Parotitis occurred in three cases of my series.

Petechiae were observed in a few of the cases showing marked toxæmia.

Many of the severe cases showed, after the hyperpyrexia had subsided, a pyrexia; for several days the temperature being about 102° or 103° (see Charts 3 and 4). In one case the fever lasted three weeks. Numerous blood cultures were made in these pyrexial cases, with negative results. Recurrences of hyperpyrexia were very likely to occur after an attack of heat-stroke unless the patient was kept in a cool atmosphere, which was often impossible. There were several instances of two and three recurrences (Chart 5).

After convalescence from hyperpyrexia attacks of headaches were common, and exposure to slight heat would induce them. These patients for a long time were very sensitive to heat, and evacuation to a cool climate was essential. In some of the severe cases showing marked persistent nervous symptoms it was clear that permanent organic changes had resulted from the effect of heat on the brain cells. Dr. R. M. Stewart⁶ has described a case with persistent cerebellar symptoms following an attack of heat hyperpyrexia in Egypt.

TREATMENT.

1. *Heat exhaustion* required no special treatment beyond rest, keeping cool, and aperient medicine.

2. *The gastric type* was dangerous, and required great care in treatment. Free purgation, great care in protection from heat, large doses of sodium bicarbonate (30 grains every three hours), and rectal injections of cold solution of the same salt (2 drachms to the pint) gave the best results. The diet in all "heat" cases was chiefly lacto-vegetarian, the fat and protein being reduced as far as possible.

3. *The choleraic type* required treatment on the lines of cholera cases, including normal or hypertonic saline subcutaneously, and cardiac stimulants—for example, digitalin, strychnine, adrenalin, pituitary extract given hypodermically. Protection from heat was most important.

4. *Heat hyperpyrexia* demanded immediate application of measures to reduce the temperature. Thus, the stripping of the patient and constant application of a spray of cold water, or rubbing with blocks of ice, were essential until the rectal temperature fell to 102°, the patient being under a fan during the process. In the hospitals in Mesopotamia special heat-stroke wards were established, with overhead fans and portable electric fans for each acute case. Ice-cold water was supplied to each bed, so that the patient could have a constant spray of this; there was also an ample supply of ice. At my suggestion the acute cases were treated on an ordinary iron bed, a rush mat, with a smooth Japanese reed mat above it, being placed over the iron framework. This allowed a free current of air all round the patient, from below as well as above.

By these means the hyperpyrexia could be controlled. If enlargement of the spleen was observed, or if there was a previous history of malaria, quinine bihydrochloride gr. x was given either intravenously or intramuscularly without delay, and during the carrying out of the hydrotherapeutic measures. An injection of quinine gr. x was given if the temperature was not readily controlled by the above methods. Blood films were made at once and examined for malaria, and if the result was positive, active quinine treatment was continued.

Convulsions, which were of very common occurrence, were treated most satisfactorily by venesection, 10 to 20 oz. of blood being withdrawn. Intravenous saline after venesection was not found beneficial, since it tended to cause recurrence of the convulsions. Rectal injections of ice-cold water or of ice-cold solution of sodium bicarbonate (2 drachms to the pint) were beneficial.

Cardiac failure was treated by digitalin, strychnine, adrenalin, or pituitary extract hypodermically.

Failure of respiration was treated by artificial respiration and oxygen, or oxygen bubbled through alcohol.

Some cases with violent delirium and convulsions were treated by morphine hypodermically, and chloroform inhalations, but these methods were usually inferior to venesection.

PROPHYLAXIS.

Every care was taken by the army authorities in the prevention of heat-stroke. As far as possible no military operations were carried out during the hot weather, and

as far as possible also troops were relieved from any duty between 10 a.m. and 4 p.m. Head and spinal protection were ensured by the issue of efficient helmets and topees, and spinal pads. Special light summer clothing was issued to troops in the hot months. A free supply of water was allowed to troops, and every man had a 1 gallon canvas *chagul*, so that by keeping drinking water in it efficient cooling was obtained by evaporation.

Army Orders were issued, on the advice of the D.M.S., warning against the risks of constipation and the taking of alcohol.

Billets and huts for troops were supplied with electric fans. In the case of troops under canvas special care was taken as regards the management of tents so as to ensure maximum heat protection.

Hospitals were equipped with an ample supply of electric fans and ice. In hospitals where patients suffering from other diseases showed a tendency to hyperpyrexia it was found advisable to place them in the coolest part of the wards under a fan and to cover them with a sheet kept wet with cold water.

