areolar tissue in which are large lymph spaces. An organ of this structure lends itself to great variations in size according to the amount of fluid in the lymph spaces between the bundles of muscle fibres. This is exemplified in acute inflammation or oedema of the tongue—say, after a sting from a wasp in a person susceptible to the poison of that insect. Once the structural nature of the substance of the tongue is comprehended, it is easy to understand what follows.

A tongue which is indented by the teeth is obviously one that is too large for the mouth, and if enlargement be only temporary it will be one in which the lymph spaces in the intermuscular areolar tissues are filled and even distended with fluid containing the waste products of the surrounding tissues, if not of others derived from various organs and tissues of the body. This state of the tongue is, to my mind, an indication, not of any peculiar local condition in this organ, but of a similar condition throughout the body wherever the tissues, from their physical structure, will allow of the accumulation of fluid—lymph of normal composition or one charged with deleterious substances. Accordingly the indented oedematous tongue tells first of all that there is an excess of fluid in the tissues of the body, and my own clinical experience shows that this excess of fluid is most commonly associated with undue delay in the transit of refuse along, and retention of faeces in, the large intestine—coprostasis. Delay in the expulsion of formed and moulded faeces, even if it extends to a period of many days, is not in many persons attended with any ill effects, and this is doubtless within the experience of all of you. This fluid in excess is, we may be quite sure, not mere normal lymph, but lymph charged with subtle chemical substances which probably vary a great deal in their composition. When this accumulation of faeces—coprostasis—comes to exist, the first sign of that physiological uncleanness I have spoken of shows itself. I am convinced that this condition of excessive fluid in the lymph spaces of the body is a most potent, but not of course the only, factor in making disease possible in any given individual, and the most powerful in controlling the results of one and all surgical operations. Therefore the conditions which may and do arise in consequence of irregularities of many kinds in the transit of the common refuse of the body, chiefly along the first portion of the large intestine, are very numerous and of great importance to the physician and surgeon.

CONCLUSIONS.

The interest taken in the colon and its functions during the last few years has been very great. In 1901 Dr. Barclay-Smith put forward a suggestion that in consequence of the advance in the preparation of food, rendering it digestible, nothing now remains for the colon to do, and that it may be regarded as a useless appendage to our bodies. Sir Arbuthnot Lane goes further, and characterizes it as a cesspool, presumably either to be cleansed at periodic and stated intervals, as our sanitary cesspools are to-day in some old-fashioned places, or to be altogether done away with, as in the modern method of sanitation. Metchnikoff regards it as having developed in order to act as a reservoir, so that primitive man might run after his prey or away from his pursuing enemies without undergoing the risk of stopping or slowing his rate of progress to evacuate his intestine. Professor Keith, without expressing any decided opinion for or against the above hypothesis, wonders whether we cannot restore to the colon its former function. He appears to suggest that ingenuity might yet be exercised with advantage in the direction of finding an agreeable dietary which will give back its old work to this large tract of the alimentary canal, and that unless something useful be done the colon will certainly come to be regarded under our present civilization as an incumbrance to man in the performance of his daily work.

In conclusion I would say the work of the colon, apart from its use as a storage and expellor of the common refuse, is, so far as I have been able to discover, (1) to dry the contents as they leave the small intestine, and (2) to get some useful substance out of the refuse while it is mixed and churned and undergoing fermentation with, it may be, disintegration. This substance, though as yet of unknown quality, gives to the body that which it

requires for the development of that feeling which is best described as being "in the best of health and spirits"; further, it is something of all-important value to the individual. Excess of it is deleterious; lack of it is attended with pronounced changes in general nutrition, and perhaps progressive inanition, leading after a variable time to death from simple loss of vigour and strength.

ON HEALTH, FATIGUE, AND REPOSE.

BEING EXTRACTS FROM THE LADY PRIESTLEY MEMORIAL
LECTURE DELIVERED BEFORE THE NATIONAL
HEALTH SOCIETY.

