition, which appeared suddenly.

The patient's father and grandfather had suffered from functional night-blindness on a number of occasions, usually in summer.

The boy was healthy in appearance and said he felt perfectly well except for occasional heaviness in the stomach after meals. There was no evidence of scurvy or beriberi. Heart and lungs were normal. The eyes were externally normal and reacted to accommodation and light. The visual fields for white were normal, and the daylight vision perfect.

Diet. The boy's family had left their home in South Newfoundland for the Labrador fishery on June 10th. In Newfoundland the boy's diet had been good, including fresh meat once or twice a week, two eggs a day, a tumbler of goat's milk a day, and plenty of potatoes and turnips.

On the Labrador coasts the family was living on a much poorer diet. They had white bread, fresh fish, salt meat, beans, peas and a little oatmeal and margarine. No fresh meat, milk, butter, vegetables or eggs. The boy had been eighteen days on this diet when he developed hemeralopia.

The patient was told to take "cod oil" (made locally from the fresh livers), but when we returned to the same settlement on August 10th, we found him still night-blind and refusing to take cod oil. His general health remained good. By impressing on his mother the horrors of death by drowning, cod oil was at last administered. The patient's vision returned to normal after two large tablespoon doses.

Case 3.

Mrs R., Francis Harbour Bight, Labrador. Aged 26. Married. No children. Seven months pregnant.

This patient was seen on August 7th, and said she had been night-blind since April. The condition had come on gradually, that is to say, she had found a steadily increasing difficulty in seeing night after night. She stated her general health had remained good.

In the dark she was quite helpless and could see only bright stars and the lights of the coastal boat in the harbour. In a room lit by a good paraffin lamp her vision was normal.

On examination she appeared somewhat anaemic in appearance. The eyes were externally normal and reacted to accommodation and light. Dr Phinney, an ophthalmic surgeon of Philadelphia, who was with me, examined her fundi and found them normal. The visual fields for white were normal. General examination was negative. There was no evidence of scurvy or beriberi.

The patient's diet when the condition developed had included white bread, a little fresh meat, salt meat and salt fish, beans, peas, and margarine. She had been able to afford a little condensed milk in tea, not, however, for use every day. No eggs or vegetables. During the summer, fresh meat became unprocurable, but fresh cod-fish was plentiful.

Her night-blindness cleared up in three days after three large tablespoon doses of cod oil. Two days after the condition disappeared the child was born prematurely. It died on the tenth day. The patient continued to take cod oil.

Cases 4 and 5.

The following cases had suffered from hemeralopia three weeks before I saw them and had treated themselves. The graphic description given by the sufferers and their mates left no doubt of the reality of the condition. In four members of the same fishing crew, night-blindness developed three weeks out from home, where a fair mixed diet had been available. All continued to work strenuously. Two members of the crew, M.H., 19, and P.R., 48, whom I saw three weeks after the condition cleared up, appeared in the best of health, with no evidence of scurvy or beriberi. In one case hemeralopia had appeared suddenly, in the other gradually. Neither connected the condition with strong sunlight. After these two men had been complaining for some days, one of the crew shot a seagull and the sufferers ate half its raw liver apiece. Their vision returned to normal in twenty-four hours.

Diet. In these cases hemeralopia developed after three weeks on the following diet: white-flour bread, fresh fish, salt meat, ships' biscuit, margarine, molasses, beans, peas and a few potatoes.

Case 6.

R.T., 18, Hawkes Harbour, Labrador. Employed at a whaling factory. This patient had suffered from hemeralopia and recovered fourteen days before I saw him. Here again the difficulties attending the condition were vividly recalled by the boy and his friends.

In this case night-blindness appeared suddenly and the patient definitely connected its onset with a day of strong sunlight. After suffering for fourteen days he took a large dose of cod oil (1 to 2 oz.) and the hemeralopia disappeared in twenty-four hours. When I saw him fourteen days later he appeared a strong, healthy boy with no evidence of disease.

