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SOME ESSENTIAL FACTORS IN THE CONSTRUCTION OF FIELD SERVICE AND EXPEDITIONARY RATIONS.

By Lieutenant-Colonel W. W. O. Beveridge, D.S.O.
Royal Army Medical Corps.

In the formulation of a ration for an expeditionary force one is faced by a formidable array of factors which demand consideration—some common to the formulation of all dietaries, some peculiar to the special conditions which must be met. It is with certain aspects of the latter—some of which present complex difficulties—that this article is concerned; the former call for no comment here, save that it is instructive to review certain differences between the factors which govern respectively the construction of rations for expeditionary purposes and dietaries suitable in civil life.

Civil dietaries—even for use in jails—present comparatively few problems. The demands of labour are mostly moderate and uniform, conditions of life are equable, the choice of articles of diet is wide, there is available an ample variety of fresh foods to suit all individual tastes and needs, and the food supply is organized and maintained by private competitive enterprise.

For an expeditionary force, when once it has left its base, each of these factors is radically changed. Work, arduous at all times, becomes exhaustive under the stress of exposure, mental tension and loss of sleep, the full force of adverse climatic conditions...
must be met by the unaided resistance of the individual, infective
disease dogs each step of the debilitated, rigidly inelastic condi­
tions limit both the choice and amount of the diet available, and
the peculiar communistic needs make no concession to idiosyncrasy.

Great as the sum total of these difficulties is when the force is
in touch with its base, it is enhanced when the individual is
detached and wholly dependent upon such food as he has himself
carried in anticipation of this emergency—an emergency which
must be provided against from the moment when he first takes
the field. These are some of the difficulties, inherent in the
problem, which can only be fully realized by those who have been
called upon to provide their solution.

With this brief comment on the general bearings of the
problem, we may pass on to consider the construction of rations—
for (a) a military force in the field, and (b) for parties engaged in
Polar exploration. Repetition will be obviated by dealing at the
outset with certain points common to both.

SPECIAL FACTORS BEARING UPON EXPEDITIONARY RATIONS IN
GENERAL.

The generally accepted present-day view is that a diet providing
3,000 calories of potential energy is ample for men doing moderate
work, but not adequate for the demands made upon men in the
majority of campaigns and expeditions.

During a recent experimental march under active service condi­
tions, the total work—internal and external—represented 4,033
calories per man per diem, and this, high as it appears, is still less
than the average energy expenditure of actual campaign service:
A ration supplying from 4,500 to 5,000 calories would not be
excessive from either the practical or theoretical point of view. In
order that health and efficiency may be maintained at the necessary
high level, the body must receive adequate nutriment for both
energy production and tissue repair, for, as an ancient Chinese
proverb puts it, "If you put the pot on the fire with nothing in it
the pot will burn." From the law of the conservation of energy it
is obvious that the energy expended in the form of muscular work
must be balanced by the potential energy provided in the form of
food, and the amount of food required must therefore vary directly
as the amount of work that the individual has to perform. It is,

however, not sufficient to aim merely at establishing a calorie balance; while this is obviously essential, other factors which may be less obvious are of at least equal importance and call imperatively for recognition. The extent of the recognition which can be given is limited by the conditions under which any expeditionary force must work, and this leads to an enumeration of the principal essentials requisite for all expeditionary rations.

(a) Provision of an Adequate Calorie Value.—This must, as shown above, depend upon the amount of work demanded.

(b) Provision of a Diet in which the Proportions of Proximate Principles and Essential Ingredients are suitably maintained.—The relative proportions of protein, fat, carbo-hydrate and mineral matters which are desirable are either familiar or may be studied in any text-book on metabolism, but it must be remembered that it is not enough to observe the rules of fixed proportions, the palatability, digestibility and assimilability of such constituents must be considered. Further, the advance of knowledge leads to the addition from time to time of other ingredients of food to the list of the essentials which have to be provided—as, e.g., the vitamines, which are at present the subject of much research work which may profoundly modify our views on many important points. This question will be referred to again when we consider Polar rations (vide infra) with special reference to the provision of vegetables. Without going into detail, there is one general principle which may with advantage be emphasized here—it is that the increase of calorie value necessitated by excess of muscular work can best be provided by the addition of sugar to the ration. It is a matter of common knowledge that there is a craving for sugar among children, athletes, and soldiers on active service, and that the craving is due to the fact that nitrogenous food is utilized to better advantage in the presence of a high ratio of sugar. The present ration biscuit contains five per cent of sugar. Jam contains about fifty per cent, and sugar may be given in the form of chocolate, but this is too concentrated a food and induces thirst. In either of these forms sugar is of special value as a muscular food and is hence of great assistance to men undergoing hard physical work.

(c) Portability.—This is, above all others, the factor which is the most inelastic; we are rigidly limited to a certain weight which is fixed by the carrying capacity of the transport vehicle or the individual. We are thus restricted to a choice of such articles as give the maximum nutritive value in a minimal bulk. This object can only be achieved by concentration, that is, by the abstraction
of water; but even in our efforts to secure that concentration, we are checked by the fact that constipation results from too great a diminution in the bulk of food provided, while high degrees of desiccation involve loss of certain volatile matters upon which the palatability—and hence the digestibility—of many articles depends. In order to secure thorough mastication, easy deglutition and good digestion, I consider that no food intended to be eaten in the dry state should be concentrated beyond a point at which the residual moisture stands at six per cent. The Army biscuit, with its eight to ten per cent. of water, is well above this minimum.

