GULSTONIAN LECTURES ON THE HEAT OF THE BODY.

DELIVERED AT
The Royal College of Physicians, London,
MARCH 1871.

By SAMUEL J. GEE, M.D., F.R.C.P.,
Assistant-Physician to St. Bartholomew's Hospital and to the Hospital for Sick Children.

LECTURE II.

THE ways and means by which the body gains and loses heat having now been discussed, it remains for us to consider the balance struck between these processes; namely, the temperature of the body. Knowledge upon this subject could not advance beyond a certain point, until the thermometer was invented. Before this time, real and metaphorical heat were confounded. For example, in the investigation concerning the nature of heat, which occupies so large a part of the second book of the *Novum Organon*, Lord Bacon places, among instances agreeing in the nature of heat, oil of vitriol, spirits of wine, aromatics, nay, even intense cold. In like manner the last of the writers upon innate heat, Conringius, in his book published in 1647, maintains that vegetables produce heat. At first sight this seems a remarkable anticipation of a fact supposed to have been discovered in much more recent times. But what does he mean by heat? that pepper is hot and ginger is hot. Before this time, in 1625, Sanctorius had described an air-thermometer, but nothing could be done until Römer and Fahrenheit invented the mercurial thermometer.

It was De Haen, the Dutchman, whom Van Swieten wisely induced to settle in Vienna, who first seriously applied the thermometer to pathology, or indeed to physiology. Year by year the *Ratio Medendi* of De Haen published the results which he obtained by using the thermometer; I allude to the 2nd, 3rd, 4th, 6th, 7th, 10th, 11th, and 12th volumes of the *Ratio Medendi*, and also to the tract *De Februm Divisionibus*. In the *Ratio Medendi Continuata*, many cases of febrile disease are narrated at full length, with thermometrical observations made every day, night and morning. De Haen believed that the natural temperature of the body ranges between 96 deg. and 98 deg. Fahr. He knew that this temperature was much the same at all ages; he knew that the temperature rose during the cold stage of ague—a remark in which, however, he had been anticipated by Haller. He rejected the current Boerhaavian doctrine that the heat of the body was due to the friction of the blood; and he founded his objection upon two facts. First, he had noted that the temperature of a paralysed limb might fall as low as 73 deg., the pulse remaining good all the time; and he declares “that the heat resides in the part, independently of the blood”—that is to say, independently of the friction of the blood. Secondly, he had observed the remarkable fact that the temperature of the body sometimes rises at death; “but”, quoth De Haen, “the greatest heat of all was found in a man during the agony of dying, at the time of death, and some time after he had ceased to live. During the whole of an acute illness, this patient's temperature had not risen above 103 deg., but at the time of death, and for two minutes afterwards, a heat of 106 deg. was noted”: and he goes on to narrate another case of the same kind.

The Vienna of that day was famous in begetting and forgetting great discoveries: De Haen and medical thermometry, Auenbrugger and percussion. De Haen's case is particularly hard. His method slept till thirty years ago.

The temperature of the body being the balance struck between the heat gained and the heat lost, we might expect to find that the temperature of all parts of the body is not the same; that those parts which set free most heat should be hottest, and that those parts which lose most heat should be coldest: and observation shows that this is the case.

So far as the generation of heat is concerned, we have already seen that the glands during secretion, the muscles during work, and the blood which comes from the lungs, are the warmest parts of the body; and that the horny tissues, in which little or no chemical change goes on, are the coldest. But you will have remarked, no doubt, that one of the largest viscera has not been once mentioned with reference to the production of heat: I allude to the brain. Now the brain is, in reality, what

Hippocrates declared it to be, of a cold nature. John Davy, long ago, found the temperature of the brain to be considerably below that of the thoracic and abdominal viscera. According to Mendel, there is in the rabbit a difference of one and a half or even two degrees Fahrenheit between the cranial cavity and the rectum—that is to say, the rectum is so much hotter. The comparatively low temperature of the blood in the vena cava is partly thus accounted for. With regard to mental activity, Lombard and Brown-Séquard declare that it raises the temperature of the head one degree Fahrenheit, whilst the temperature of the limbs falls to the same amount.

