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Military Hygiene

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LECTURE.

Friday, May 27th, 1870.

SIR T. GALBRAITH LOGAN, K.C.B., M.D., Director-General Army Medical Department, in the Chair.

MILITARY HYGIENE.

By F. DE CHAUMONT, Esq., M.D., Army Medical School, Netley.

THE subject which I have the honour to bring to your notice this day is one of so comprehensive a character, that I might well hesitate before attempting its exposition in a single lecture. I hope, however, to be able to lay before you a few points of interest selected from the wide range of inquiry which the study of hygiene embraces. Let me say a few words in the first place as to the nature and character of the study. Hygiene (or *medical police* as it used to be called in this country) is that branch of study which treats of the laws of health. This is its widest application, and we hesitate to call it a science, chiefly because it is based upon many other divisions of knowledge which are themselves still imperfect; it is, in fact, as yet merely an art by which we apply to the preservation of health the points of knowledge derived from many sources. Its highest aim being to produce the "*mens sana in corpore sano*," it is obvious that nothing which bears directly or indirectly upon health is excluded from it, which is simply tantamount to saying that it includes everything cognisable by man. But, the causes that act and react upon the human economy being practically infinite, to integrate them so as to produce a definite expression, which shall be presented as a perfect science, is hopeless. All we can hope to do is to approach as nearly as possible to the limit which can never by any possibility be reached. But within this vast circle there are others to which we may profitably confine our attention for the time, and within which we may direct our inquiries to those points in the material well-being of man, which are more immediately under our control. Hygiene, then, is the art of preserving health by removing all that is injurious to life, and supplying all that is needful for life. It aims at rendering life vigorous, painless, free from disease and prolonged, so that a truly hygienic being would cease to exist purely from natural decay. Whether or not it would be possible to lengthen life materially or indefinitely, is a speculation which has often suggested itself, but which we are at present too ignorant to consider.

Hygiene, although but recently placed on a scientific basis, is by no means a new object of human study; it is at least as old as history itself. The ceremonial law of Moses was as perfect a system as the knowledge of the time could produce. Hippocrates embodied in his works the

precepts of many older and now forgotten writers. The life of the Greeks was eminently hygienic. The vast systems of baths built by the Romans, their system of sewers, their mode of water supply and many of their domestic arrangements, proved how far they understood the art of health in peace, while the rules of Vegetius may be even now profitably studied as a guide in time of war. It was reserved for the fanatical asceticism of the middle ages to outrage every law of health, to impose upon the world the idea of the contemptibility of caring for the body, and in fact to accomplish what may be fitly termed the apotheosis of filth! What can we think of a community in which the cleanliness of the body was regarded as a pollution of the soul, and the cynosure of all devout eyes was such a hideous mass of filthy insanity as St. Simeon Stylites! The outcome of all this was, that epidemics of a virulence unknown to classic times devastated Europe, and it was only with the revival of letters, when the intellect of Europe began to shake off the shackles of tradition and priestly domination, that a return was made to the paths that had been so long forsaken. Even now, with all our boasted science, we are only going back in a measure to the principles already firmly established fifteen centuries ago, but the practice of which disappeared with the fall of the Western Empire. We are even now in some practical points behind that age, and it will be long before we make up for the death-like sleep of a thousand years, during which, as Michelet says, not one in Europe ever took a bath!

Hygiene in its detailed application includes the following points:—the supply of *air, water, food, clothing, shelter* and *exercise*, and the removal of *waste* and *effete* products arising from what source soever. Deficiency in the supply of the above requisites weakens the human frame and induces constitutional diseases; neglect in the removal of waste products favours the development of actual poisons which give rise to epidemic and zymotic diseases. This is of course a general statement requiring modification according to individual circumstances. The relative importance of each cause advances, both as regards rapidity and intensity of effect. Thus, whenever a sudden invasion of disease takes place, affecting a large proportion of a community at the same time, such as an attack of diarrhœa, it is generally due to some poison introduced through the water-supply, and it is seldom that inquiry fails to trace it to this source. On the other hand, the most fruitful source of disease, although less immediately recognisable in its operation, is impure air from defective ventilation. While to bad water we owe in a large measure the propagation of such diseases as diarrhœa, dysentery, cholera, typhoid fever and the like; to bad air we owe pulmonary consumption, pneumonia, typhus fever, scrofulous disorders, and many others, some apparently *generated* by the products of respiration, others unquestionably *favoured* and propagated by a want of proper interchange of air. The importance of this question with reference to the health of the soldier is so great that I propose to ask your attention for a little to the subject. The necessity for good ventilation and the proper methods of obtaining it have been very fully discussed of late years, and it may be considered as pretty

generally admitted that it is a question of the very gravest moment. Death-rate has been shown to increase in a pretty regular ratio with the increase of inhabitants to the square mile, and, putting exceptional causes aside, the most virulent disease and the greatest mortality are to be found in the most crowded localities. Of course among the civil population, poverty and starvation have to be taken into consideration, for among them crowding necessarily means poverty, want of means compelling them to huddle together to save the crushing expenses of house-rent and fuel. Among soldiers, however, it is possible to eliminate these disturbing causes to a certain extent, for the men are selected lives, are, on the whole, well fed and clothed, and are not more exposed in time of peace to vicissitudes of temperature than the civil population. Yet, in spite of these advantages, and putting aside all other deleterious influences, the researches of the Royal Commission of 1857 showed that the death-rate of the soldier at home was up to that time *twice* that of the civil population of the same ages. To what was the death-rate chiefly owing? To two diseases mainly, viz., typhoid fever and pulmonary consumption (or a destructive lung-disease). Now the former is almost entirely due to bad conservancy, that is, neglect in the removal of excreta, and the latter, by far the more destructive, to bad air, caused by bad barrack accommodation and deficiency of the supply of fresh air. The whole question was carefully investigated by the Commissioners, and the conclusion arrived at was, that to *bad air* the greater part of the Army mortality in time of peace was due. This was a conclusion for which the public generally was hardly prepared, but its truth was borne out by other investigations, for the same results arising from similar conditions were found to obtain in Continental Armies as well as in our own. Nay, further than this, similar influences were also found producing analogous effects among the lower animals, horses in badly ventilated stables, dogs in confined kennels, and even monkeys in ill-constructed dwellings were found to fall rapid victims to destructive lung disease, having in many cases characters similar to that which carries off so many of our soldiers. Since that time a very great change has taken place, increased accommodation and better means of ventilation having been provided in accordance with the recommendations of the Barrack Commission assembled in the following year, 1858. Imperfectly as these recommendations have been as yet carried out, the results are most encouraging, for the death-rate of the soldier now is reduced to *one-half* of what it was before the Crimean War, a most cheering and gratifying fact, even if we admit that it is not entirely due to this one set of changes. For although numerous causes have undoubtedly combined to bring about this result, yet enough of it may be traced to direct hygienic improvements to encourage us to make every effort to promote further advances in this direction.