Heat-stroke stations, with all facilities for treating cases were established in each of the base areas, and each division of troops had six such stations, so that every facility was provided for the treatment of emergency cases.

My thanks are due to Major-General A. P. Blenkinsop, C.B., C.M.G., D.M.S., of the Mesopotamian Expeditionary Force, for statistical figures in this paper, and for the interest and active measures he took for preventing and dealing with heat hyperpyrexia.

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THE PHYSIOLOGICAL ASPECT.

BY

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HEAT-STROKE results from the rise of body temperature to a height incompatible with the maintenance of the equilibrium of the physico-chemical reactions in the cell on which life depends. Such rise may result from inability of the heat-regulating mechanism to control the body temperature under the atmospheric conditions, or from exhaustion of this mechanism. Infection, drink, fatigue, by weakening the mechanism, enhance the risk of heat-stroke.

Heat-stroke may occur in either dry or moist hot shade conditions, or from exposure to sun on close, warm days. While sunburn is an inflammation of the unacclimatized and untanned skin resulting from the sun rays, sunstroke is only another form of heat-stroke. There is unreasoning fear of exposure to the sun in this country; so long as the body is exposed to cooling breeze, exposure to the sun cannot produce sunstroke. The heating effect of food, especially of protein-rich food, must be borne in mind in the tropics. Alcohol is contraindicated if taken in place of natural foods. It contains no vitamins or protein-building groups, but is a fuel to the body. Monkeys fed on a light diet of bananas and rice and given plenty of water can be trained to stand exposure to the tropical sun out of doors for many hours a day. The sweating mechanism becomes more efficient by training.

The effect of enclosure and still air is very important. When surrounded by stagnant moist air in an enclosure at body temperature, any loss of heat by convection, radiation, or evaporation of sweat becomes impossible; as heat production continues, the body temperature inevitably rises. The rise of temperature accelerates the rate of combustion in the cells, and a vicious circle is established. In the Black Hole of Calcutta the air entangled between the bodies and in the clothes of the victims became saturated with water vapour and heated to body temperature; thus heat-stroke, not suffocation, put an end to their sufferings. As the body, weighing some 60 to 70 kg., takes time to heat up several degrees to the critical temperature, people withstand temporary exposure to the heat of a

crowd or immersion in a hot bath. The weakly with feeble circulations, heart disease, or vasomotor instability, are the first to suffer.

It is easy by a few minutes' immersion in a very hot bath (107° to 110° F.) to accelerate greatly the pulse and respiration, lower the systolic pressure and raise one's rectal temperature to 103° F., to a point where one feels dizzy on standing up owing to the dilatation of the cutaneous blood vessels and the influence of gravity on the circulation. A cold douche gives immediate relief by constricting the cutaneous vessels, the rectal temperature still remaining at 103° F.

Normally, in comfortable cool surroundings, we are cooled mainly by convection, cool moving air carrying away the body heat from the skin, loss by evaporation from the skin being kept at a minimum, while that from the respiratory membrane is kept at a maximum by the breathing of cool air of low vapour tension. The vessels of the skin are toned up, activity and metabolism kept at a good level by the cool touch of moving air. In warm stagnant air the emergency method of cooling by sweating is brought into play.

The power of the air to hold water vapour, its evaporative power, increases rapidly with rising temperature; thus saturated air—

At 30° F. holds 1.94 grains of water per cubic foot.				
At 50° F. " 4.08	"	"	"	"
At 70° F. " 7.98	"	"	"	"
At 80° F. " 10.9	"	"	"	"
At 90° F. " 14.7	"	"	"	"
At 100° F. " 19.7	"	"	"	"

Wind enormously increases the evaporative power so long as the air is saturated at a temperature below body temperature by continually bringing fresh unsaturated layers of air in contact with the body.

As every gram of water evaporated from the skin or respiratory membrane carries away 0.59 calorie, the emergency method of body cooling is very effective. It is brought into play when men do hard physical labour and increase their rate of heat production five or even ten times. A high cooling power, due to cool air and wind, is required to stop sweating in such workers. There is an imperative need to so adjust the cooling powers of the air by fan ventilation in workshops that men may be saved from body heat stagnation or needless sweating, and from loss of physical vigour such as is evident in cotton spinners when contrasted with miners.

The limits of an Englishman's power to keep himself cool is passed when the wet bulb exceeds 88° F. in the still air of a chamber, even when he is stripped to the waist and resting (Haldane). When muscular work is performed a wet bulb temperature of 80° F. may be the limit. Walking in a tropical climate—wet bulb 75° to 80° F., dry bulb 80° to 90° F., may raise the rectal temperature 2° to 3° F., and send the pulse rate up to 140 to 160. Breathing hot air may so heat the blood as to produce exhaustion, even when the skin is exposed to a cool atmosphere.