In the next place, those parts of the body which lose most heat by radiation, conduction, or evaporation, are the coldest: but, in fact, this applies chiefly to the skin; for, in the case of the lungs, we saw that the heat abstracted from them is more than counterbalanced by the heat which they set free; and the loss of heat from the upper part of the alimentary canal, caused by cold food, is a very unimportant circumstance.

Some parts being hotter, some parts being colder, it is obviously the circulating blood which is the great means by which the temperature of the body is more or less equalised. By the mean temperature of the body is signified the temperature of the blood. I will not occupy your time with the commonplaces concerning the temperature of the body: how in health the average temperature of the axilla is 98.5 deg., that of the rectum about a degree higher—say from 99.5 to 100 deg.; how this average temperature is remarkably uniform in the same individual, and, indeed, one might say, in all individuals; how any temperature in the axilla above 99.5 deg., the body being at rest, must be considered a febrile temperature; how, even in disease, the temperature rarely rises above 110 deg., or falls below 91 deg. The highest temperature ever observed in a living man is 112.5 deg., by Wunderlich, in a case of idiopathic tetanus, at the time of death. I myself saw a case of tubercular meningitis in which the temperature of the rectum remained for hours at 79.4 deg. Fahrenheit. Löwenhardt has noted a temperature even lower than this; namely, 77 deg., in a case of mania shortly before death; but whether the thermometer was applied in the axilla or in the rectum, I do not know.

Let us refer for a few minutes to those diurnal variations of temperature which are observed in healthy men. The general facts concerning these variations have been well made out. “The lowest temperature of the body occurs about day-break. At this time a rise begins, which continues till late in the afternoon, reaching its maximum at different hours in different persons, for reasons to be presently considered. The maximum reached, the temperature again falls (the fall and the minimum continue) till daybreak or thereabouts, when the cycle again begins.” I quote this summary from a useful paper by Dr. William Ogle in the *St. George's Hospital Reports* for 1866. Most observers have arrived at the same results. The differences in the actual temperatures which are observed in different individuals, and in the same individual, from day to day, can be partly explained by differences in the influence of the non-naturals, especially the external temperature, muscular exercise, and food. Increase in the amount of any of these circumstances is followed by increase of the body-heat. However, the influence of these non-naturals is small, and will not account for the whole of the daily fluctuation. Some experiments of Jürgensen are very valuable with regard to this point. He kept three persons in bed and noted their temperature every five minutes, as indicated by a thermometer passed two inches deep in the rectum. The influence of exercise and of change in the external temperature was hereby excluded, yet the daily variations which I have just described were as strongly marked as ever. And, with regard to food, Jürgensen found that perfect abstinence, even from water, maintained for thirty-three hours, did not affect the daily course of the temperature. Upon what, then, do these fluctuations depend? They certainly coincide with differences in the activity of the chemical processes going on in the body. The fact that more carbonic acid is excreted by day than by night has been long known; and more recently Pettenkofer and Voit have discovered that oxygen is stored up—that is to say, not used—during sleep. But the question still rises, Upon what do these rhythmical variations in nutrition depend? Dr. Ogle suggests that the explanation is to be found in the conditions which result in sleep or wakingness. He supposes that the rise of temperature at daybreak “may be due to a diminution in the intensity of sleep as morning approaches. The first sleep is the most profound. In it not only are the animal functions suspended, but also, to a certain extent, those of organic life. The latter are rested sooner than the former, and resume their full activity while these are still slumbering. This awakening of the organic functions occurs about daybreak, and manifests itself by quickening of the pulse, increased exhalation of carbonic acid, and consequent rise of temperature.” The daily difference of temperature between the minimum and maximum never exceeds 3.5 deg.

But, whatever be the daily fluctuations, and whatever be their cause, the mean daily temperature is remarkably uniform in the same person. Jürgensen found that the mean of seven days did not vary more than a quarter of a degree. Complete abstinence from food for thirty-three hours depressed the mean half a degree: the daily fluctuations being unaffected, as I said before. Cold baths did not affect the mean; which would serve to confirm the opinion, which shortly we shall have to discuss, that there is an increased generation of heat during a cold bath.