I have alluded to the recommendations of the Barrack Commission as having been imperfectly carried out; let me now explain what I mean. The recommendations were that each soldier should have 600 cubic feet of space in barracks, and 1,200 in hospitals, and that the air of this space should be changed *twice* in the hour, thus giving

1,200 cubic feet per head per hour, in barracks, and 2,400 in hospitals. To accomplish this, improved methods of ventilation were recommended and in some cases supplied. I have now made detailed experimental inquiries in a good many barracks and hospitals, and I take this opportunity of laying before you very briefly the results, which may be seen by a glance at the accompanying table. From it you will observe that the rate of change of air is considerably below *twice* in the hour in the majority of instances, so that to provide even the moderate amount of air proposed by the Barrack Commissioners, a much larger initial cubic space would be requisite, or in other words the number of occupants ought to be reduced :—

Place.	No. of times air changed per hour.	Cubic space required per man to give the proposed amount of air, viz., 1,200 in barracks, and 2,400 in hospitals.	Average actual amount supplied, taking the initial space at 600 per man.
Barracks.			
(a) Netley	3.30	365	1980
(one room)			
Hilsea.....	3.25	370	1950
(brick huts)			
Fort Brockhurst	3.00	400	1800
Aldershot.....	2.35	520	1410
(ventilated on principles of Barrack Commission)			
Chelsea.....	2.20	550	1320
(no outlet shaft)			
.....			
Hilsea.....	1.74	690	1044
(room over stable)			
(a) Chatham	1.70	710	1020
(a) Netley.....	1.65	730	990
Fort Elson....	1.30	925	780
(no shaft)			
Gosport	1.20	1000	720
Tower.....	1.20	1000	720
Anglesey	1.20	1000	720
(a) Milton Bar- racks, Grave- send.....	1.18	1010	708
(original rooms in permanent barracks)	1.16	1020	696
(a) Chatham.....	0.80	1500	480
(a) Netley.....	0.72	1670	432

Hospitals.	No. of times air changed per hour.	Cubic space required to give the proposed amount of air, viz., 2,400 feet per hour.	Average actual amount supplied taking the initial space at 1,200 cubic feet.
Hilsea.....	3.12	770	3741
Herbert..... (Woolwich)	2.20	1095	2610
.....			
Portsmouth*... (Garrison Hos- pital)	1.10	2180	1320*
(a) Chatham..... (Fort Pitt)	0.90	2660	1080
(a) Netley.....	0.90	2660	1080
(a) Chatham..... (Fort Pitt)	0.55	4350	660
(a) Netley.....	0.55	4350	660

From these numbers we see that the results contemplated by the Commission have been obtained in only *five* barracks and *two* hospitals, viz., those above the dotted lines in each table. The experiments from which the calculations have been made were carried out by myself, except in those cases marked (a).

I think it will be admitted, on considering these results, that a good deal still remains to be done, even to arrive at the moderate degree of ventilation proposed by the Commission. I am, however, far from admitting that even this would be sufficient to ensure perfectly hygienic conditions, but it would still be a great advance upon the actual state of things. It cannot be too frequently insisted upon, that there is a practical limit to the number of times that air can be changed *without draughts* by ordinary appliances, and that therefore there is a limit to the number of occupants in an air space, which cannot be exceeded without serious danger to health, and even life. Theoretically speaking, the cubic space a man occupies is immaterial, *provided* always that the power of changing the air is unlimited; but it is perfectly plain that, if we cannot change the air more than twice in the hour, four men in that air space will only get each one-half as much as two. Therefore in placing a limit to the cubic space allotted, the possibility of changing the air sufficiently often, ought to be one main element of the calculation. The whole question is one of expenditure, for of course increased cubic space means more extended barrack accommodation, and greater outlay, both for warming and other things. On the other hand, special appliances for ventilation are also costly, and few have as yet given much satisfaction. I do not doubt, however, that we shall arrive ultimately at some means of combining economy with efficiency in this

* In this case the initial cubic space was only 800 feet, so that the air supplied was only 895 cubic feet per hour. Had the wards been full the space would have been only 630, and the amount of air 748 cubic feet only.

matter, and securing to the soldier an habitation which shall be really a shelter, and not a manufactory of disease.

I have dwelt thus particularly upon the question of ventilation as being the most important with regard to the soldier's health in time of peace; it is the most fruitful source of mortality, and the most constantly operating cause of disease. Of course it is not actually of less importance in time of war, but it is relatively less so on account of the presence of so many other causes which unite to attack the health of the soldier. I propose now in the remainder of this lecture to refer to some of the more important of these.