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LORD BEACONSFIELD in one of his many luminous utterances declared that the great social question which should engage the attention of statesmen is the health of the people. The health of the people is the wealth of the nation, and Huxley, in one of his letters to John Morley, wrote that "The great thing to work for, as time goes on, is vigour as one lives," that is to say, "health," which is just another way of saying "fitness" for the duties that lie before us. With Sir Philip Sidney we may say: "The ingredients of health and long life are great temperance, open air, easy labour, little care."

In health the machinery does not chafe in the working—all goes on silently, smoothly, and without noise, while there is complete adaptation to the environment. The one part of the body cannot say to the other, I have no need of thee. Organs, however insignificant they may seem, may prove to be of paramount importance in the economy, as has been proved by the recent discoveries regarding the functions of such little-known and apparently unimportant organs as the pituitary body, the pineal, thyroid, and thymus glands, not to mention others whose functions and history we are just beginning to discover.

Most of the breakdowns in a man's life, however, are due to the driver himself, either because of ignorance or recklessness, or both. "We do those things we ought not to do, and we leave undone the things which we ought to have done," and then we wonder "that there is no health in us."

Our forefathers used the word "health," wholth or whole-ness, to indicate soundness not only of their bodies, but also of their implements and utensils used for hunting, for cooking, and for weapons of war and the chase. The highest perfection is a "sound mind in a sound body." "Life without health is a burden, with health it is joy and gladness."

Fatigue is the result of over-action, and above all sustained and continuous action of an organism as a whole, or of one or more of its organs. Not only is the over-worked organ itself affected, but owing to the chemical or metabolic changes underlying all sustained strenuous endeavour and action—without sufficient periods of rest or repose—other organs and parts of the body are speedily implicated. In fact, as pointed out by F. S. Lee, fatigue is a universal biologic phenomenon, while the activity of living substance tends to inhibit or restrain its further activity.

MUSCULAR FATIGUE.

In muscular fatigue the chemical reserves upon which our movements depend are gradually used up; the greater the effort the greater the metabolism and consequent expenditure. In addition, however, poisonous by-products, more especially carbonic acid and lactic acid and acid potassium phosphate, are formed. These products are not removed with sufficient rapidity, and remain to clog the machine, and indeed act as toxins. These fatigue products not only poison the organ in which they are formed, but they pass into the blood and are conveyed by it to other parts of the body, and poison them also, before they are destroyed or excreted.

The study of fatigue, therefore, is largely a study of chemical metabolism. When the muscles are in action normally their activity depends in part on the supply of

substances allied to the sugars. In overworked muscles protein bodies are also broken up. The result is the over-formation and imperfect removal of the "fatigue products" or body toxins which have a powerful depressant action. Overwork without sufficient repair of an organ, be it brain or eye, the digestive organs or muscles, is the primary cause of fatigue. The symptoms and signs, therefore, will be as varied as the organs themselves.

All the organs of the body cannot run at full speed at the same time. Severe bodily exercise is incompatible with full digestive activity. "After dinner rest awhile" is part of the proverbial wisdom of Salerno. Mental fatigue greatly impairs bodily activity, and physical or muscular fatigue has a distinct effect on brain activity. Every organ in activity requires a larger supply of blood—its blood vessels dilate—and there is not enough blood to give all organs an extra supply at the same time. It was never so intended in the scheme of Nature, though some people seem to act as if it were so, and they reap the disastrous consequences. Not only the amount of blood but the quality of the blood is of importance.

Muscles tire very quickly when they are under tension. With what a sense of relief does the trained soldier on occasion welcome the command "Stand at ease"! It is easier to walk and keep moving than to stand still in one position. The continuous strain of standing is only too well known to teachers, to shop girls and shop men. Something has been done recently to ameliorate the condition of shop life by the provision of seats for resting when occasion affords.

There is a limit to a man's working power, both physical and mental, varying with the individual. Weber long ago showed that in order to obtain the greatest amount of mechanical work from a muscle, the weight the muscle had to lift must not be too great. So it is with the working hours of the working man. Long hours do not necessarily mean more work or better work.