In addition to the saving thus effected in the weight of water carried, it is desirable that economy should be effected in the weight of the material in which the concentrated diet is carried. Approximately two-thirds of the weight of tin plate cans might be saved by substitution of aluminium; other substitutes for tin are pegamyn, keratin, and waxed paper, all of which serve the purpose of preventing decomposition by excluding moisture.

(d) Procurability.—The importance of this factor depends upon the size of the expedition, the time available for preparation, the duration of the expedition, and the possibilities of replenishing its supplies. For military purposes it is important that a choice should be made of such articles as will be available at short notice and in adequate amounts. In this aspect of the problem is also involved that of expense, for the adoption of articles not in common use would add enormously to the cost of the periodical turn-over, which is necessary to maintain the reserves kept in peace time fresh and in good condition. This leads to the remark that in our field service ration probably the inclusion of bacon is, on these grounds, the only weak point, in that it is doubtful if the bacon in the country at any given time would suffice for the needs of a large force, and our supplies from abroad might not be maintained. This might be met by the institution of Government factories, which would not only take advantage of favourable markets for the creation of an ample reserve, but would further be able to check the inflation of prices by civilian contractors which otherwise would follow the outbreak of hostilities.

For the foregoing reasons it would be obviously undesirable to incorporate patented foods in rations designed for military purposes.

(e) Preservation.—The ration must be so preserved that it will keep wholesome for a period which affords an ample margin beyond the time of preliminary storage and that of the probable duration of the expedition. It may be accepted that modern methods of
sterilization and packing make the addition of preservatives unnecessary, and they should never be permitted. On the other hand, it must be recognized that the prolonged heat to which foods have been subjected in commercial processes of sterilization are liable to destroy certain essential constituents, and it is therefore necessary that control should be exercised over those processes.

When once sterility—absolute or relative—has been secured, access of air and moisture must be prevented in the case of all foods liable to undergo decomposition, and especially the nitrogenous articles. The selection of the enclosing material has been referred to, but as tinplating is still in general use, certain points regarding it may be noted. If inferior quality of tin-plate be used, it is liable to rapid erosion, especially in the presence of acid contents. Meat and vegetable rations packed in tin-plate of good quality may safely be kept tinned for at least a year, but that period should not be exceeded in the tropics. It may be laid down in general that food containing more than 800 milligrammes of tin per kilogramme is unfit for consumption.

It is important to remember that preparations suitable for use in cold or temperate climates may be unsuitable for expeditions working in the humid heat of the tropics.

It may be added that, contrary to popular belief, bacon does not keep well for long periods, and unless it is tinned, rapidly deteriorates in moderately warm climates.

(f) Variety.—In this respect not only have we to consider the range of articles needed to supply in proper proportion all essential food principles, but also the maintenance of appetite by the avoidance of a monotonous dietary. In this connection it is significant that articles providing the basis of a normal dietary do not tend to become monotonous; whereas men rapidly tire of such accessories as provide for exceptional and temporary needs. Bread and fresh meat can be eaten for long periods with zest—the British soldier has elected to have beef every day in the year and delete mutton wholly from his dietary—while distaste rapidly follows the continued use of sugar, which provides for unusual muscular exertion, or of highly seasoned foods, which provide so valuable a stimulus to digestion for men in conditions of exhaustion. It is therefore necessary to avoid monotony in the ration with regard to articles which fall into the latter class. Where there is a possibility of utilizing for this purpose the natural produce of the country, every opportunity of doing so should be taken; but in the cases where this is impossible, the system of alternative rations should be adopted.
(g) Conformity to Habit.—It is desirable that the expeditionary ration should conform as far as possible to the normal dietary of the men, and that an abrupt transition to unaccustomed articles of food should be thus avoided.

(h) Applicability of Diet to Climatic Conditions.—It is obvious that a diet suitable for a Polar expedition, with its enormous demands upon the heat-producing powers, and hence its need for an excess of fats, would be most unsuitable for a campaign in a climate where the demands call for an excess of muscular work with the minimum evolution of internal heat. In the case of the striking force which might at any minute be called to operate in climates with as wide a range as that of the Empire, it is necessary that a mean should be struck which would serve as a basis in either case.

(i) Ease of Preparation.—Under conditions in which every man must serve as his own chef, it is a matter of moment that the ration should be such as lends itself to rapid and simple preparation. This aspect has been simplified by the introduction of travelling field kitchens, the use of which should ensure that men have not to go on duty without their rations having been cooked.

(j) Facility for Rapid Issue.—The rations should be so divided into appropriate portions and so packed that issue of the correct amounts can be effected easily and rapidly. This obviates wastage and does away with the long wait which is so distressing to bodies of men at the end of the day’s work when the main meal is urgently needed.

(k) Cost.—The question of relative expense is one which affects, or may dominate, the choice of the several items for an expeditionary ration. This factor may be summarized as that of the provision of the greatest possible energy value at the least possible cost compatible with the requirements already given.

Although this list does not purport to afford an exhaustive enumeration of all the factors concerned, it probably suffices to show that the problem of their co-ordination is a complex one, and to indicate that the evolution of the ideal expeditionary ration has yet to be achieved.

RATIONS FOR A MILITARY FORCE IN THE FIELD.

The first point to be considered is the necessary energy value, and it must be emphasized that habitual underfeeding of an army on active service is bad policy. Not only is the fighting efficiency of the individual thereby reduced, but his increased liability to
sickness, consequent on lowered vitality, involves wastage in numerical strength of the force. Replacement of that wastage takes transport which would be better employed in securing that the men already placed in the firing line are adequately fed.