In the first place, the actual amount of physical exertion to be gone through is generally greater in time of war. Can we do anything in time of peace to prepare the soldier for this? For we must never forget that the trade of the soldier is war, and that, but for the existence or the possibility of war, he would cease to have a *raison d'être*. Many soldiers pass through their whole career without ever encountering actual warfare, but their whole training is to render them fit for a possible contingency, which, it is true, may never arise, but which the soldier must ever be prepared for. The amount of physical exertion which a man can undergo depends upon many things, the way he is fed, the way he is clothed, the climate he is in, and innumerable other causes which influence his health, morally and physically. Our first care, then, should be to preserve his health at the highest standard in time of peace by supplying an ample and wholesome diet, appropriate clothing, well ventilated barracks, &c. But there still remains the question of training and exercise. How far should these be carried in peace, with a view to the severer trials of war? It is the opinion of some that the amount of physical labour in peace should be strained to the utmost, even beyond what is likely to be required in war, so that when the latter comes it may be found more easy of endurance. It was on something like this principle that the Romans acted, giving their men so much labour in peace time, that they hailed the approach of war with delight, as a season of rest and variety. This was, perhaps, good policy in a nation eminently aggressive, who loved war better than peace, and claimed to make it an object of attraction to its citizens. But the condition of matters is changed at the present day; we keep an army as a necessity, but a necessity which we regret. We do not desire to instil a longing for war into our citizens; we merely wish to keep the instrument of defence in the highest state of efficiency, ready to be used on the instant when the hour of war does come. Under such circumstances it seems to me that it would be an eminent mistake to train the physique of the soldier too far; full and constant occupation he ought to have, but considerably within the limits of extreme physical effort. It stands to reason that a cord perpetually stretched will lose its elasticity, and probably give way when the important moment arrives. I think this is now pretty generally understood, and it receives an instructive illustration from the practice of professional singers, who by exercising their voices within a moderate compass, find that they can the more easily make an extreme effort when the occasion calls for one.

It is not, however, only in the preparation in time of peace that the power for physical effort depends. Man is a machine, just as much as a steam-engine or a galvanic battery; the amount of force he gives out is exactly proportioned to the amount of convertible material he takes in. We can calculate to a grain the force obtainable from the burning of a certain amount of coal, or the oxidising of a certain amount of zinc, and similarly (though, as yet, somewhat less perfectly) we can calculate the amount of force obtainable from the amount and quality of food supplied to the human economy. And this question of food is at the bottom of all the difficulties and disasters of a campaign. It used, in the great war in the beginning of this century, to be a favourite joke of the French soldiers against the English to say that you should never ask an Englishman if he has *fought* well, but ask if he has *dined* well, and then you may be sure he has fought well. Like many a word spoken in jest, there is deep truth contained in this, of whatever nationality the soldier may be. There can be no doubt that armies have performed prodigies of valour under circumstances of great privation, but we may be sure of this, that as Providence has been said to be on the side of the largest battalions, so it will also be on the side of the best fed battalions. This is well put in the report of an experienced French Officer, Colonel Comte de Clonard, commanding the 81st regiment of the Line. He says: "Devant l'ennemi, il suffit de payer un instant de sa personne; l'exemple des chefs entraîne, électrise: le drapeau fait le reste. Hors de là, c'est autre chose, car on ne se bat pas toujours. Dans les marches et les camps, au milieu de fatigues et d'épreuves souvent nécessaires et glorieuses, c'est par une bonne ou une mauvaise administration qu'on prépare les hommes à vaincre ou qu'on les perd. Il faut donc savoir faire durer le soldat, mais c'est à la condition d'en avoir soin, de lui donner une alimentation suffisamment réparatrice et parfois tonique et variée; il sera dès lors en état de braver impunément toutes les autres misères de la guerre." (Chenu, Campagne d'Italie.) Nothing, indeed, lays a man more open to an attack of disease than encountering it insufficiently nourished. On this principle medical men and the attendants on the sick never, as a rule, visit a contagious case on an empty stomach, if it is possible to prevent it. Now, in providing for the diet of the soldier in war, two important points have to be borne in mind:—

1st. To provide a diet that shall furnish sufficient force for the work required of him; that is, to make the food proportionate to the exercise.

2nd. To provide a diet of sufficient variety to prevent the occurrence of scurvy.

The importance of the first point has been more or less recognized at different times, and it would appear that Hippocrates (the great father of medicine) had very clear notions on this point. It was, however, possible to come to a definite conclusion on the subject only after the sciences of chemistry and natural philosophy had been brought to a high stage of advancement, and after the theory of the conservation of force had been recognized. So long as heat, light,

electricity, chemical action, vital force, &c., &c., were considered separate entities, it was hardly possible to treat the question scientifically; but now that all these are admitted to be mere forms of force, or, perhaps more correctly, to be universally and perpetually convertible into each other, equivalent for equivalent, we are enabled to approach the inquiry with more confidence, and to place our conclusions on a more strictly scientific basis. The question is still obscure, but researches are gradually throwing more and more light upon it. After Liebig had pointed out the two important divisions into which food may be separated, the nitrogenous or plastic, and the carboniferous or combustible, the idea long held almost undisputed sway that the former went to repair the tissues whose waste supplied muscular energy, and that the latter were burned off in the lungs and supplied the necessary animal heat. It was therefore supposed that a certain amount of nitrogenous matter and a certain amount of carboniferous matter being given, life could be sustained in efficiency. Further inquiry showed that these views were only partially true, for it was found that all nitrogenous substances were not equally assimilable, some, notably gelatine, although largely present in the bodies of animals, not being capable of being substituted for albumen or fibrin, and not being nutritious at all except under peculiar circumstances. It was also ascertained that the carboniferous aliments required subdivision into two classes, the fats and the carbo-hydrates (the latter including the starches and sugars), which two classes could reciprocally replace each other in certain proportions, but not entirely. A certain amount of mineral matter in the form of salts, either existing in the articles of diet or added in bulk, was also found to be absolutely essential for the preservation of health. Up to this point, the results ascertained were the following:—

1. Living animals absolutely require nitrogenous matter in their diet.
2. The nitrogenous matter may be animal or vegetable.
3. Most animals require a certain amount of fat.
4. Many animals require, in addition, a certain amount of starch or sugar.
5. All animals require a certain amount of salts.

A second series of conclusions are the following:—

1. Some animals (such as dogs and rats) can live on a purely meat diet.
2. Many animals (carnivora) can live upon meat and fat.
3. Many animals (herbivora) live upon vegetable products only (including nitrogenous matter and starch chiefly, with a small quantity of fat.)
- 4a. *Man* can live on vegetable products only, provided they contain nitrogenous matters, starch, and fat in due proportion.
- b. *Man* cannot live and maintain health upon meat alone, or upon meat and fat alone; he requires the addition of starch.