The effect of wind in promoting the cooling of the body is illustrated by measurements taken with the "kata" thermometer. This is a big-bulbed spirit thermometer which is warmed up so that its rate of cooling—from 100° to 95° F.—can be taken in seconds. The cooling power of the "kata" surface at body temperature is then deduced by means of a factor in millicalories per square centimetre per second. Readings are taken with the "kata" bulb dry and wet (covered by a wet knitted cotton glove). To take an example: On a certain day the temperature out of doors in India was dry bulb 89° F., wet bulb 73° F. Now the cooling powers are as follows:

	Still Air.	Wind 1 Metre per sec.	Wind 9 Metres per sec.	
Dry "kata" ...	1.3	3.6	6.7	With dry bulb 89° F.
Wet "kata" ...	9.8	22.4	36.7	With dry bulb 89° F. and wet bulb 73° F.

The cooling powers in still air are intolerably low, those with wind 1 metre per second quite tolerable for a sedentary person, those with wind 9 metres per second quite cool

Suppose the air were saturated, the wet bulb also standing at 89° F., then the wet "kata" readings become:

Still air ...	3.3
Wind 1 metre per second ...	8.0
Wind 9 metres per second ...	15.1

and a wind of 9 metres a second (20 miles an hour) is required to secure comfortable cooling. In ordinary work-rooms in this country a dry "kata" reading of 6 and wet "kata" reading of 18 to 20 are commonly found, and appear to be comfortable for light work. Out-of-door workers in this country are exposed to far higher cooling powers, chiefly owing to the far greater movement of the air. The stimulating effect of the cooling powers of outdoor air on metabolism is of great importance to health.

In Borneo the wet bulb temperature not uncommonly reaches 90° F., and if there is no wind the conditions must be met by punkahs and electric fans and bathing in cool water. For such conditions compressed air douches would be of value. Water condenses out of air when it is compressed, and the air escaping from compression is both cool and dry. Such air offers a method of cooling far more practicable than any method of cooling by freezing machines. It is a method used in mines where the tools are driven by compressed air.

Now let us consider warm dry air at temperatures near to blood heat. So long as the sweating mechanism remains active and there is a breeze, there is no danger of heat-stroke. On the other hand, with hot dry air (well above body temperature) and a wind, the cooling power due to evaporation of sweat may be overpassed by the heating power of the air. The simoon kills by the hot wind drying the skin quicker than it can be kept wet by perspiration, and so heating the blood. The Arab crouches down on the ground and covers himself with clothes to avoid the drying and heating effect of the simoon, and hopes it will pass before his body becomes overheated. If a hot desert wind dries the skin absorption of sun heat takes place, which is normally checked by the layer of sweat. So long as the skin is thoroughly wet with sweat the sun heat is mostly expended in evaporation and is kept from the blood.

The glistening wet skin reflects the sun rays to a large degree. The black, with his tissues protected by pigment from the lethal effect of the sun, can have a thinner skin and blood vessels closer to the surface. Thus the cooling of shaded parts of his body is better secured. The pigment on absorbing the sun rays heats the cutaneous nerve endings, and these activate the sweat glands, dilate the cutaneous blood vessels, probably through "axon" reflex, and with very little delay.

While the "kata" thermometer indicates conditions of the atmosphere which are likely to cause heat-stroke, the surface temperature of a piece of black fur (taken by stroking it with the bulb of a sensitive thermometer) gives a simple measure of the radiant heat of the sun.

The loss of heat of a resting man may be taken as about 1 millicalorie per square centimetre of body surface per second; the extra heat production due to work may put this up to 3 millicalories. The exposure of half the body to the sun may result in the absorption by the clothes of 5 to 10 millicalories per square centimetre per second. Exposure to the sun, then, greatly increases the strain on the sweating mechanism. Hence the conditions for causing heat-stroke are given by soldiers heavily clothed marching in close column in the sun on a calm day. The air surrounding their bodies becomes saturated and warmed, and the sun heat is absorbed by their clothes. The stripping off of clothes, open order, frequent rests, plenty of drinking water, and avoidance of the heat of the day for marching are the proper precautions. Clothes for the tropics should be of thin cotton material: a shirt open at neck and sleeves—the shirt worn outside the belt when conditions are trying—shorts, boots, and knitted puttees, and a light sun helmet well ventilated and impermeable to sun rays. The clothes must be light in colour to reflect the sun. The man should allow his skin to tan, so that he can wear thin material. He must avoid sunburn while tanning by wearing an opaque garment whenever the skin becomes tender. There is not only no advantage in red linings, but disadvantage owing to the double layers. The work of Hare, L. Rogers, Haldane, Pembrey,