The data obtained from the experimental march already referred to show that the energy of 3,903 calories provided during the South African war was insufficient and the 1913 field service ration, which replaced it, increased the value to between 4,500 and 5,000 calories.

### TABLE I.-British Field Service Ration, 1913.

<table>
<thead>
<tr>
<th>Article</th>
<th>Amount</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrates</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh meat</td>
<td>1(\frac{1}{2}) lb.</td>
<td>68.88</td>
<td>103.69</td>
<td>-</td>
<td>1,298</td>
</tr>
<tr>
<td>Or preserved meat</td>
<td>1</td>
<td>100.59</td>
<td>43.50</td>
<td>-</td>
<td>807</td>
</tr>
<tr>
<td>Bread</td>
<td>1(\frac{1}{2})</td>
<td>52.14</td>
<td>7.36</td>
<td>300.97</td>
<td>1,515</td>
</tr>
<tr>
<td>Or biscuits (8), or flour</td>
<td>1</td>
<td>75.31</td>
<td>6.67</td>
<td>361.35</td>
<td>1,853</td>
</tr>
<tr>
<td>Bacon</td>
<td>4 oz.</td>
<td>11.29</td>
<td>76.44</td>
<td>-</td>
<td>756</td>
</tr>
<tr>
<td>Tea</td>
<td>1(\frac{1}{2})</td>
<td>23.56</td>
<td>31.29</td>
<td>3.48</td>
<td>402</td>
</tr>
<tr>
<td>Cheese</td>
<td>1(\frac{1}{2})</td>
<td>18.95</td>
<td>0.75</td>
<td>35.15</td>
<td>507</td>
</tr>
<tr>
<td>Peas</td>
<td>2</td>
<td>12.75</td>
<td>1.02</td>
<td>33.97</td>
<td>201</td>
</tr>
<tr>
<td>Or Beans</td>
<td>2</td>
<td>4.82</td>
<td>0.23</td>
<td>45.87</td>
<td>210</td>
</tr>
<tr>
<td>Or potatoes dried</td>
<td>1</td>
<td>11.29</td>
<td>76.44</td>
<td>-</td>
<td>756</td>
</tr>
<tr>
<td>Jam</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>88.24</td>
<td>362</td>
</tr>
<tr>
<td>Sugar</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>36.05</td>
<td>313</td>
</tr>
<tr>
<td>Salt</td>
<td>3(\frac{1}{2})</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mustard</td>
<td>3(\frac{1}{2})</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pepper</td>
<td>3(\frac{1}{2})</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lime juice</td>
<td>1(\frac{1}{2}) gill</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rum</td>
<td>3(\frac{1}{2})</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tobacco per week</td>
<td>2 oz.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fresh vegetables when available; when these are supplied, peas, beans, dried potatoes, and lime juice will not be issued</td>
<td>1(\frac{1}{2}) lb.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>70</td>
</tr>
</tbody>
</table>

When fresh meat, bread, and fresh vegetables are issued, calorie value = 4,717.

When preserved meat, biscuits, and dried vegetables are issued, calorie value = 4,704.

Without detailed discussion of its several constituents, the proximate principles and calorie values of the 1913 general field service ration may be used to illustrate how a diet of the necessary energy may be constructed. These are shown in Table I.

Certain innovations—adopted or desirable—may be briefly referred to.

1. The principle of alternative issues is fully recognized.
2. The size of the biscuit formerly used called for reduction, and small biscuits, of about the size of the terminal thumb phalanx,
are preferable. The drying stage of manufacture is thus shortened, so that moths are less liable to deposit ova and thus lead to the biscuits becoming weevilly, while small biscuits can be readily stowed in odd corners of the haversack and are more easily masticated.

(3) In future European wars it is probable that motor transport facilities will permit of frozen meat replacing tinned meat, and the latter will be used only for reserve rations.

(4) The provision of travelling field cookers for units will obviate the need for supply of the bulky, but appetizing, tinned rations of meat, gravy and vegetables already cooked and needing only to be warmed before use. The difficulties of preservation of such rations have largely been surmounted, and if they were capable of sufficient concentration they would afford a most desirable alternative issue to corned beef and dried potatoes, in that they give a variety in protein, supply all needs in the one tin, save fuel for cooking, are most savoury and stimulate both appetite and peristalsis—the latter by their large bulk.

As at present made, however, they give a calorie value of only 75.1 per cent of that provided by an equal weight of corned beef and dried potato. This militates against their use in areas where transport considerations are of great importance, although in my opinion the benefits to be anticipated from such an issue, say once a week, would justify the consequent addition to the weight which must be carried.

Such a ration consists of:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Oz.</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat—without bone</td>
<td>12</td>
<td>54</td>
</tr>
<tr>
<td>Potatoes</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Haricot beans</td>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td>Onions</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Stock gravy</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Total: 22 oz.

and gives a value of 963 calories.

**RESERVE RATION.**

Not only must provision be made for units when intact, but troops cut off temporarily from the field cookers of their units, or from their supply columns, must also be provided with a small ration sufficient to tide them over such periods. This has led to the construction of the "reserve ration," or its German equivalent
the "iron ration," which is carried by the individual; it suffices to keep him going for twenty-four or forty-eight hours respectively, and is only to be used by order of an officer when all other sources of supply fail.

Limitation of weight makes it possible to provide only some 2,500 calories and Table II indicates the composition and values of the British ration. The fat deficiency of the previous reserve ration has been remedied by the addition of cheese. It is unfortunate that cheese—one of the most valuable and concentrated of all foods—does not keep well and an alternative should be adopted when such is forthcoming.