These being the main conclusions, how were they interpreted? It was considered that the carbo-hydrates—starch and sugar—were chiefly employed in giving out the animal heat; that the fat acted

partly in this way, and partly was stored up in the system against contingencies; that the nitrogenous went to repair the wasted tissue, chiefly the muscles, and that it was the wasting of these that supplied the physical force manifested by the individual. These principles are still defended by Baron von Liebig, Lyon Playfair, and other distinguished men; but, on the other hand, a large number of experiments have been made by men of great scientific acquirements, such as Pettenkofer and Voit, Fick and Wislicenus, Lawes and Gilbert, Haughton, Parkes, and others, which seem to point the other way. If the waste of the muscles were the direct or sole cause of force, then, in cases of excessive exertion, some increased elimination of nitrogenous matter would be observable; but the majority of the experiments seem to show that this is not the case, so much so, that in some cases the elimination seems to be lessened, apparently from the increased exercise causing retention of the nitrogen to provide for the increase in size of the muscles, which usually follows. On the other hand, increased exertion is attended with increased elimination of carbonic acid and vapour of water, showing a marked excess in the combustion of the carboniferous matter in the system. The inference suggested by these observations is, that the body is, in the main, like a steam-engine, and that the force evolved is due to the combustion of the fuel supplied. Therefore, it is to the carboniferous elements of food that the energy is in the main due, and not entirely, as was supposed, to the nitrogenous. The body, however, differs materially from an ordinary machine, for the latter wears away without power of reparation, all we can do being to diminish as much as possible the effects of friction. The former, however, has the power of perpetually assimilating fresh material, and continually repairing the waste as it occurs. It is obvious, however, that in the latter case *some* force must be evolved, just as there is force (in the form of heat chiefly) evolved in the friction of the wheels of a machine, and it is important, therefore, to inquire what becomes of this force, how it is employed, or how it is neutralized. It would seem probable that it is partly employed in the digestion and assimilation of the nitrogenous matters, and partly in the elimination of the waste products. Now, as the balance seems to be kept pretty strictly between the amount of nitrogen ingested and egested in a person well fed and in good health, it is probable that the amount of nitrogenous food necessary for the highest efficiency is that which shall preserve this balance most perfectly under varying circumstances. If the amount of nitrogen be diminished below the proper standard, weakening is produced, with emaciation, the result of more rapid destruction than can be repaired by the fresh material supplied. But if at the same time the amount of physical exertion is proportionately diminished, this lessening of the nitrogen is balanced to a certain extent, and can be endured within certain limits, whilst a comparatively small quantity is required for actual subsistence in a state of complete rest. If, however, exercise be continued, then, as it appears that the muscles while in action appropriate nitrogen, this nitrogen must either be supplied by the food, or be drawn from some other part of the body. In short, in the absence

of a proper supply of food, the active muscles feed upon those parts which are less actively employed, or which are less capable of resisting the depredation. In this way, the heart is apt to suffer; it is itself in constant action, and therefore requires a large supply of nitrogen, which supply is diminished if the voluntary muscles are thrown severely into play without sufficient provision being made by increased food. It is thus evident that an increase of nitrogen is necessary in direct proportion to the increase of work; but the energy necessary for the work is certainly not wholly, nor even mainly, derived from the nitrogenous matter. It is quite true that the body is able to use nitrogenous matter in this way, but generally this is on compulsion, as it were, and when no other material has been supplied; but the loss of force under these circumstances is so great that the system soon becomes exhausted. It is, therefore, necessary to supply material which is easily oxidised, and capable of rapidly yielding up its potential energy under the influence of the changes wrought upon it in the lungs and circulation. This material is supplied in the fat and carbo-hydrates of which I have already spoken. Weight for weight, the fat has about $2\frac{1}{2}$ times the potential energy of the carbo-hydrates, but it is doubtful if it could be used alone in their stead. In the Arctic regions it appears to be capable of being used in this way to a very great extent; but in temperate and tropical climates it does not appear capable of entirely replacing starch. A practical proof of this was given me by an Officer who served in the Cape, and who told me that on one occasion he formed one of a party of men who for three weeks had nothing but mutton (with, of course, the usual amount of fat) and water. They managed to march on this diet, but their strength gradually gave way, and at the end of the time they were barely able to stand. On the other hand, it is doubtful whether a diet composed of fat-free meat, starch, and water, could support life in a state of efficient health. I am not aware of any satisfactory experiments on this point. One difficulty attending such experiments would be that there are few natural starches which are not mixed with other constituents. All the cereals, for instance, contain both nitrogenous and fatty matters. Potatoes and rice probably contain least fat of the natural starchy matters generally obtainable. It would seem, then, on the whole, that we cannot completely replace either starch or fat, and that a considerable quantity of these substances is necessary for health. Further, as the greatest part of the energy necessary for work is due to them, they must be materially increased whenever more work is demanded.

There still remains another class of substances which are essential to health, this is the *salts*, including the sodium chloride chiefly, the potassium chloride, calcium and magnesium phosphates, &c. All these, except the first, are taken entirely in the food, which requires to be sufficiently rich in them to be thoroughly nutritious. The sodium chloride is also present largely in the food, but the requirements of the body necessitate in addition a considerable quantity to be taken in bulk,—and it may be a question whether some of the others might not

also be taken in the same way with advantage. The use of the salts, apart from those such as the calcium and magnesium phosphates which enter into the composition of the tissues, is rather obscure; but one use can be pretty clearly shown, viz., that they materially assist in the oxidation of matters, whether effete or otherwise, and therefore play an important part in the animal economy. Wherever, then, increased energy is demanded, calling for, of course, increased oxidation, a considerable increase of salts must accompany the additional food. Part of this will of course be supplied in the food itself, whilst part must be added in bulk, chiefly the sodium chloride, but perhaps also some of the others, as the potassium chloride, &c.