Overwork or any unwonted physical exertion gives rise to a sense of weariness or tiredness which indicates a lessened capacity for exertion both of body and mind. Fatigue, therefore, has a double aspect—first, a sensation of tiredness more or less definite in character, and, secondly, a decrease in the power of exertion, so that one cannot go on with the effort or can do so only after powerful excitement or stimulation. A diminution or slowing down of the muscular power represents the physical or objective side, and the sensations of fatigue the psychical or sensory side.

GYMNAST'S FEVER AND THE IMPORTANCE OF OXYGEN.

After a long day's walk, more especially to one unused to it, not only are the legs tired, but one feels "sore all over," in the arms and trunk alike, though these parts have participated relatively little in the actual expenditure of energy. The enormous strain of what is called "forced marching" is well known amongst soldiers. Ergographic tracings prove convincingly how severe is the strain and drain on the soldier's physical resources and also the prolonged effect in his output of mechanical work. The too ardent untrained Alpine climber, the enthusiastic unseasoned gymnast, may at night have marked symptoms of fever, due to the action of the poisonous toxins produced in his own body, and it is some time before their effects pass off. The best remedy is sleep. So marked are the effects of the toxins that this post-athletic febrile attack has been called "gymnast's fever."

It would not serve any good purpose to discuss here the means by which physiologists have analysed the seat of fatigue in a nerve-muscle preparation or the relation between what is called the "refractory period" and fatigue. The gist of study of the refractory period of the heart and other organs is thus expressed by Verworn: "In all living substances, directly following an excitation, there must exist a period in which its irritability is reduced." The important observations of Dr. Leonard Hill on the effects of a liberal supply of oxygen in fatigue are most important, while Verworn goes so far as to say, "Fatigue is invariably asphyxiation."

FATIGUE OF ORGANS OF SENSE.

Medical men are constantly warning the public, and pointing out to teachers of youth, the disastrous effects of eye-strain. Tea-tasters know well how rapidly the sense

of taste—the palate, so-called—becomes fatigued. We all know how soon our sense of smell is paralysed. It is partly for this reason that persons breathing an almost putrid atmosphere fail to detect what is painfully unpleasant to any one entering such a room from the fresh air outside. For the same reason one has to sniff a rose in order to smell its perfume.

The sense of hearing under certain conditions is no exception. The dull dreary drip of a long and uninteresting lecture, or a monotonous discourse delivered in, it may be, an atmosphere not too hygienic, soon has its effect on the audience. The hearing centre of the brain through the ear is soon lulled to inactivity, a condition which speedily affects neighbouring regions of the brain. The combined result is somnolence, and it may be sleep. Then a sudden loss of control and relaxation of the muscles of the back of the neck, and the senseless head nods. When chin meets chest the sleeper awakes in a state of semi-somnolent surprise. In this case there is weariness and lassitude rather than fatigue in the true sense of the word. To what extent the loss of tone of one's muscles and the occasional somnolence in certain churches—and, it may be, in chapels—is due to the poisonous nature of the atmosphere I am not prepared to say. Perhaps there are other factors. Somnolence is not in all cases to be attributed to the sermon, but rather to the badly ventilated atmosphere. Although Sunday is officially the first day of the week, to most churchgoers it is the close of the week, a factor not without significance in the explanation of the phenomenon.

PLEASURES AND EMOTIONS.

It is the same with over-driven pleasures, and also with intense emotions, as may be seen in the beautiful picture of St. Catherine by Sodoma in the church of San Domenico in Siena. We say pleasures pall. It is that their evanescent character necessitates frequent repetition, and hence they soon pall.

ATTENTION AND MEMORY.

Darwin considered attention one of the most important of the human faculties for the development of the human understanding. With it must be associated memory, which depends on the disposition of our nerve cells to retain impressions made on them, and to reproduce them when required. Over-exertion of the brain necessitates prolonged rest; sleep, and something more, is required to restore mental activity. Observant teachers in our large public schools know full well that if there be excessive mental work, the effects cannot be immediately compensated by prolonged sleep—the remedy lies in diminishing the work, and in giving more time for recreation. Insufficient sleep from any cause in children practically amounts to overwork—a condition that diminishes the resistance to disease.