Let us now pass on to consider another question, namely; how is it that, seeing the factors which result in the temperature of the body are so variable, the result itself is so uniform? Yet, obviously, it is the very variability of the factors which secures the uniform result. The heat of the atmosphere which surrounds the body being variable, it is necessary that the heat set free by the body itself should vary; and vary inversely as the heat of the atmosphere. If the atmosphere maintained an uniform temperature of 99 deg., the body need not generate heat at all. But it is easy to see that a constant external temperature of 99 degs., would still require that the body should have some means of regulating its warmth, inasmuch as the characteristic function of animal life, voluntary motion, is attended by the generation of heat. And at a temperature of 109 degs. the body begins to be permanently destroyed. But, in fact, the uniformity of the body-heat is maintained by a double safeguard: our bodies can not only regulate the loss of heat, but, having to make good a certain deficit abstracted by the atmosphere, they can also regulate the supply.

The chief means, by which the equilibrium is kept, are voluntary on our part. We shall shortly find that, when the temperature of the body sinks to 97.5 degs. in consequence of an hour and a quarter's exposure to cold, violent shivering ensues. On the other hand, an internal warmth of 100 degs. is attended by an unpleasant sensation of heat. These sensations guide our volition. You will understand that I am not now speaking of diseased states, in which the sensations are perverted. We regulate the amount of heat produced by varying the food and exercise we take. We regulate the loss of heat by means of clothing and external warmth. But this voluntary balancing of the temperature of the body has reference chiefly to considerable periods of time. We wear more clothes in winter than in summer, but we do not change our clothes several times a day; we eat more food in winter than in summer, but we do not so arrange our meals as to suit the daily oscillation of our temperature and that of the atmosphere. In short, volition regulates the warmth of the body in the gross, and orders it so that the heat produced or lost shall not transgress certain limits.

But when we come to look at the finer equilibrium which the body maintains—an equilibrium, not from day to day, but from hour to hour, and from minute to minute, under sudden and frequent changes in the conditions of body-heat—we have to acknowledge the operation of an involuntary control. Accordingly, we see when the body is heated, say by muscular exercise or a hot air-bath, how the respiration becomes more frequent, how the circulation becomes more rapid, the skin full of blood and sweating. Again, when the body is cold, the skin becomes pale and bloodless, protecting the inner parts from loss of heat. By these means, any great change in the temperature of the body is provided against. But I think that presently we shall learn enough to make us suspect that this involuntary control of the body-heat is exerted within very narrow limits. Else why, so soon as the temperature of the air approaches that of the blood, do sunstrokes become common among those who neglect the voluntary means of preventing a dangerous elevation of their body-heat? And why is the naked body unable to resist, for more than an hour, an external temperature which is not lower than 60 deg.? To sum up: it is only within limits of 18 deg. or thereabouts, say from 80 to 98.5 deg. of surrounding temperature, that the body can maintain a constant temperature for any length of time without voluntary and external aid.

The powers of the involuntary control are put to the test when, in spite of the warnings of the sensations, the will is not exerted whilst heat is greatly added to, or greatly abstracted from, the body. I need not dwell upon the potential heat contained in food or air, for excess in these particulars is limited; we cannot digest much more food or air than usual, even if we would. Again, muscular exercise is limited by fatigue. But the addition or abstraction of external heat is illimitable; let us, then, investigate how the body behaves under great external heat or cold.