The point now to be considered is: How much food ought to be supplied? To answer this we must refer to some of the recent experiments which have been made to calculate out the potential energy obtainable from different kinds of food. This is generally stated as so many foot-tons, that is, as equal to so many tons raised through one foot. There are various ways of expressing it, but we may adopt this one as being very generally used and easily understood. It being possible, then, to calculate how much energy is obtainable from each substance, what we require to know, in order to apportion diet to exercise, is the amount of force required. Now, we can calculate pretty correctly the amount of work done by an individual, and we can also (from Professor Haughton's ingenious researches) ascertain the force expended by the involuntary work of the body, such as the heart's action, &c.,—but there still remains a quantity more difficult to estimate, viz., that required for the evolution of the animal heat and other processes in the system. We can, however, arrive at this experimentally by finding the amount of food which will keep a man alive at rest, considering this as the minimum, and also the amount which will keep him in health at average work. To this latter we can then add proportionately for excessive work. The subsistence diet for a man at rest, calculated from Frankland's figures (Parkes's Hygiene, p. 170), is the following:—

Nitrogen.....	138 grains	} Equal in potential energy to about 2,330 foot-tons.
Carbon	3,030 „	
Salts	219 „	

Now, as the work of the heart, &c., has been calculated at about 260 foot-tons, there would remain 2,070 as absolutely required for the animal heat and other processes at the lowest calculation. But this must be materially increased with every increase of exertion, for the heart works more rapidly, the circulation moves quicker, the chemical changes go on at a greater rate, and more animal heat is wasted. Accordingly we find that the standard average diet for a man at work is as follows:—

Nitrogen.....	316·5 grains	} Equal to about 3,833 foot-tons of poten- tial energy.
Carbon	4862·0 „	
Salts	461·0 „	

If now we consider that a man on this diet is doing a good day's work,

equal to 300 foot-tons, and add to this 260 for the internal mechanical work, we have remaining for the animal heat, &c., 3,273, or an increase over the subsistence-diet of 1,200. It would therefore seem as if for every foot-ton of external work, we ought to add in addition about four more for the internal processes, or we must supply five times the potential energy as food that we expect to obtain as labour. Even this calculation, however, is short of the mark, for we find that the amount increases at a greater rate as the work advances. For a man doing laborious work, that is, equal to about 450 tons per diem, the following is the mean calculated diet:—

Nitrogen.....	450 grains	} Equal in potential energy to about 4,784 foot-tons.
Carbon	6,242 „	
Salts	580 „	

Or an increase of 1,049 potential tons to provide for the additional 150 tons of productive labour; here the increase is seven times instead of five,—so that the addition required as work increases is almost in a geometrical instead of an arithmetical ratio. Let us now examine the diets issued to soldiers, and compare them with the above standards. The ordinary diet of the English soldier at home is the following (as calculated by Dr. Parkes):—

Nitrogen.....	266 grains	} Equal in potential energy to about 3,640 foot-tons.
Carbon	4,718 „	
Salts	354 „	

In this diet the carbon is about sufficient, but the nitrogen is much too small, and the salts are also deficient in quantity. It is right to mention that Dr. Playfair has calculated out the diet as rather more nutritious, bringing up the energy to 3,848·5 tons. I cannot help thinking, however, that there has been some difference in the mode of estimate, and that Dr. Playfair has calculated the ration of meat as *without* bone, whereas it is really reckoned including bone. Adopting, then, Dr. Parkes's calculation, we find that the above diet is much below the average of a working-man's standard, and that it is a diet in short on which we could not demand more than a very moderate day's work, say 150 to 200 tons. It is true that in time of peace the soldier's duties are not so arduous as those of the majority of labourers, but still the above diet is insufficient to keep him as he ought to be kept, in the highest state of health. Were the meat ration to be increased, as was at one time proposed, from 12 to 16 oz., including bone, the diet would then stand thus—

Nitrogen.....	303 grains	} Equal in potential energy to about 3,838 foot-tons.
Carbon	4,948 „	
Salts	379 „	

The salts would still be rather low, but the diet on the whole would be a fair one, sufficient for average work of from 250 to 300 tons—not by any means an excessive estimate, seeing that a march of ten miles in heavy marching order is alone equal to 250 tons. When, however, troops come into the field much more is demanded of them, and the

diet ought to be arranged accordingly. We have to bear in mind that not only is there more actual work, more waste of tissue, bodily and mental, but that also the food is in many cases not so good in quality, and, therefore, incapable of yielding the same amount of potential energy. A war-diet ought to provide for a minimum work of 350 to 400 tons, and be capable of being increased at the shortest notice to 500 tons or more, as circumstances call for it. Such a state of things would be met by a diet of the following proportions:—

Nitrogen.....	350 grains	} Equal in potential energy to about 4,280 foot-tons.
Carbon	5,500 „	
Salts	450 „	

To be increased as circumstances demanded to—

Nitrogen.....	450 grains	} Equal in potential energy to about 5,000 foot-tons.
Carbon	6,500 „	
Salts	500 „	

Now, in scarcely any instance has a war-ration reached this amount. In the Crimea, in our own Army the ration *nominally* came to about 272 to 290 grs. of nitrogen, about 4,400 to 5,000 of carbon, and about 280 to 320 of salts; but it was only late in the campaign that this ration was really issued. It will be but too well remembered by those who passed through the first year of that memorable war, how miserably deficient the ration really was. Our own errors and misfortunes at that time have, however, been fully criticised and exposed, and I should fear to weary you unnecessarily by going over the same ground again. But it is only comparatively recently that a full account of the experiences of our allies has been published in the two great works of Dr. Chenu, viz., the Reports on the Crimean and Italian Wars, the latter work containing in an appendix many documents referring to the former campaign. From this we find that the ration in February, 1856, consisted of the following:—

Bread..	..	750 grammes	= 26·50 ounces	} Total 41·04 ounces.
Meat..	..	300 „	= 10·60 „	
Rice ..	..	60 „	= 2·12 „	
Sugar	..	20 „	= .70 „	
Coffee	..	16 „	= .56 „	
Salt ..	..	16 „	= .56 „	

Fresh meat was distributed four times in ten days, salt meat (250 grammes = 8·8 ounces) on three days, and preserved meat on three days. If biscuit was issued, 550 grammes (= 19·4 ounces) were given. An *occasional* extra ration was issued, according to circumstances, of—

Biscuit	..	100 grammes	= 3·6 ounces.	
Wine	..	$\frac{1}{4}$ litre	= 8·8 „	three times a week.
Brandy	..	$\frac{1}{16}$ „	= 2·2 „	four times a week.