**TABLE II.—BRITISH ARMY RESERVE RATION, 1913.**

<table>
<thead>
<tr>
<th>Article</th>
<th>Amount</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbo-hydrates</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td></td>
</tr>
<tr>
<td>Preserved meat</td>
<td>12 oz.</td>
<td>100.59</td>
<td>42.5</td>
<td>—</td>
<td>807</td>
</tr>
<tr>
<td>Biscuits (6)</td>
<td>12 &quot;</td>
<td>56.48</td>
<td>5.0</td>
<td>271.02</td>
<td>1,389</td>
</tr>
<tr>
<td>Cheese</td>
<td>3 &quot;</td>
<td>23.56</td>
<td>31.3</td>
<td>3.48</td>
<td>402</td>
</tr>
<tr>
<td>Sugar</td>
<td>2 &quot;</td>
<td>—</td>
<td>—</td>
<td>51.80</td>
<td>201</td>
</tr>
<tr>
<td>Tea</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Salt</td>
<td>1 &quot;</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Meat extract (3 cubes)</td>
<td>4 &quot;</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Total weight</strong></td>
<td>31.125</td>
<td>180.63</td>
<td>78.80</td>
<td>326.40</td>
<td>2,508</td>
</tr>
</tbody>
</table>

The cubes of meat extract not only give a valuable gastric stimulant—invaluable for wounded or exhausted men—but they afford a ready means for making beef-tea in which biscuits may be soaked and rendered more digestible. A little hot water must be obtained for this purpose, but otherwise the requirement that reserve rations should need no cooking has been complied with.

Plasmon and chocolate, which figured in former reserve rations, have been discarded as they were so concentrated as to be relatively indigestible and provocative of thirst.

The weight is shown in Table II as nearly 2 lb., exclusive of the material in which the ration is packed. This adds one-third to the total weight of the ration and a lighter material should be used; packing of the component parts in separate packages would also add to facility of carriage and permit distribution of the component parts among the equipment. If a single metal case be adopted it should be of a flat oval shape in preference to an angular package.
RATIONS FOR POLAR EXPEDITIONS.

On approaching this subject one is confronted by the fact that, while in other zones the study of dietetics has passed progressively from empirical to scientific control, in polar regions the scientific control of empiricism is so slight that the practical experience gained by explorers is of paramount importance and apparently conclusive arguments based on calculation and analogy cannot justify radical dietetic innovations which have not been tested by practical trial under arctic conditions. While dietetic empiricism has led to the evolution of diets proved capable of maintaining life in polar regions, bromatology has not as yet had a like opportunity. Experimentation is, therefore, not permissible with regard to the essentials of a diet upon which the lives of members of an arctic expedition are unalterably dependent from the day on which they leave the confines of civilization.

The problem is to provide a diet which will serve to keep a party fit for 128 consecutive days and will not exceed in weight thirty-five ounces per man per diem.

(a) Calorie Value.—That more food is needed under conditions of extreme cold is well known. Increased heat production necessitates more rapid metabolism, which, in turn, involves a proportionate increase in food containing carbon compounds. For this reason fat must form a large proportion of all polar dietaries, as it provides—weight for weight—a higher calorie value than that afforded by other proximate principles.

There are, however, other factors of which few but the explorers themselves have any adequate conception. The intense and sustained muscular effort, want of sleep, the mental tension of constant anxiety and ceaseless vigilance, the dyspepsia and constipation consequent upon a monotonous, imperfectly cooked and highly concentrated diet—all these combine to tax the physical and mental powers to an extent far beyond that indicated by the considerations of heat maintenance and labour demands. This prolonged high tension further indicates that the reparative properties of protein, as compared with those of carbohydrate, should be taken full advantage of in the construction of the dietary—although the calorie values of these proximate principles are similar.

Before proceeding further it may avoid confusion to explain that it is with the expeditionary aspect of the problem of polar rations that we are now dealing. So long as an expedition is on its ship,
or in huts at a base in close touch with the ship, there is available a variety and amount of supplies which reduce the difficulties to the level of those to be met in rationing a ship's company for a prolonged voyage. It is on sledge journeys, when every additional pound of weight to be carried by the individual may mean possibly a matter of life or death, that the problem becomes acute. It is then that the explorer has to balance the vital equation between the work which must be done and the calorie value of the food which can be carried. The former is ever an unknown quantity and the explorer who finds himself with his food supply exhausted and his journey still unaccomplished must needs pass on his longer journey into the greater unknown.

Examination of previous records show that De Chaumont calculated the average daily work per man done by the Nares sledge expedition of 1875 at 534 foot-tons. He remarked, however, that the actual work done appeared to have largely exceeded the theoretical energy value of the diet and Captain Markham, criticizing De Chaumont's data, maintained that 1,000 foot-tons was a more accurate figure.

Adopting the higher estimate it was decided to aim at providing for 1,000 foot-tons of daily labour per man. This is equivalent to 649 calories, and adding 4,851 calories, for heat maintenance and internal work, brings the daily total up to 5,500 calories per man. This gives about 1,000 calories more than was provided by the ration carried during Captain Scott's last antarctic expedition.

(b) Selection of Articles of Diet which will meet all Needs.—In the selection of articles to comprise the ration attention had to be paid to all the special factors concerned, not the least among which was that of weight, which made it imperative to choose the most concentrated products which would fulfil the special purposes in view. Table III gives the constituents and values of a complete ration.