First, when the body is exposed to a temperature higher than itself, the surrounding medium must be atmospheric, because the body cannot bear baths of liquid which are but a few degrees higher than itself. And even an atmosphere saturated with watery vapour at 130 deg. cannot be borne. The reason of this is clear: if radiation, conduction, and evaporation from the skin and lungs be thus rendered im-

possible, what other means does the body possess of reducing its temperature? In dry air, an animal can exist for a time at 270 deg. But suppose the external temperature to be much below this extreme, and yet not lower than the body-heat; what is the effect? The temperature of the body rises. Schuster found that, in warm baths of the same temperature as the rectum or higher, the temperature of the rectum rose about two degrees. Mayer quotes from Douville the observation made upon a negro who, while lying dirty and lazy in his cabin, had a temperature of 98.6 deg., which when he lay in the sun rose to 104 deg. Ackermann found that dogs, kept in an atmosphere equal in temperature to that of the body, but breathing air of an ordinary temperature, quickly became much hotter than natural. And, reversely, when they breathed air of the temperature of the body, but were surrounded by an atmosphere of ordinary heat, their temperature rose likewise, but much less quickly than in the previous experiment. The effects of more prolonged exposure to heat have been studied by Walther; and experiments of this kind afford an excellent means of noting the effects of a high temperature, simply as a high temperature, upon the body. Rabbits and dogs, when tied to a board, and exposed to a hot sun, reach a temperature of 114.8 deg., and then they die. The frequency of the pulse and breathing increases enormously; there is a heat-dyspnoea. This dyspnoea ceases rapidly when the animal is plunged into cold water; or when cold defibrinated blood is injected into the jugulars. Artificial respiration has no power to diminish the dyspnoea, even when pushed so far as to render the venous blood of an arterial colour. When death draws nigh, the frequency of the respiration diminishes, the action of the heart becomes extremely weak and rapid, cyanosis and muscular cramps ensue. The temperature continues to rise after death, and may even reach 122 deg. Fahr. After death, the muscles are found stiff as if cooked; the heart in a state of diastole, the blood venous, the internal viscera full of blood. I wish that the microscopical examination of the tissues of animals killed in this way had been carried further; much light would thereby have been thrown upon the lesions coincident with fever; that is to say, we should be better able than we are to say what lesions directly depend upon the elevated temperature. The nearest approach to experiments of this kind upon the human subject has been made by Bartels. He raised the temperature of a healthy person to 107.5 deg., by a vapour-bath, for forty minutes. The first symptoms produced were a sense of heat and oppression, with discomfort and restlessness. These were followed by weakness and faintness; pain in the head; muscular movements unsteady and tremulous; skin red, swollen, sweating; frequency of pulse much increased; but frequency of respiration not always much increased. When the experiment is carried as far as it can be with safety, the sensorium is affected, and there is a strong disposition to swoon. In Bartels's case, the temperature reached, as I have said, 107.5 deg., the pulse 172, when the person was removed from the bath on account of swooning. Let us remark, in passing, that the hyperæmia of the skin which serves to get rid of an excess of body-heat under ordinary circumstances, becomes, when the body is in a hot atmosphere, positively pernicious, and favours the absorption of heat. Experiments such as these have practical value. They seem to me to leave no doubt possible that what is commonly called sunstroke is really the result of raising the body-heat beyond a certain point. In order to secure the greatest possible functional activity, hot-blooded animals are constantly living upon the very verge of danger and of death from their hot blood. And we have just seen that the power of the body to regulate its heat involuntarily is very limited; above a certain point, say 108 deg., the body becomes passive to any external influences; what regulating power it had, is lost.

The extremely hot summer of 1868 gave many of us opportunities of seeing examples of sunstroke. On July 22nd, the hottest day of that summer, with the thermometer standing at 90 deg. in the shade of the Royal Exchange, a young man was wheeling a baker's barrow along the sunny side of Fleet Street, when he staggered and fell. He was at once brought to St. Bartholomew's hospital in a cab, within about half an hour from the attack, but he was already moribund, perfectly unconscious; pulse extremely frequent and feeble; temperature in axilla 109.5 deg.; skin covered by an universal livid mottling, precisely like the subcuticular rash of typhus; a loud systolic murmur over the pulmonary artery. He soon died, within an hour from the beginning of the sunstroke. No *post mortem* examination could be made: but I find that, in a much less rapidly fatal case seen by Dr. Bäumlér at the German Hospital, the muscular fibres of the heart, the cells of the liver, and the epithelium of the kidneys, were observed to be highly granular. This is very interesting, because we shall see hereafter that precisely the same lesions attend the pyretic state. But not only exposure to the direct rays of the sun, but also prolonged abode in hot rooms, can produce sunstroke, or rather heat-stroke. In India, soldiers are frequently attacked in their barracks; and the temperature of those rooms is some-