This was equivalent to the following:—

Nitrogen..	..	263 grains	} Equal in potential energy to about 3,318 foot- tons.
Carbon ..	..	4327 „	
Salts ..	..	472 „	

The additional ration when issued would add about 78 grains of nitrogen, 660 of carbon, and 26.6 of salts, and of potential energy about 400 tons. It is obvious from what has gone before that such a diet was totally inadequate to support men on active service. It is true that additional rations might be issued “à titre de remboursement,” but the pay of the French soldier is very small, and he could hardly have added much to his diet in that way. Besides this, I am afraid that even this insufficient diet existed chiefly on paper, for from the information I could myself gather in conversing with French Officers, it would seem that fresh meat was not as a rule distributed anything like so often as four times in ten days. The insufficiency of this diet was fully recognized and protested against by the Medical Officers, whose remonstrances were, unfortunately, too often disregarded.

In the rations of the Prussian, Austrian, and Russian Armies, the same error seems to prevail as in the French and English, viz., a deficiency of nitrogen and a too great preponderance of starchy matters, a diet, in short, insufficient to preserve men in health during active work.

I have gone in some detail into the *quantity* of food, let me now say a few words as to the *quality* and *kind* of food required. If it be necessary to supply a sufficient amount of food to yield energy adequate for the work required, it is not less essential that the food should be properly proportioned and sufficiently varied. An apparently sufficient amount of energy would be obtained by *calculation* from a diet consisting of pure starch and pure albumen, but such a diet would be practically useless, for it could not long sustain life. There are four essential divisions into which the food requires to be separated, viz., albuminates or nitrogenous substances, fats, starchy or saccharine substances, and salts, and these ought to be in something of the following ratio:—

Albuminates ..	..	..	..	10
Fats ..	..	..	..	6
Starches (or carbō-hydrates) ..	..	..	..	30
Salts ..	..	..	..	2

These are taken in their proportions when thoroughly dried, all the water being completely driven off. Now in the soldier's diet generally there are the following fundamental errors:—

The albuminates are *deficient*.

The fats are *very deficient*.

The starches are *somewhat in excess*.

The salts are *rather deficient*.

Another important error (now somewhat rectified) is the great same-

ness of the diet. Monotony of diet soon causes the food to pall, the appetite is diminished, and the health suffers. The great enemy that armies have to contend with is scurvy; but for the scorbutic taint it would be comparatively easy to deal with the other causes of disease. Even cholera would lose half its terrors in presence of a thoroughly well-fed body of men. We are still very much in the dark as to what the nature of scurvy is, but we know a good deal empirically of the ways in which it is induced; the following have been ascertained:—

<i>Scurvy may be induced</i>	<i>May be cured by the use of</i>
By deficiency of fresh vegetables.	Fresh vegetables, lime-juice, vine-
By deficiency of nitrogenous food.	gar, salts of vegetable acids,
Probably also by deficiency of fat.	increased nitrogenous food,
By mere sameness of diet.	variety of diet.

The effects of want of vegetables, and the beneficial results from the use of lime-juice, are well known. With regard to the effects of deficient nitrogenous food, various cases are on record, one of the most striking being that of the Perth Penitentiary, as recorded by Professor Christison. Scurvy there came on in consequence of a ration of molasses being substituted for milk from motives of economy. On the milk being restored, the scurvy rapidly disappeared. It is true that here there were salts also concerned, for milk contains them in large quantities. Still I think it may safely be said that scurvy is likely to follow any material or prolonged disturbance of the equilibrium, which ought to be maintained between the different articles composing a diet, and that even with this equilibrium kept up, mere sameness of diet will after a time induce it. Once it is set up in a body of men, the most disastrous consequences follow—dysentery, diarrhoea, typhus, rheumatism, ulcers, &c., are sure to break out, and it besides leaves the system totally unfitted to resist any epidemic poison that may present itself upon the scene, so that cholera and typhoid fever find easy victims. To see the truth of these remarks we have only to look at the history of many campaigns. Scurvy seems to be everywhere, accompanied or closely followed by dysentery and typhus. We shall not be surprised when we bear in mind that the two main causes of these diseases are bad and insufficient diet and crowding, two causes which have almost always been but too generally present in wars. If there is more or less starvation without crowding, fever will always follow, but it is a fever of the relapsing type, and of itself rarely fatal; it, however, weakens the system extremely, and lays it open to attacks of other diseases. But if to starvation we add crowding, then typhus is inevitable.

Now, it is almost impossible, from the nature of things, to avoid crowding in war, as an army must necessarily occupy a smaller proportionate space than the most crowded city. In the Report of the Royal Commission of 1857, some calculations are given on this point. In East London, the most densely populated part of the kingdom, the number of persons per square mile is 175,816. To provide even the amount of space which this represents, we should have to give

300 square yards to each tent; but the area allowed is only 145 square yards, representing about 320,000 men per square mile. In some cases only 50 square yards have been given, representing 930,000 men per square mile, and it has not unfrequently happened that the tents have been pitched as close as they could stand, giving some 22 or 23 square yards for each, or representing about 2,000,000 persons per square mile, supposing that each accommodated only 15 men. Such a condition of matters is bad enough, but if to this we add food, both insufficient in quantity and bad in quality, what can we look for but all the long train of fatal diseases, which have too often decimated, and sometimes annihilated armies? Perhaps the most notable recent illustration occurred in the French Army, during the winter and spring following the taking of Sebastopol. As may be remembered, the French arrangements were somewhat better than ours at first, and they did not suffer during the first winter to so great an extent as we did, but during the second winter the conditions were reversed. Wise by experience, no efforts were spared by our administration to provide proper food and shelter for the troops, and the errors of the first winter,—less the faults of individuals than the inevitable results of an obsolete system, which a long peace had given no opportunity of correcting,—were most nobly repaired. The result was one of the most healthy armies ever known. The sick list was reduced in many cases below 1 *per cent.*, whilst whole battalions were often without a single man unfit for duty. On the other hand, the rations of the French soldier, far from improving, appeared rather to deteriorate, whilst crowding increased with the inclemency of the weather, and personal cleanliness was naturally much neglected. The Medical Officers foresaw what would be the result, and strongly urged immediate measures to be taken. As early as April, 1855, Dr. Levy warned the French authorities of the threatening dangers of typhus and dysentery in an epidemic form. In November, 1855, Dr. Baudens, Inspector-General, addressed a letter to the Minister of War, pointing out the insufficiency of the soldiers' diet, the want of fresh vegetables, &c., all tending to produce scurvy, and strongly enjoining the immediate issue of preserved vegetables, condiments, &c. He also called attention to the wretched tent accommodation, and the miserable clothing that the men had to put up with. That these prognostications were but too true is seen by the subsequent letters and reports:—