Protein was the first principle to be dealt with, and this had necessarily to be in concentrated form, for although fresh meat (seal, gull, penguin, or bear flesh) may be available at the base, its high water-content prevented its incorporation in the 'sledge ration.' The choice of protein lies between that derived from animal sources—such as casein, meat fibre, desiccated egg or pemmican—and that from vegetable sources—such as wheat (gliadine), nuts or biscuits. As all vegetable protein lacks the essential appetizing flavour of meat preparations, and is associated, save in the case of such pure extracts as gliadine, with inert cellulose
TABLE III.

BREAKFAST.

<table>
<thead>
<tr>
<th>Article</th>
<th>Amount</th>
<th>Moisture</th>
<th>Mineral Matter</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrates</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>2 oz.</td>
<td>4.03</td>
<td>0.88</td>
<td>12.94</td>
<td>5.34</td>
<td>33.02</td>
<td>236</td>
</tr>
<tr>
<td>Lard</td>
<td>3½ oz.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>99.23</td>
<td>—</td>
</tr>
<tr>
<td>Sugar</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>14.17</td>
</tr>
<tr>
<td>Beef powder</td>
<td>1½ oz.</td>
<td>0.99</td>
<td>3.85</td>
<td>35.29</td>
<td>2.37</td>
<td>—</td>
<td>166</td>
</tr>
<tr>
<td>Gliadine</td>
<td>1 oz.</td>
<td>1.28</td>
<td>0.08</td>
<td>11.75</td>
<td>0.14</td>
<td>0.82</td>
<td>53</td>
</tr>
<tr>
<td>Biscuits</td>
<td>1 oz.</td>
<td>3.52</td>
<td>0.30</td>
<td>9.21</td>
<td>0.85</td>
<td>14.45</td>
<td>105</td>
</tr>
<tr>
<td>Trumilk</td>
<td>1 oz.</td>
<td>0.13</td>
<td>1.66</td>
<td>6.70</td>
<td>8.00</td>
<td>11.63</td>
<td>150</td>
</tr>
<tr>
<td>Sugar (additional), as</td>
<td>1½ oz.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>42.51</td>
<td>174</td>
</tr>
<tr>
<td>lump sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11½ oz.</td>
<td>9.95</td>
<td>6.77</td>
<td>75.92</td>
<td>115.93</td>
<td>126.55</td>
<td>1,865</td>
</tr>
</tbody>
</table>

LUNCH.

<table>
<thead>
<tr>
<th>Article</th>
<th>Amount</th>
<th>Moisture</th>
<th>Mineral Matter</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrates</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
</tr>
<tr>
<td>Biscuits</td>
<td>5 oz.</td>
<td>17.60</td>
<td>1.50</td>
<td>46.05</td>
<td>4.25</td>
<td>72.25</td>
<td>525</td>
</tr>
<tr>
<td>Nut-food (+ 1 oz. tru-</td>
<td>6 oz.</td>
<td>6.31</td>
<td>3.81</td>
<td>27.30</td>
<td>54.14</td>
<td>81.03</td>
<td>948</td>
</tr>
<tr>
<td>milk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trumilk</td>
<td>0.25 oz.</td>
<td>0.06</td>
<td>0.41</td>
<td>1.74</td>
<td>1.99</td>
<td>2.90</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>11½ oz.</td>
<td>23.97</td>
<td>5.72</td>
<td>75.09</td>
<td>60.38</td>
<td>156.18</td>
<td>1,508</td>
</tr>
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</table>

SUPPER.

<table>
<thead>
<tr>
<th>Article</th>
<th>Amount</th>
<th>Moisture</th>
<th>Mineral Matter</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrates</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>2 oz.</td>
<td>4.08</td>
<td>0.88</td>
<td>12.94</td>
<td>5.34</td>
<td>33.02</td>
<td>236</td>
</tr>
<tr>
<td>Lard</td>
<td>4½ oz.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>127.57</td>
<td>1,187</td>
</tr>
<tr>
<td>Sugar</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>14.17</td>
<td>58</td>
</tr>
<tr>
<td>Beef powder</td>
<td>1½ oz.</td>
<td>0.99</td>
<td>3.85</td>
<td>35.29</td>
<td>2.37</td>
<td>—</td>
<td>166</td>
</tr>
<tr>
<td>Gliadine</td>
<td>1 oz.</td>
<td>1.28</td>
<td>0.08</td>
<td>11.75</td>
<td>0.14</td>
<td>0.82</td>
<td>53</td>
</tr>
<tr>
<td>Biscuits</td>
<td>1 oz.</td>
<td>3.52</td>
<td>0.30</td>
<td>9.21</td>
<td>0.85</td>
<td>14.45</td>
<td>105</td>
</tr>
<tr>
<td>Trumilk</td>
<td>1 oz.</td>
<td>0.13</td>
<td>1.66</td>
<td>6.70</td>
<td>8.00</td>
<td>11.63</td>
<td>150</td>
</tr>
<tr>
<td>Sugar (additional), as</td>
<td>1½ oz.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>42.51</td>
<td>174</td>
</tr>
<tr>
<td>lump sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11½ oz.</td>
<td>9.95</td>
<td>6.77</td>
<td>75.92</td>
<td>144.27</td>
<td>126.55</td>
<td>1,139</td>
</tr>
</tbody>
</table>

Meat extract, ½ oz. issued with supper ration.
Tea, ½ oz. issued with lunch ration.
Concentrated lime juice ½ oz., cerebos salt ½ oz., daily.

Total calories per day = 5,512.
Total fat per day = 320.58 grammes.
Total protein per day = 226.93 grammes.
Total carbohydrate per day = 409.28 grammes.
which also checks assimilation, animal protein was selected. The total daily amount is 226.93 grm., which, although a very high figure, appears to be demanded by the special conditions already discussed.