times as high as 114, 118, nay, it is said, 125 deg., and even by night the temperature may not fall below 105 deg. And it is only what we should expect, when we are told that moisture of the atmosphere and muscular exertion, the one diminishing the loss of heat by evaporation, and the other increasing the heat set free by the body, are powerful excitants of sunstroke, in addition to the mere heat of the air. The deleterious effect of the heat seems to be largely explicable even in the present state of animal chemistry. Weikart declares that the blood begins to clot in the vessels at 109 deg.; the muscles of warm-blooded animals set instantly at 118 deg., and set more gradually at lower temperatures; 113 degs. Fahr. of heat abolish the excitability of nerve in frogs. The rational treatment of heat-stroke which suggests itself is strongly supported by experience; we must aim at reducing as quickly as possible the heat which is killing the patient.

[To be continued.]

LECTURES ON DERMATOLOGY.

DELIVERED AT

The Royal College of Surgeons of England.

By ERASMUS WILSON, F.R.S.,

Professor of Dermatology in the College.

LECTURE VI.

In reference to treatment, eczema must be regarded as a "solution of continuity", and as such requires a dressing to defend the lesion, for the purpose of keeping its broken edges in contact, and of excluding the operation of external irritants of every kind. A dressing with the benzoated ointment of oxide of zinc fulfils this indication completely. The ointment should, in the first instance, be smeared upon the eczema; the smearing process should be repeated twice or more frequently in the day, so as to secure a permanent covering; and, wherever practicable, strips of linen rag spread with the same ointment may be placed over the eruption and maintained in position by a roller, so as to keep the ointment and the dressing in permanent contact with the diseased skin. In this relation the ointment fulfils the purpose of a light unirritating plaster; it preserves the natural moisture of the skin, and excludes the stimulant operation of the atmospheric air. It is easily replaced when accidentally removed, and in many cases will accomplish every object of treatment from the beginning to the cure of the case. Let me instance an eczema infantile, in which the body is covered with eruption from head to foot; it is hardly possible to conceive a remedy more admirably suited in such a case to meet the exigencies of treatment than the benzoated ointment of oxide of zinc.

It has long been my custom to combine with the zinc-ointment a small quantity of spirits of wine, in the proportion of one drachm to the ounce: the spirit softens the ointment and facilitates its application; it produces a sensation of coolness which is agreeable to the heated surface, and it has besides a gently stimulant effect on the nerves of the skin. The application, as I have already observed, relieves the heat, the stiffness, and the itching, and the relief continues until the ointment dries up or is accidentally removed. When either of these events takes place, the ointment must be repeated in the same manner as before. Our aim should be to favour a thin deposit or concretion on the surface, which should occupy the place of the broken or excoriated epidermis; such a deposit or concretion is, in fact, an artificial cuticle, a kind of natural plaster, under which the skin is preserved in a state of repose, and the inflamed and irritable tissues have time given them to recover their normal status. You will perceive that eczema brings before us a surgical lesion in which the application of a plaster or dressing of any kind is often perfectly impracticable, and therefore we are obliged to have recourse to a remedy which shall possess the intrinsic property of adhesion to the skin without the aid of other coverings. This will explain our anxiety to have the inflamed surface thoroughly coated with the ointment, and to have the ointment repeated as often as, from any accident, it may by chance be displaced; and, of course, wherever practicable, means may be contrived, such as bandages and compresses, to render the dressing permanent. Above all, it is important to avoid washing the skin at this stage of the disease: washing would remove the ointment and open up the excoriation afresh; it would be undoing that which it had taken much

labour to do; it would be unsurgical, by creating disturbance where rest and position were of the utmost importance. There can be no want of cleanliness where a pure oxide of zinc ointment is properly used; and if secretions be poured out from the skin, they may always be absorbed by means of a soft napkin, and, together with crusts, may be gently wiped away. Mothers will sometimes hear with wonder the command to avoid washing their children in a case of eczema infantile; but they are generally ready to admit that the eruption is always more uneasy after the washing than it was before, and their instinct quickly assures them that their instructions to avoid washing are correct.