On the 8th of February, 1856, he writes, "Typhus threatens to assume the proportions of a great epidemic." On the 11th, the number of cases is still increasing, but with the significant fact that as yet no officer (generally well fed and sheltered) had been attacked. By the 28th, fresh cases, at the rate of 150 to 200 per day, were declaring themselves, and several Medical Officers had already perished. The rapid increase may be conceived by the following abstract of the total cases and deaths, both in the Crimea and at Constantinople:—

		Cases.	Deaths.
November, 1855	.. ..	16	8
December "	.. ..	775	332
	2 c		

		Cases.	Deaths.
January, 1856	.. ..	3,185	1,129
February ,,	.. ..	7,834	4,339

And a most instructive table is added, comparing the French and English forces during February, 1856:—

FRENCH ARMY (strength 132,000 men).

	Admitted.	Per cent. of strength.	Died.	Per cent. of strength.
Wounded and general patients ..	11,732	8·8	1,190	0·9
Typhus cases	7,834	5·8	4,339	3·3
Scorbutic, &c.	6,772	5·1	349	·26
Total	26,338	19·7	5,878	4·46

ENGLISH ARMY (strength 70,000 men).

	Admitted.	Per cent. of strength.	Died.	Per cent. of strength.
Wounded and general patients ..	3,984	5·7	43	·08
Typhus	0	0	0	0
Scorbutic, &c.	34	·05	0	0
Total	4,018	5·75	43	·08

The death-rate in this ratio would amount in the French Army in one year to 58 per cent.; or more than half the force, and this without much severe work, for the fighting was practically over, and the wounded trifling in number. On the other hand the English death-rate would have only been about 1 per cent. per annum, or little over that of the most healthy classes of the civil population. Altogether in the first four months of 1856, the French Army lost from typhus alone about 4,000 in the Crimea, and as many more at Constantinople, including about 40 or 50 medical officers. As regards the losses at Constantinople, these were hurried on and intensified by the crowding of the hospitals, consequent on the increased arrivals of sick from the Crimea. On the 1st of January, 1856, with 869 sick in the Daoud Pasha Hospital, Dr. Garreau reports the sanitary condition to be fairly good. On the 28th of the same month, there were 1,140 sick; from that day dates the rapid increase of typhus, for want of room had rendered it necessary to bring the beds closer together, and so crowd the wards. In short the state of things induced, was exactly parallel to that which prevailed in our own hospitals at Scutari, just one year before.

That we were enabled to show so marked a contrast in the second year was due to two main causes: 1st. To the free circulation at home of the actual truth, and the consequent rousing of public opinion to insist upon adequate measures of relief being adopted; and 2nd. To the fact that the Medical Department of our Army was an independent body, communicating directly, through its own head, with the Commander-in-Chief. In the French service, on the other hand, where the pernicious system of Intendance prevails, all representations and suggestions have to be filtered through the Intendant-General and his subordinates, the independence of the Medical Officer is destroyed, and his spirit crushed. It is true that a right of appeal exists from the Intendant to the General Commanding, but considering that all proposals of promotion or advancement in the Department are made by the Military Intendant, I leave it to the judgment of my hearers to infer how many appeals are likely to be made? It is greatly to be hoped that this evil system will, ere long, be abandoned in France, and the Medical Department placed on a similar footing to that of Prussia.

In criticising the diet usually issued to troops in war, I have not referred much to the individual details. I now wish to say a few words on that point. As Dr. Serive says in one of his reports—"War rations form a coarse diet, which ere long fatigues the stomachs of 'the most robust.'" Even if they were given in sufficient abundance, their sameness and monotony are highly objectionable.

1. *Nitrogen.* A ration of a pound of meat, including bone, would probably be sufficient—provided that fresh and preserved meat were issued as often as possible, and salted meat as rarely as possible. Beef and mutton should be made to alternate as much as can be managed. As one pound of meat, however, would not yield enough of nitrogen alone, a small ration of cheese might be advantageously added, as well as a certain quantity of peas or beans—to be increased as extra work demanded.

2. *Fat.* This has always been deficient, and yet it is one of the most important articles for hard-working men. Indeed a mere increase of fat alone would often be sufficient in cases of extra work. Under any circumstances, a ration of bacon-fat or butter should be issued. It would be a good thing if the use of oil could be introduced into our Army; it is extremely wholesome and palatable, and I believe any prejudice against it would soon be got rid of.

3. *Starch, or Carbo-Hydrates.* This ingredient has always been rather in excess in the diet—at least in comparison to other articles; it would be better to diminish it a little, if fat were substituted instead, the potential energy of the latter being as 2·4 to 1 of the former. The best form is fresh bread, which ought always to be used instead of biscuit, when it can possibly be obtained. Potatoes and rice are also exceedingly good forms.

4. *Salts.* These have generally been rather deficient. In addition to the common salt used in bulk, it might be well to add potassium chloride, &c., in small quantities, should there be any difficulty about a supply of fresh vegetables—but it is by these that we ought to

endeavour to introduce them. No effort should be wanting to procure regular supplies of vegetables, either fresh or preserved, as the best safeguard against scurvy. Another article of great value, but much neglected in our Army, is *vinegar*, which should always be freely used in a campaign. It would be an excellent plan to get the soldiers to make salads with oil and vinegar, as a means of introducing both fat and salts into the system. For a salad it is not necessary to have carefully-culled lettuce, or blanched endive, or other garden refinements,—a very excellent salad can be made of many ordinary wild plants; dandelions, for instance, or any vegetables boiled and used cold, such as cabbage, brocoli, carrots, lentils, peas, beans, potatoes,—in short, almost anything that can be digested by the human stomach.

5. *Condiments*. These are of great importance. Mustard and pepper should always be issued, and, if possible, other spices as well. The judicious use of condiments makes all the difference between a grateful and appetising dish and an insipid and repulsive mess.