In fatigue of the brain one is conscious of a diminished mental grasp of a subject, and that an increased effort is necessary for mental work. There is also diminished capacity for attention, marked impairment of memory, and great difficulty in concentration of thought. To these may be added restlessness and irritability, and impairment of the sense of touch, and also diminished muscular power, although the muscles of the body may have been practically quiescent during the whole period of the overwork. The facial expression may also be altered.

FATIGUE IN SCHOOL LIFE.

The effort of attention is the expression of a state of tension of the nerve cells of the brain. The act of attention is most tiring when a voluntary effort is made. Attention is correlated with expenditure of energy by the particular nerve cells affected. It is, therefore, extremely important that teachers should recognize how exhausting sustained attention is, especially in young children. The brain and the organs of sense soon become fatigued, and require frequent intervals for repose if the receptivity of the nerve cells is to be maintained. Not only is fatigue fatal to attention but, according to Ribot, it is equally fatal to memory. "The impressions received under such conditions are not fixed, and the reproduction of them is very laborious and often impossible. Fatigue is regarded as a state wherein, owing to the normal acting of an organ, the nutrition suffers and halts. When the normal conditions are restored memory comes back again."

Lombard has shown that the energy of nerve cells and muscles exhibit rhythmical variations in the course of the day. Both nerve cells and muscles are most energetic between 10 and 11 a.m. Therefore these periods should be selected for the lesson that is apt to cause most brain fatigue. The Germans have a proverb, "The morning hours have gold in the mouth." In schools much can also be done by changing the subject of study and so arranging the daily lessons that a subject like mathematics, which causes brain fatigue, should be followed by one of quite a different nature, such as drawing. Drawing and writing, which are apt to cause eye-strain, should not follow each other.

Many methods have been used to measure fatigue. One of the indirect methods is by means of the aesthesiometer, an instrument for determining the spatial sensibility of the skin, which is diminished in fatigue. The reaction-time method measures the time taken to react to a given signal, which becomes longer in fatigue. Others have employed dictation or arithmetical calculations or counting letters—that is, certain letters are struck out from a page of print. In fatigue the number struck out diminishes; others, again, employ memorizing.

It is well known that certain school subjects produce fatigue sooner than others. It has been attempted to obtain fatigue coefficients by means of the aesthesiometer (Wagner), and by the dynamometer. The following represents the order of subjects arranged according to difficulty:

Mathematics (standard) ...	...	...	100
Latin ...	...	...	91
Greek ...	...	...	90
Gymnastics ...	...	...	90
History and geography ...	...	...	85
French and German ...	...	...	82
Natural history ...	...	...	80
Drawing and religion ...	...	...	77

There is much to be said against home lessons, more especially when the conditions in many homes in which the young scholar has to work in the evening are remembered.

FATIGUE IN RELATION TO DIGESTION AND THE KIDNEYS.

Let us enlarge our view of fatigue a little, and take a wider and withal practical application of the subject. What does the question of "quick lunch" mean in this age of hurry and worry? It means over-stimulation of the digestive glands. Recent investigations have shown how intimately the quality of certain of the digestive fluids depend on the condition of the nervous system. The business man who has a quick lunch day after day wonders why he feels dyspeptic. He calls it indigestion, and flatters his soul that he has a touch of "liver," and that all will soon be well. Yes, so it would—if he would but act rationally. Glands, like muscles, suffer from fatigue. Even the tear glands of some lachrymose individuals require a rest.

The kidneys are, perhaps, the best-abused organs in the body. Some people stimulate them to activity morning, noon, and night—fatigue them, in fact. The kidneys are excited to activity chiefly by the chemical substances present in the blood, and the duty devolves upon them of excreting the waste products resulting from an unnecessarily large intake of nitrogenous food, a habit all too common.

RHYTHM.

Bichat, at the beginning of the last century, spoke of the "tripod of life":

Brain.
Heart. Lungs.