With regard to fat, not only are large amounts desirable on theoretical grounds, but such amounts have in practical experience been consumed without producing digestive disturbance or distaste: the sledge ration of the Nares expedition, e.g., contained no less than 329 grm. of fat. It was decided to provide 320.48 grm. per diem, of which lard contributes roughly fifty-five per cent; nut food thirty per cent, in the form of sesame oil; dried milk ten per cent; while the balance is derived from various sources. It is thus seen that animal fats largely predominate and that lard is the most important contributor. Lard was chosen as being the most palatable form for continuous use; the most readily assimilable; and the most concentrated. It may be noted that concentration depends upon the amount to which the residual water may be reduced without the necessary heat causing charring of the fat. Lard may thus be rendered practically water-free, while the residual water in beef-fat cannot be reduced much below thirteen per cent of the total weight. Another factor which led to the selection of lard is the fact that, owing to its being almost water-free, it keeps better than other fats; if mixed with ten per cent of sugar it has been proved after months of incubation at 37° C. and even after mixture with moulds, to undergo no appreciable change. Butter was discarded on account of the large proportion of water which it contains, and because the large quantity of water necessitates the butter being packed in heavy tins in order to prevent it becoming rancid.

The amounts of protein and fat having been determined upon, the balance of calorie value must be derived from carbohydrate. This has been replaced by fat to the fullest permissible extent, owing to its higher value weight for weight, but a limit is set to this interchange ability by the value of carbohydrate as a sparer of protein; it delays and diminishes muscular fatigue, owing to its rapid oxidation; its bulk also checks the tendency to constipation which is consequent upon adoption of relatively water-free foods.

The carbohydrate to provide the necessary balance of 409.28 grm. is mainly supplied by oatmeal, biscuit, nut-food and sugar, the last of which provides about thirty per cent of the whole. It is important that only the purest sugar should be used and the centrifugalized variety, in cubes, is perhaps the most convenient.
The mineral matter must be dealt with in view of the fact that saline-free melted snow is the only source of water. This results in a deficiency of salts of approximately 1.5 grm. per diem, the deficit being largely of calcium salts, which are important in their action on the blood coagulability and in the promotion of sustained muscular effort. This deficit may be met by the addition of five grammes daily of cerebos salt, which consists of sodium chloride with four per cent of earthy phosphates. It may be noted that the hyper-acidity caused by a diet so rich in protein is checked by calcium liberated from the breaking up of unstable calcium carbamate if ample calcium salts exist in the diet. To ensure that ample provision is made for this purpose, a reserve of four grammes of cerebos salt per head per diem was placed at the disposal of the medical officer. The ration itself gives 25.06 grm. of mineral matter. It provides the necessary ten milligrammes of iron daily, while phosphorus is present in sufficient amount in the cereals, casein, milk powder and biscuit.

The next point demanding attention was that of selection of such dietetic articles as tend to ensure immunity from diseases which have been grouped as "deficiency diseases," of which scurvy and beriberi may be cited as examples. Recent research indicates that each disease of this group is due to dietetic deficiency in a substance etiologically specific to that disease and such substances have been provisionally named vitamines. All that may certainly be said at present of vitamines is that they are unstable, metabolic, nitrogenous bodies of uncertain composition which are essential to perfect metabolism. It has been considered that in fresh foods the salts are in a state of dissociation, and thus contain the dissociated ions necessary to metabolic processes, while that state of dissociation is disturbed by certain methods of preservation and especially by exposure to high temperatures. Cabbage juice, e.g., loses its antiscorbutic properties when heated to 60° C. and the vitamines of beriberi are destroyed in rice at 120° C.

There is much valuable work being done on the nature of these bodies, and Dr. E. A. Cooper of the Lister Institute has very kindly ascertained for me that desiccated yeast has the property of curing pigeon beriberi.

The most important deficiency disease with which we are now concerned is scurvy. While we have little knowledge of the vitamines of this disease, it is certain that they are contained in green foods, which are both protective and curative. The first consideration therefore is the extent to which fresh green food
can be supplied at the base, both to ensure that the expeditionary party is in perfect health when they start off on their sledge journey, and that they have a certain amount of fresh green food to take with them.

A temperature of 50° F. may be counted upon in the ship or huts at the base and incandescent lamps provide the necessary light, so that seeds such as oats, barley, mustard, and cress, and rape can be made to germinate on moistened textiles and their green shoots can be reaped in successive crops.

On the datum that guinea-pigs need between $\frac{1}{10}$ and $\frac{3}{50}$ of their body-weight of fresh cabbage daily as an anti-scorbutic, a man should need daily from 7 oz. to 16 oz., but for short periods it is probable that 7 oz. every third day might suffice. The smaller amount will probably be obtainable at the base and should be compressed for addition to the sledge ration, but it is obvious that this must not be relied on. On the other hand, the idea that dried vegetables (as ordinarily preserved), jam, bread and preserved meat possess anti-scorbutic properties must be discarded, although an ample supply of potatoes, onions, turnips, cranberries, &c., will form part of the supplies for ship and base rations. It has been found that if cabbage juice, dried in vacuo over sulphuric acid at 37° C., be kept in vacuo it retains its anti-scorbutic properties for one and a half years, but the value of this discovery is discounted by the fact that as much of the dried juice is required as of the fresh cabbage —i.e., a daily ration of $\frac{1}{15}$ of the body weight.