6. *Beverages*. Unquestionably the best beverages to work on, are *tea*, *coffee*, or *cocoa*, and these should be supplied without stint, and with plenty of sugar to sweeten them. Of course milk cannot be always looked for in a campaign, but when procurable ought to be issued, either fresh or preserved. As to the vexed question of alcohol, I am of opinion that the *spirit* ration is a mistake; but I think that a moderate ration of good *beer* or *red wine* would be beneficial. *Spirits* should never be issued, except on very special occasions, and then only on the recommendation or with the approval of the Medical Officer.

Tobacco is a substance that should also be supplied in moderation, as I believe most men are the better for a little of it, although, like alcohol, many can do without it altogether. In cases of extreme fatigue, I think great benefit would be derived from a liberal use of Liebig's Extractum Carnis. I know of nothing which so rapidly recruits the exhausted frame. It can be prepared in no longer time than is necessary to get water heated, or it may be taken, less advantageously it is true, cold. But I can conceive no more useful thing than a cup of the *tea* made from it, issued to men going on trench or picket duty on a cold wet night, or starting on a toilsome march. I believe it would do more than anything else towards keeping up their strength and spirits. Similarly, on coming off heavy duty, cold and weary, often too fatigued to sleep, a cup of it would be exactly what would be wanted to restore the balance of the disturbed and exhausted frame.

To sum up, then, I would propose as a war-ration some such diet as the following, to be varied as much and as frequently as the ingenuity or opportunity of the commissariat can devise, or as the skill of the cook can accomplish:—

PROPOSED RATION IN TIME OF WAR.

	Gross weight.	Water.	Albumi- nates.	Fat.	Carbo- hydrates.	Salts.	
	oz.	oz.	oz.	oz.	oz.	oz.	
Meat, 1 lb., less bone, say.... }	12·8	9·6	1·9	1·1	...	0·2	
Bread	20·0	8·0	1·6	0·3	5·9	0·3	
Potatoes	16·0	11·8	0·2	...	3·7	0·2	
Vegetables	4·0	3·4	...	...	0·3	0·03	
(as carrots)							
Peas or Beans....	3·0	0·4	0·7	0·1	1·6	0·1	
Cheese.....	2·0	0·7	0·7	0·5	...	0·1	
Bacon-fat, oil, or butter	2·0	0·1	...	1·8	...	....	
Sugar.....	2·0	0·1	...	...	1·9	....	
Salt	0·5	....	...	...	...	0·5	
Vinegar.....	2·0	1·9	...	...	...	0·1	
Condiments	as required	....	...	...	...	....	
Tea	0·5	....	...	...	...	....	
or							
Coffee	2·0	....	...	...	...	....	
or							
Cocoa.....	2·0	?	0·3	1·0	0·5	....	
Beer.....	20·0	17·8	...	...	1·2	0·1	{and 1 oz. of alcohol
or							
Wine (red).....	10·0	8·9	...	...	...	0·1	Ditto.
Totals	86·3	53·8	5·7	4·8	15·2	1·8	1
	to	to	to	to	to		
	74·8	44·9	5·4	3·8	14·0		

This would give of nitrogen, carbon, and salts, about :

Nitrogen....	375 to 390 grains	} equal in potential energy to from about 4,800 to 5,300 foot-tons.
Carbon*	5,300 to 5,930 "	
Salts	780	

Such a diet would, if properly varied, be amply sufficient for the ordinary fatigues of war, and might be easily supplemented in cases of extreme exertion. Could such a diet have been regularly supplied during the Crimean campaign, the horrors of the first winter would have been in a great measure spared us, and the ultimate gain, even at a great apparent immediate outlay, would have been enormous in a mere monetary point of view. Of course we should still have had our losses by the enemy's fire, but these are always trifling in comparison with the ravages of disease; besides which, in a truly hygienic force, but few of the wounded ought to die. Disease is the real enemy to dread, and the best weapon to fight him with, is good, abundant, and varied food; this given, our soldiers will easily contend with aught

• Not including the alcohol.

else. It may serve to illustrate what I have said if I state shortly the comparative losses by disease and actual wounds in action at different times.

Crimea. English Army.

Killed and died of wounds.....	4,602
Died of disease	17,580
Total	22,182

The admissions into hospital from wounds, amounted to only 11 per cent., and from disease to 89 per cent.

In February, 1855, at Scutari, the deaths to admissions were at the rate of 467 per 1,000.

In the *first seven months* of the war the mortality was at the rate of 600 per 1,000 per annum.

In the *last five months*, under a hygienic régime, the deaths were at the rate of 11 per 1,000 per annum.

Peninsula.

During the last three years ending in 1814, the sick and wounded amounted to 22·5 per cent. of the strength, thus distributed:—

Wounded	1·5
Sick	21·0
Total	22·5

In the French Army in the Crimea:—

During the *first winter* (November, 1855, to April, 1855), a period of hostilities giving 8,000 wounded, there were 90,000 sick and 11,000 deaths.

During the *second winter* (November, 1855, to April, 1856), a period of hardly any hostilities, giving only 323 wounded, there were 107,000 sick, and 21,000 deaths, of which 10,000 were from typhus.

In contrast to these, we have the examples of two campaigns, short certainly, but in hot countries, and at an immense distance from our resources, which show very different results, viz., those in China and in Abyssinia. In China, during the period of active hostilities, the following were the ratios of deaths:—

Total deaths per 1,000	65·54
Of these were killed and died of wounds ..	12·66

The greater part of the mortality was due to cholera, diarrhœa, and dysentery; but scurvy and typhus were absent.

Again, in Abyssinia, a country quite within the tropics, the results of the campaign were the following:—

Total deaths per 1,000.....	13·0
No deaths from action.	—
Total sick admitted into hospital per 1,000 ..	49·8

The health of the troops would have been much better but for the break down of the transport, and the consequent reduction of the rations to mere bread and beef, instead of the excellent and varied diet originally intended.

The happy results—although still falling short of what we should aim at—following the employment of true hygienic measures in these two short campaigns, as well as the wonderfully healthy condition of our Army in the latter part of the Crimean campaign, are highly encouraging, and prove on what sound principles the rules of hygiene are based. Let us only hope that these lessons may not be lost, and that should unhappily the necessity arise for putting to the test again the experience we have so dearly bought, we may not be found trying “how not to do it.”