Eczema enjoys the peculiarity of presenting, in a general attack of the eruption, a variety of degrees or forms of manifestation on different parts of the body; thus it may be erythematous in one place, ichorous in a second, and squamous in a third. The zinc-ointment is equal to the relief of every one of the forms of the eruption; but it not unfrequently happens that we may find an advantage in using a powder in one situation, the lime-water and zinc-lotion in a second, and the ointment in a third. And in the adoption of these means we are to be influenced rather by the sensations of the patient than by any preconceived theory of the disease. In general terms, it may be said that whatever gives rise to pain or uneasiness is bad, and will require to be changed.

Eczema is essentially chronic as to its course; but it manifests stages in its progress which are as decidedly acute. The treatment which we have just been considering is strictly palliative, and is therefore especially adapted for the early and acute stages and acute manifestations of the disease, but is equally applicable for the relief of heat, itching, and dryness, in every stage of the affection. If I were asked how I should distinguish between an acute and a chronic eczema, I should say that the acute stage was denoted by erythematous congestion and moist excoriation, and the chronic stage by infiltration and desquamation, the infiltration giving rise to thickening and induration. I shall now suppose that the eczema has reached its dry, squamous, thickened, and indurated stage. It has assumed that condition which, in ulcers, for example, is termed indolent, inveterate, and so forth. The zinc-ointment removes the scales, heals chaps and fissures, and relieves in some degree the itching, but does nothing towards the dispersion of the thickening and induration of the tissues—that is, towards the cure of the disease. The time, in fact, has come when we must contrive to awaken the tissues from their indolence and lethargy, and direct, as far as we are able, the newly awakened life towards a normal state of action—that is, towards a restoration of healthy function and tone.

Our purpose, therefore, is no longer palliative; it is stimulant or tonic; the palliative treatment has accomplished all that it can; now we have to consider the nature and mode of application of the stimulant treatment. Our stimulants possess a great range of power, and, if we knew exactly the amount of resistance which we should meet, we might apportion our power with exact accuracy. But as this can never be the case in dealing with so delicate a machine as living organisation, the laws of surgery would prescribe to us that we should begin with the mildest of our stimulants and advance progressively and to the best of our judgment to the higher degrees. The philosophic surgeon will not hesitate to adopt this course as one in every way consistent with his knowledge of vital phenomena; and, therefore, we may proceed to inquire, In what do our stimulants consist?

The first and best of our tissue-tonics or local stimulant remedies is undoubtedly soap. It will be remembered that I have prohibited soap in the earlier and acute stages of the eruption; therefore soap is new to the morbid skin, and capable, consequently, of producing a more powerful effect than would otherwise be the case. The chronic eczema should be thoroughly washed with soap, combining with the solvent action of the soap upon the epithelium such an amount of moderate friction and compression as may reach the vascular and the infiltrated tissues. After the washing, the surface is to be dried with a soft napkin, and, as soon as dried, dressed with the zinc-ointment like an eczema of an earlier period. The next day we examine very carefully our eruption, and, if we find no signs of excessive irritation present, we renew the saponaceous washing and repeat it again and again until the eczema is healed. It will soon be apparent how frequently the process may be repeated, whether once a day only or twice, or whether the reapplication must be deferred for several days. The immediate consequence of the stimulant treatment will probably be the development of an exudation on the surface, which will relieve the infiltration and turgescence within; and a few repetitions of this exudation will so far tend to empty the tissues of their excess of fluids that they will be enabled to return by degrees to their normal state.

This, in fact, is the explanation of the *modus operandi* of the powerful stimulants which we hear of as being from time to time useful in the cure of chronic eczema; such as strong alkaline soaps, strong solutions of potash, strong mercurial ointments, strong solutions of nitrate