We are thus driven to rely mainly upon lime-juice as the most convenient concentrated product for our purpose. The first question regarding lime-juice is the extent to which the water may be reduced with safety. The eighty-seven per cent of water in the commercial product may be reduced, by cold extraction, to ten per cent without destruction of the essential vitamins and without loss of solubility. The resulting semi-solid extract retains its flavour, keeps well at laboratory temperatures, and has the advantage of being less liable to freeze and burst the bottles. If made into cubes by addition of gelatine this danger would be wholly obviated, while slow sucking of the cubes would aid digestion by promoting a free flow of saliva after the main meals of concentrated and comparatively water-free foods.

It is interesting to note that a similar suggestion is found in the records of an investigation into the causes of scurvy on the Nares Arctic Expedition in 1875. Dr. Donnet and Dr. Fraser (now Sir Thomas Fraser, of Edinburgh University) suggested that lime-juice
be evaporated to five per cent bulk and preserved by addition of sugar and rum or glycerol and then made into lozenges. No opportunity arose for practical tests of these suggestions.

Having discussed the above requirements, it may be interesting to take next the forms in which the requisite proximate principles have been worked into the ration and the reasons why certain articles have been omitted.

One of the staple items of polar menus is “hoosh,” which can conveniently consist of fat, oatmeal, meat fibre and sugar. This forms a sort of porridge which is readily prepared, is most appetizing, and does not tend to produce distaste when partaken of for long periods. The bulk of the fat is taken in this form, and the lard neither separates out on cooking, nor imparts its peculiar flavour to the “hoosh,” which forms the staple item for breakfast and supper, while mastication is provided for by biscuit. The biscuit further affords the necessary bulk and the cellulose which is needed to prevent occurrence of constipation. It is the necessity for this inert bulk which makes it improbable that reliance upon tabloid foods alone will ever become practicable. The biscuits are made from baked wholemeal flour and have not been seasoned by addition of protein, as this has been found to induce distaste after prolonged consumption. Tea is taken with these meals and sufficient desiccated milk is provided to add to the tea or to be taken with the “hoosh” as may be preferred. This milk, containing only 2 per cent of water, is an ideal concentrated form for the purpose, as 2 oz. of the dried product gives 50 oz. of good milk which is practically indistinguishable from the fresh variety.

Biscuits and milk again form part of the mid-day meal, but variety is secured by substitution of nut-food for “hoosh.” The nut-food consists of almonds, sesame seeds and oil and gives a palatable preparation, similar to nougat, which was much appreciated during a recent preliminary trial of the rations in Norway.

The division of the ration into daily meals is shown in Table III, and it is seen there that concentrated lime juice, meat extract and cube sugar are provided, with cerebos salt as an accessory. It is necessary to add to the ration some form of concentrated soup or meat extract, so that this may be available as an invaluable gastric adjuvant immediately after the arrival of the party at its camping ground, when the men feel the stress of their long day’s work most acutely. The cube of meat extract may either be sucked, or made into a pint of beef-tea as soon as hot water is ready. The lime-juice and cerebos salt have already been discussed. The omission of
three items which have figured so prominently in former polar rations may call for comment. The first is pemmican, which consists of dried, powdered meat-fibre mixed with sixty-three per cent of beef-fat and has a high calorie value—3,316 calories per pound—besides being palatable. This has been omitted on account of the difficulty of preserving it referred to previously, consequent upon the amount of water which remains in the beef-fat.

Next comes chocolate, and this was omitted because it promotes thirst and because it requires a large expenditure in assimilation, owing to the melting point of its natural fat being higher than that of the body temperature.

Finally comes alcohol, which has been wholly omitted. The following quotation may be made from the paper by Drs. Donnet and Fraser already alluded to: "It is a significant fact in the history of the recent expedition that the first two cases of scurvy occurred in men who were addicted to an immoderate use of alcohol and who had not been exposed to the determining conditions that existed during sledge travelling. It appears also that in former arctic expeditions scurvy has occurred in men who indulged in alcohol to excess, while at the same time the disease was not prevalent among the rest of the crew. From the nature of the injurious action on nutrition of alcohol taken in immoderate quantity, it may be assumed that when so used it becomes a powerful predisposing cause of scurvy. . . . It is a remarkable fact that the men employed in the Hudson Bay Company's service, who rarely drink alcohol in any form, enjoy almost complete immunity from this disease, notwithstanding prolonged exposure to an arctic climate and fatiguing sledge journeys which on some occasions have lasted for several months."

As compared, with tea, alcohol has, in my opinion, the only advantage of requiring no preparation. On the other hand, men find that they can work longer and harder after luncheon, if tea be included, than they can during the morning. Tea is less liable than coffee or cocoa to produce distaste, and the exhausted leaves may themselves be eaten and give bulk to the food should further bulk be necessary. They possess, however, none of the anti-scorbutic properties with which tradition has credited them.

(c) Portability.—In this connection the only simplifying factor is that water is always available within the regions of perpetual snow, and this enables the percentage of water in the ration to be reduced to the minimum which will leave the nutritive value
Field Service and Expeditionary Rations

unimpaired. On the other hand, snow-water lacks the saline constituents of ordinary potable water.

The necessity of providing a calorie value of 5,500 calories in a weight of thirty-five ounces being admitted, this has been

TABLE IV.—RATIONS FOR SLEDGE PARTIES OF H.M.S. "ALERT" AND "DISCOVERY," NAVES ARCTIC EXPEDITION, 1875.