The condition developed after one month on the following diet: bread, molasses, salt meat, margarine and potatoes: no fresh fish, milk, eggs, or other vegetables. Whale meat was available, but the boy did not like it. Previously the diet had been satisfactory.

Another employee in the same factory on the same diet had had night-blindness simultaneously. This had cleared up spontaneously, following which a severe conjunctivitis developed. This latter responded immediately to boric applications and cod-liver oil internally.

ETIOLOGY.

(1) *Vitamin A deficiency.*

Functional hemeralopia occurs in Newfoundland and Labrador among people whose diets are markedly deficient in vitamin A. In my experience the disease is commonest in men pursuing the summer fishing, but it occurs all the year round. Appleton (1921) described a spring outbreak among men. Women and children are attacked only very occasionally.

On the Labrador coasts during July, August and September most of the fishermen, far from their homes in South Newfoundland, live on schooners or in huts on the mainland. As stores they usually carry white flour, ships' biscuit, salt beef and pork, molasses, margarine, potatoes, beans and peas. Only occasional crews carry tinned milk and fresh vegetables, and eggs are not available. Some carry no potatoes. They do not often suffer from beriberi, which has its maximum incidence during the late spring months, the chief difference between the summer diet at the fisheries and the late spring diet being the absence from the latter of fresh fish. Fresh fish muscle probably reduces the incidence of beriberi and supplies vitamin C, but not vitamin A. The average summer diet on the Labrador coasts is almost totally lacking in vitamin A, which is ordinarily supplied by butter, milk, eggs and green vegetables. Vitamin A deficiency is clearly evident in the diets of the cases of hemeralopia recorded.

The condition yields immediately to vitamin A containing foods. The fact that it is curable by liver oil, as well as by liver, eliminates the possibility of a water-soluble liver constituent, such as that which relieves pernicious anaemia, being concerned. Appleton (1921) made in Newfoundland the interesting observation, which I think is unique in the literature, that functional night-blindness is readily curable by vegetables, butter, or eggs. Zak (1917) observed that fresh carrot juice caused immediate improvement, and it has been recently shown by Collison *et al.* (1929); and by Moore (1929), that carotin is closely allied to, and a probable precursor of, vitamin A. Thus, the distribution

of the factor which cures functional hemeralopia corresponds to that of vitamin A.

The rapidity of relief when cod-liver oil or liver is used is difficult to credit, for those who have not observed it. It is the rule rather than the exception for the vision to be normal twelve to twenty-four hours after liver or liver oil is taken. Mori (1924) has recorded similar results in Manchuria. The usually immediate success of the "cure" is common knowledge on the Newfoundland and Labrador coasts.

Association with pregnancy. In women night-blindness is uncommon, and usually occurs only in association with pregnancy, tending when untreated to clear up spontaneously *after* the baby is born. I was given a clear history of this in five cases, and the female case recorded (Case 3) was pregnant. Association with child-bearing is characteristic of vitamin deficiency. It is interesting to remember that adult rickets, or osteomalacia, due to deficiency of the other known fat-soluble vitamin (D), usually attacks pregnant or puerperal women. In the case of beriberi, probably due mainly to lack of vitamin B₁, the greatest strain on the mother is during lactation and she usually *succumbs* to the disease after the child is born. Similarly, both initial and recurrent attacks of pellagra tend to occur during the puerperium, an observation made by Siler, Garrison and MacNeal (1917).

(2) *Exposure to strong sunlight.*

Of twelve cases interrogated specially on the point, seven connected the condition definitely with exposure to strong sunlight, usually for prolonged periods in open boats. Out of fifteen cases the disease came on suddenly in eleven, gradually in four. These cases include those directly observed and those who suffered in recent years and seemed to have a clear recollection of the circumstances. In a developed case, more dark adaptation may be possible after dull than sunny days. The relatively greater liability of men is presumably due to more frequent and prolonged exposure to sunlight, and the seasonal incidence may be similarly explained. It is probable that, in the majority of cases, the two factors, vitamin deficiency and exposure to sunlight, each play their part, though hemeralopia does not arise when the diet is good, no matter how great the exposure.