Respiration or breathing is a more fundamental function than the circulation of the blood. All animals breathe, but not all animals have blood or a heart. The beating of the heart goes on before birth, and the cessation of its beat marks the cessation of life itself. How is it the body—a harp of thousand strings—keeps in tune so long? The secret is to be found in rhythm. Heart and diaphragm beat and contract rhythmically, and after each beat there comes a pause which permits of restitution of matter and energy, and gives time for the waste products to be removed, and thus leaves both muscles recuperated to begin a new beat. The heart rests, or is not in action, three fourths of its time; the act of expiration is chiefly

due to mechanical causes; inspiration is chiefly a muscular act. We must acknowledge the necessity as well as the universality of rhythm. What is sleep but the quiescent period of our nerve cells? It is more, for we say, with Macbeth, that it is chief nourisher in life's feast. The nerve cells, though resting, are storing up matter, and are being flushed and cleaned. Some folks indulge in what they are pleased to call a "spring cleaning." Well, our brain cells should have what corresponds to a spring cleaning every twenty-four hours.

CAUSES OF FATIGUE.

As to the causes of fatigue, the idea that the chemical substance in the muscle or in the blood (which are the sources of the chemical and thermal energy) are used up more rapidly than they are replaced is substantially true. That muscular fatigue is part of a chemical process is shown by the fact that if an extract made from the muscles of an animal that has been fatigued be injected into the muscles of a fresh animal, they show phenomena which cannot be distinguished from those of fatigue.

Professor A. Mosso showed that the blood of a fatigued animal contains toxic or poisonous substances. If the blood of a fatigued dog be injected into the blood vessels of a fresh, untired dog, the latter shows the symptoms of fatigue and changes in the heart-beat and breathing like those of fatigue.

If the blood vessels of a fatigued muscle be washed with oxygenated water containing a little common salt—a liquid which has no nutritive properties—the waste products are removed. Nothing that can yield energy to the muscles is added, yet the muscle regains its activity. Professor Kronecker showed experimentally that when a tired muscle is massaged to squeeze out the waste products it regains its activity. Massage was long ago practised by the Hindus, and the gladiators of ancient Rome had their muscles rubbed after the contests; the poisonous substances were thus quickly got rid of. Galen himself in the early part of his career was physician to the gladiators of his time.

Putting it broadly, then, the problem has a threefold aspect:

1. Using up of matter and energy. Restitution does not keep pace with waste. There is a run on capital.
2. Clogging of the machinery by the products of its own making, and the transference of these products by the blood to affect injuriously other organs.
3. The lack of oxygen. Thus both local and general effects must be studied. If fatigue be even in small part due to poisoning of the body, is it not obvious that from the employer's point of view he ought to strive to place his employee under the best conditions as to ventilation and other hygienic measures? In every case where this has been done both employers and workmen have been gainers. In Manchester in 1892 the firm of Mather and Platt adopted a forty-eight hours week. Sir William Mather, in commenting on the result, expressed the view that the most economical production is obtained by employing men only so long as they are at their best. When this stage is passed, there is no true economy in their continued work.

REPOSE.

All this makes it plain why repose is the necessary complement of fatigue. The idea conveyed by the word "repose" is to put things back in their places. I stand by the Jewish code, one day's rest in seven. By repose and restfulness I do not mean that as set forth by Tennyson in the choric song of the "mild-eyed melancholy" lotus eaters; rather would I put it in the words of Plutarch:

Rest is the sweet sauce of labour.

In addition to sleep—if it can be obtained naturally—the true rest of many a brain is to change to something less exciting, but at the same time useful occupation in which the sufferer gets interested. For many, something approaching manual labour in the open air is best. Not only is change of occupation important and beneficial, but change of scene also. What has been called the "magic of change" is more potent for good than any panaceas of the alchemists. Change is the very essence of life, for all manifestation of life is due to change—incessant and varying in degree—in the cells that compose our bodies.

For this of old is sure,
That change of toil is toil's sufficient cure.