<table>
<thead>
<tr>
<th>Articles</th>
<th>Amount</th>
<th>Fat</th>
<th>Protein</th>
<th>Carbohydrates</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pemmican</td>
<td>16 oz.</td>
<td>233'8</td>
<td>158'6</td>
<td>—</td>
<td>3,013</td>
</tr>
<tr>
<td>Biscuits</td>
<td>14 oz.</td>
<td>2'90</td>
<td>46'0</td>
<td>299'04</td>
<td>1,436</td>
</tr>
<tr>
<td>Bacon</td>
<td>4 oz.</td>
<td>76'44</td>
<td>11'22</td>
<td>756</td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>2 oz.</td>
<td>0'23</td>
<td>4'82</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>Rum</td>
<td>3/4 gil</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Chocolate</td>
<td>1 oz.</td>
<td>4'20</td>
<td>1'4</td>
<td>19'06</td>
<td>122</td>
</tr>
<tr>
<td>Sugar for ditto</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>14'17</td>
<td>58</td>
</tr>
<tr>
<td>Tea†</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sugar for ditto</td>
<td>1 oz.</td>
<td>—</td>
<td>—</td>
<td>42'51</td>
<td>174</td>
</tr>
<tr>
<td>Sterarine</td>
<td>3</td>
<td>76'44</td>
<td>11'22</td>
<td>756</td>
<td></td>
</tr>
<tr>
<td>Spirits of wine</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Tobacco</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Salt</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pepper</td>
<td>3/4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Onion and curry powder</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Actual weight of food</td>
<td>39 1/2 oz.</td>
<td>337'57</td>
<td>222'04</td>
<td>420'65</td>
<td>5,769</td>
</tr>
</tbody>
</table>

* Increased in some cases to 6 oz. in lieu of pemmican.
† Double allowance of tea was carried in lieu of rum.

TABLE V.—SCOTT ANTARCTIC "SLEIGH RATION."

<table>
<thead>
<tr>
<th>Article</th>
<th>Amount</th>
<th>Fat</th>
<th>Protein</th>
<th>Carbohydrates</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grammes</td>
<td>Grammes</td>
<td>Grammes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pemmican</td>
<td>8 oz.</td>
<td>126'9</td>
<td>79'50</td>
<td>1,506</td>
<td></td>
</tr>
<tr>
<td>Biscuits</td>
<td>14 oz.</td>
<td>2'9</td>
<td>46'00</td>
<td>1,486</td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>5 oz.</td>
<td>2'9</td>
<td>46'00</td>
<td>1,486</td>
<td></td>
</tr>
<tr>
<td>Tea</td>
<td>1 oz.</td>
<td>2'9</td>
<td>46'00</td>
<td>1,486</td>
<td></td>
</tr>
<tr>
<td>Raisins</td>
<td>2 oz.</td>
<td>1'70</td>
<td>1'30</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Cocoa</td>
<td>1 oz.</td>
<td>2'10</td>
<td>0'70</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Chocolate</td>
<td>2 oz.</td>
<td>8'40</td>
<td>2'80</td>
<td>245</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32 oz.</td>
<td>142'00</td>
<td>130'00</td>
<td>507'2</td>
<td>4,010</td>
</tr>
</tbody>
</table>
carried on the Nares expedition weighed thirty-nine ounces, while that of the last antarctic expedition under Captain Scott provided 1,000 calories less potential energy, although it weighed an ounce less than that now being described. The rations of these expeditions are shown in Tables IV and V for comparison. Reduction of water not only diminishes weight but has the advantage of lessening the disintegration which follows the freezing of all foods not wholly water-free, when exposed to temperatures sometimes as low as \(-70^\circ\) C.

The use of foods which have to be packed in such heavy materials as tin must necessarily be avoided, and articles substituted which, on account of being practically water-free, are not liable to decomposition at the uniformly low temperatures at which they can be maintained throughout. The articles which constitute the "hoosh" and the nut-food may be safely packed in such light wrappings as grease-paper. The lard, which forms so large a proportion of the ration, has already been stated to resist decomposition and may be packed in bladders or in sausage-skins.

(d) Ease of Preparation.—For polar expeditions it is obvious that rations which require cooking, in the full sense of the word, are inadmissible. All that can be done on the line of march is to raise the ration to boiling point before putting out the stove, but hot water is obtainable thrice daily as a means of dissolving the dried milk and making tea.

The "hoosh" merely needs addition of water and heating to the boiling point in one mass, while the nut-food and biscuit need no preparation. The "hoosh" consists of oatmeal two ounces, lard three and a half ounces, sugar half an ounce, meat powder one and a half ounce, and gladiine half an ounce, mixed together in packing to form a semi-solid mass which requires addition of one pint of water and heating to the boil to make an appetizing meal. The semi-solid mass is made up in packages of the appropriate weight and keeps indefinitely if packed in bladders, which may be eaten if more bulk be required—thus avoiding the carriage of any useless material whatsoever. This further saves delay and difficulty in serving out the daily rations in appropriate amounts.

Remaining Factors.—Of these little remains to be said. Certain factors which control the rations for military expeditions—such as facilities for replenishment, cost, etc.—are not applicable in the case under review. The questions of divisibility, variety, climatic applicability and preservation have been dealt with already. The only remaining point is that the ration should be composed of
articles to which the men have been accustomed. To a certain extent this is met by the fact that members of the expedition will have become accustomed to some of the constituents of their ration during the period of preparation at the base. Otherwise the brief and definite duration of the sledge journey is such as to make it more important to get the men in the best condition possible by a generous and varied diet up to the actual date of starting than to attempt to accustom them in advance to the diet upon which they must solely rely on the sledge trip.

It is impossible to refrain from concluding this section without a tribute to the quality of the courage which upholds those who undertake the exploration of frozen zones, and to the attention to minuteness in preparation which has so vital a bearing upon the question of success or failure—life or death.