The relative immunity of women and young children on the same diet, together with the extremely short period of time during which some of the cases described had been on a deficient diet, seems to accentuate the importance of strong sunlight as a causal factor. Experiments on rats have shown that considerable vitamin A can be stored in the tissues, and it is difficult to suppose that in man an advanced degree of vitamin A deficiency could be produced in as little as one month. In the clear North American atmosphere the effect of summer sunlight reflected from water is peculiarly trying.

Functional hemeralopia and visual purple.

The association of visual purple with dark adaptation rests on good, though indirect, evidence, such as the similarity of the curves given by the threshold of visual sensation and the absorption of light by visual purple. It is, therefore, reasonable to suppose that functional night-blindness follows some change connected with visual purple, and the fact that strong sunlight predisposes to the condition, suggests that we are dealing with a change in the amount rather than in the nature of the photo-sensitising substance. The obvious explanation is delayed or absent regeneration of visual purple, and that the former is the underlying pathological condition is supported by some evidence. An observation was made by De Gouvea (1883) that Brazilian slaves, blind on returning from work after sunset, could see when setting out before sunrise. Fridericia and Holm (1925) exposed vitamin A deficient rats to strong light under anaesthesia, and demonstrated a delay in the regeneration of visual purple, though it does not appear clearly from their experiments whether complete regeneration was possible in the deficient animals.

In Newfoundland and Labrador it proved impossible to find evidence confirming the idea that dietetic hemeralopia is a condition of retarded dark adaptation. Cases could not be traced which recovered after varying intervals in the dark, or cases which began by increasing periods of impaired dark adaptation. The gradual onset, when it occurs, is described as a steadily increasing difficulty in adapting the eye to dim lights.

A delay of two to three hours in dark adaptation would, however, practically cover the facts observed on the coast. In practice a night-blind individual does not linger in the dark, and circumstances rarely arise in which it is necessary for him to do so; there is no point in a fisherman getting up before dawn. But it must be remembered that clinical observations confirming the theory of perfect, though delayed, dark adaptation in functional hemeralopia, are very few, and it is possible that in some cases the faculty may be altogether absent.

There is some evidence, summarised in the *Medical Research Council's Report on Dark Adaptation* (1929), that the light sensitivity of the fovea rises after exposure to darkness in the normal individual, but the rise is very small compared to that which takes place at the periphery. One is often surprised at the difficulty in reading small print on a moonlight night which seems "as clear as day." The light sensitivity of the dark adapted eye increases steadily towards the periphery, as do the number of rods relative to cones, and the amount of visual purple in dark adaptation. The periphery is sixty times as sensitive to light as the central parts (Helmholtz).

It is a matter of experience that, whether the fovea is capable of dark adaptation or not, the central parts of the retina are sufficiently sensitive, when dark adapted, to be stimulated by the amount of light present on ordinary nights. For practical purposes on average nights the centre of the retina is used, though the light threshold of the periphery is far lower.

In functional night-blindness it is presumably in the central parts of the retina, containing fewer rods and visual purple, that the light threshold first rises above ordinary twilight and night illuminations. I have often obtained histories from night-blind patients of "seeing something of a thing by not looking at it" (for example, a man remarked that, when night-blind, he could see a little of what was straight ahead of him by looking down at his feet). This suggests that in functional night-blindness, in which the light threshold of the whole retina is raised, the periphery, containing more rods and visual purple, retains its relatively greater light-sensitivity. These cases, though they may be able to discern a little indirectly, are helpless in dim lights. They are in the same position as a normal individual in almost complete darkness, who is still able to pick up minimal stimuli on the periphery of the retina.

The apparent close association between vitamin A and the photo-sensitising substance in the retina, of whose nature little is known, is interesting. An exact quantitative relation is suggested by the observation that night-blindness often recurs after treatment by liver or liver oil, and the eyes are sometimes kept normal through the summer by doses of cod oil repeated every four or five days. One is sometimes seriously told by courteous fishermen anxious to assist in a scientific investigation, that a certain definite dose of cod oil given to a night-blind patient will give a certain number of nights' immunity. In a good summer the amount of exposure to sunlight is fairly constant.

Association of functional night-blindness with other conditions.

I learnt from the St Anthony Hospital records and from local medical men that occasional cases of hemeralopia develop external eye conditions, but the sequence is rare. Possibly the lack of infecting organisms due to isolation explains the infrequent occurrence of xerophthalmia and keratomalacia, which are usually associated with functional night-blindness elsewhere, or possibly these severe lesions occur when the vitamin A deprivation is more extreme. Little (1912) noted so many cases of beriberi complaining of night-blindness that he thought night-blindness an early symptom of beriberi. I saw this summer a case of beriberi suffering from hemeralopia.

The occurrence of hemeralopia in pregnant women is interesting, in view of Mellanby and Green's recent attempt (1929) to treat puerperal sepsis by vitamin A concentrates, since it suggests that vitamin A requirements are increased in pregnancy. Puerperal sepsis is not common in Newfoundland.

In individual cases functional night-blindness is compatible with health. Cases will sometimes allow the condition to drift for weeks if cod oil or fresh liver is not readily available, simply taking care not to be caught in the woods or afloat at sunset. If difficulties arise, they will make an effort to secure the curative agent. Skippers of fishing parties will sometimes insist on their men treating themselves with liver or cod oil, since a night-blind man may become a nuisance or danger to his fellow fishermen.

Since vitamin A deficiency, as seen in the laboratory, is associated with

increased susceptibility to infection, it may be mentioned that the Newfoundland and Labrador fishermen suffer very severely from "water pups" or "salt-water boils" on the wrists and forearms, of which the exciting cause is the friction of the wet sleeve. Brass chain bracelets are often worn for protection. This painful and incapacitating condition does not appear to have been described in surgical literature, but Kipling, in his story of the Newfoundland Banks, *Captains Courageous*, mentions the crop of "gurry sores" that made his hero a "full-blooded Banker." Salt-water boils are common among English and Scotch fishermen, and there is no reason to suppose that their prevalence on the Labrador coasts in summer is related to faulty diet.

The tradition of treatment by liver.

The effectiveness of liver in functional hemeralopia seems to be popularly known in various places all over the world. The Newfoundlanders have made the further refinement, which has probably a scientific basis, that while cod liver, cod-liver oil, rabbit's liver, seal liver, hen's liver, etc., are all effective in night-blindness, by far the most potent treatment is the liver of a sea-bird, such as gull or puffin. A sudden attack of night-blindness leaves a very vivid impression on the mind, and it is not perhaps surprising that record of the condition extends far back into antiquity. It is remarkable, however, to find that knowledge of the cure is almost as old as medicine. The following curious passage which occurs in Eber's papyrus (about 1500 B.C.) was unearthed by Van Leersum (1924). "Because the unknown disease was cured by the roast liver of an ox, the disease was supposed to be night-blindness. Also the patients were recommended to hold their heads over the steam rising from the roasting liver. By early writers the liver of a black cock was also recommended." Newfoundland sufferers sometimes steam their eyes over cooking liver, and the custom has been recorded elsewhere in quite modern times.

By comparison the reference in Hippocrates comes late in the history of the disease. It runs: "Treatment of night-blindness. Let the patient take elaterion to clear his head. Let as many cups as possible be applied to his neck to maintain by pressure the flow of blood for as long as possible. After some time let him eat, once or twice, as big an ox-liver as possible, raw, and dipped in honey." (From Littré's translation.)

To eat a whole ox liver seems a superhuman feat, even when we reflect that the ox of antiquity was a much smaller and more weedy creature than the fleshy monster of to-day.

GENERAL INCIDENCE OF DISEASE.

The fact that considerable numbers of the population live on a diet which, being often deficient in milk, eggs and green vegetables, is low in vitamins according to modern ideas, does not appear to affect the general incidence of disease in any obvious manner. Lung tuberculosis is common everywhere in Newfoundland and Labrador, though the men lead an active outdoor life.

Surgical tuberculosis appears to follow the presence of cows, being rare on the Labrador and becoming more prevalent further south. Minor stomach complaints and severe constipation are constantly met with in the poorer settlements, and the universal prevalence of "bad stomach" (as it is known locally)—consisting of pain and heaviness in the stomach coming on after meals and lasting about an hour—is striking. In spite of the frequency of functional stomach complaints, gastric or duodenal ulcer, severe enough to reveal itself by haematemesis or perforation, is extremely rare. Diabetes and obesity are uncommon.

PHYSIQUE OF CHILDREN.

The physique of the children in the remoter settlements is often very poor. They are usually up to normal height, but under weight. Clear, healthy skins are uncommon and there is an absence of high spirits amounting sometimes to apathy.

SUMMARY.

1. Beriberi occurring on a white-flour staple is similar to that occurring on a rice staple.
2. Under the difficult climatic conditions of North Newfoundland and Labrador, families are obliged to buy food stores in November or December to last until the following May or June. When poverty prevents a sufficient variety of foodstuffs, and calories are the foremost consideration, white flour with few extras forms the main dietary, and beriberi tends to occur in April, May or June. It occurs in families who have grown few vegetables and shot little game.
3. The disease attacks more men than women, and very rarely children between the ages of infancy and puberty. The age and sex incidences of beriberi are difficult of explanation and differ in different countries.
4. Infantile beriberi probably occurs in Newfoundland and Labrador, but is largely unrecognised.
5. The main cause of beriberi is vitamin B₁ deficiency, but the diets of patients suffering from beriberi are deficient in other respects.
6. It is suggested that the infrequency of wet beriberi in Newfoundland may be due to the fact that wheat flour has a higher protein content than polished rice.
7. Since poverty and deficiency disease are rigidly associated, prevention is an economic rather than a medical problem.
8. Severe scurvy and rickets are not often met.
9. Functional hemeralopia or night-blindness occurs mainly during the summer among men. It occurs on a diet deficient in vitamin A, and is rapidly curable by vitamin A containing foods, a fact well known to the Newfoundlanders. The disease may occur in men taking a deficient diet for less than one month. Other evidences of vitamin A deficiency are lacking.

10. Tuberculosis, severe dental caries, functional stomach complaints and constipation are common. Gastric and duodenal ulcer, diabetes and obesity are rare.

ACKNOWLEDGEMENTS.

I have to thank almost the entire medical profession of Newfoundland for help and information given at various points in the prosecution of this research. I am particularly grateful to the International Grenfell Association, and Sir Wilfred Grenfell for hospitality and permission to use the admirable records at St Anthony Hospital, and to Dr Curtis, the medical superintendent, for allowing me to observe and treat cases in his wards. I must also acknowledge assistance and hospitality from many friends on the Newfoundland and Labrador coasts.

I am grateful to Colonel McCarrison for the published graph and information, and to Dr Chick and Sir Charles Martin for helpful criticism.

REFERENCES.

- APPLETON (1921). Observations on deficiency diseases in Labrador. *Amer. J. Public Health*, **11**, 617.
- AYKROYD (1928). Vitamin A deficiency in Newfoundland. *Irish J. Med. Sci.* **28**, 161.
- AYKROYD AND ROSCOE (1929). The distribution of vitamin B₂ in certain foods. *Biochem. J.* **23**, 483.
- BRAY (1928). Vitamin B deficiency in infants. *Trans. Roy. Soc. Trop. Med. and Hyg.* **22**, 9.
- CHICK AND HUME (1917, 1). The distribution in wheat, rice and maize grains of the substance, the deficiency of which in a diet causes polyneuritis in birds and beriberi in man. *Proc. Roy. Soc.* **90**, 44.
- — (1917, 2). The distribution among foodstuffs of the substances required for the prevention of beriberi and scurvy. *Trans. Roy. Soc. Trop. Med. and Hyg.* **22**, 9.
- COLLISON, HUME, SMEDLEY-MACLEAN AND SMITH (1929). The nature of the vitamin A constituent of green leaves. *Biochem. J.* **23**, 4, 634.
- COOPER (1913). On the protective and curative properties of certain foodstuffs against polyneuritis induced in birds by a diet of polished rice. *J. Hygiene*, **12**, 436.
- DE GOUVEA (1883). Beiträge zur Kenntniss der Hemeralopie und Xerophthalmie aus Ernährungsstörungen. *Graefe's Arch. f. Ophthal.* **29**, 1, 167.
- FRASER AND STANTON (1910). The etiology of beriberi. *Philippine J. Sci.* **5**, 55.
- FRIDERICIA AND HOLM (1925). Experimental contribution to the study of relation between night-blindness and malnutrition. *Amer. J. Physiol.* **73**, 79.
- GOLDBERGER, WHEELER AND STUCKER (1920). A study of the relation of diet to pellagra incidence in seven textile mill communities of South Carolina in 1916. *U.S. Public Health Reports*, **35**, 648.
- HOLM (1925). Demonstration of hemeralopia in rats nourished on food devoid of fat-soluble A vitamin. *Amer. J. Physiol.* **73**, 79.
- HIROTA (1900). Noch einmal zur Kakke der Säuglinge. *Zentralbl. f. inn. med.* **273**.
- KOHMAN (1920). The experimental production of edema as related to protein deficiency. *Amer. J. Physiol.* **51**, 378.
- LITTLE (1912). Beriberi caused by fine white flour. *J. Amer. Med. Assoc.* **58**, 2029.
- (1914). Beriberi. *J. Amer. Med. Assoc.* **63**, 1287.
- LITTRÉ (1914). *Œuvres complètes d'Hippocrate*, **9**, 159.
- MCCARRISON (1928). Beriberi Columbarum. *Ind. Med. Res. Memoirs*, No. 10, 1.

- MEDICAL RESEARCH COUNCIL (1929). Dark adaptation. *Med. Research Council, Special Report Series*, No. 127.
- MELLANBY AND GREEN (1929). Vitamin A as an anti-infective agent. *Brit. Med. J.* 1, 984.
- MOORE (1929). The association of vitamin A activity with carotene in the carrot root. *Biochem. J.* 23, 4, 803.
- MORI (1924). Report on the present state of knowledge of the accessory food factors (vitamins). *Med. Research Council, Special Report Series*, No. 38.
- MUSGRAVE AND CROMWELL (1926). In Osler and McCrae's *Modern Medicine*. Art. Beriberi.
- OHLER (1914). Experimental polyneuritis. *J. Med. Res.* 1, 239.
- PILLAT (1929). The frequency of deficiency diseases of the eye due to lack of vitamin A in a military camp north of Peping. *Nat. Med. J. of China*, 15, 5, 585.
- SILER, GARRISON AND MACNEAL (1913). *First Report of the Thompson McFadden Pellagra Commission of the New York Post-Graduate Medical School and Hospital*.
- (1917) *Third Report of the Thompson McFadden Pellagra Commission of the New York Post-Graduate Medical School and Hospital*.
- SPRAWSON (1920). Beriberi in the Mesopotamian force. *Quart. J. Med.* 13, 337.
- STEFÁNSSON (1918). Observations on three cases of scurvy. *J. Amer. Med. Assoc.* 71, 1715.
- VAN LEERSUM (1924). Vitamine-voorziening. *Nederl. Instit. voor Volkvoeding Nederl. Tijdschr. voor Geneesk.*
- VEDDER (1913). *Beriberi*. London: John Bale, Danielson, Ltd.
- ZAK (1917). Beobachtungen an Hemeralopie und Skorbutkranken. *Wien. klin. Wochenschr.* 30, 592.

(MS. received for publication 24. III. 1930.—Ed.)