and others established that heat-stroke is caused by overheating the body. It is not an infectious disease, as Sambon has suggested (supported by Manson's authority), but is more liable to occur in those whose vasomotor mechanism is unstable, in the constipated, the drunken, the fatigued, or infected. Heat-stroke can be produced in normal men by appropriate conditions in the experimental chamber of the physiologist. Many cases occurred in fresh troops sent straight from England and certified free from malaria on their arrival at Basra. It can be prevented by simple treatment based on the physical laws of cooling. 107° to 108° F. seems to be the critical rectal temperature at which grave effects such as unconsciousness and convulsions result. Speedy reduction from such a temperature is demanded to avoid not only a fatal termination but tissue degenerations.

Men vary in their capacity of sweating, and thus, when in Mesopotamia in 1917, the temperature rose in stages, groups of cases occurred at 105°, 110°, 115°, 120° F. Such shade temperatures out of doors meant 130° to 140° F. in the still air of a tent on the hottest days! Thick walls, double roofs, and wide verandahs well ventilated, and fans are required to make such conditions tolerable. There were none of these things to start with. The treatment often recommended in 1917 appears to have been the rubbing of the skin with ice and ice enemata. Venesection and infusion were also tried as a last resource.

While evaporation of water at body temperature carries away 0.59 calorie per gram, the melting of ice only takes away 0.08 calorie per gram; rubbing the skin with ice, moreover, obstructs evaporation. Again, 70 grams of water evaporated from the skin takes away as much heat as 1,000 grams of iced water used as an enema.

The direct cause of heat-stroke in a hot, dry atmosphere such as Mesopotamia seems to be exhaustion of the sweating mechanism, hence diaphoretics are useless; the one treatment to immediately apply is artificial sweating, established by means of a water spray and fan. Such a method of treatment was, as Director-General Goodwin tells me, well known and practised in India before the war, but it had not become generalized and taught in the books. Fans and sprays were wanting to meet the fierce heat of the summer of 1917 in Mesopotamia.

G. K. Hearne found that he could pick out in his wards at Basra all cases in danger of heat-stroke by their dry skin; cessation of sweating, generally coupled with increased micturition, in every case preceded the rise of body temperature. Those who ceased to sweat asked for the roof fans to be turned off, because they, like the dry "kata" thermometer, were heated up by the wind—the air temperature being above body temperature. Those who were sweating, on the other hand, begged for the fans to be kept on because they were cooled by evaporation, just as the wet "kata" thermometer was cooled.

Hearne used the "kata" thermometer at Basra, and so secured a demonstration of these facts. Finding out the "dry" cases by frequent visits to each patient in his wards, he put on the water spray and fan treatment; by these simple means, so he tells me, he was able to stop all further cases of heat-stroke both in the wards and in the troopships. The great thing is to recognize the danger of the dry skin and get treatment in time. People must be warned of the danger of the skin going dry. Hearne found no signs of general exhaustion of the sympathetic system; it is the sweating mechanism in particular which fails. In the final stage of heat-stroke the patient lies cyanosed and comatose, with signs of respiratory embarrassment. The quick shallow breathing excited by heat washes CO₂ out of the blood, and so increases the alkalinity of the tissues. There is no acidosis then and no indication for the intravenous injection of a sodium bicarbonate solution. Gum saline may be tried for cases which come under treatment when collapsed, but the spray and wind treatment must first be set going.

Post mortem the organs of a case of heat-stroke show capillary congestion, as in wound-shock. Cramer lays stress on the signs of hyperaemia, followed by exhaustion of the thyroid and adrenal glands. Either infection or exposure to over-warm atmosphere has these effects. Hyperadrenalism leads to increased change of glycogen into sugar and greater heat production. Injection of a small dose of tetrahydrocannabinol into mice produces pyrexia with signs of increased activity of the sympathetic system. If the mice are kept in a cool room

they survive, but if crowded in a warm place they die of heat-stroke. The drug causes intense congestion of the thyroid, with changes in the colloid and very active secretion of adrenalin. It dilates the pupil, constricts the blood vessels, causes rapid respiration, restlessness, and spasms, changes liver glycogen into sugar, and increases the respiratory metabolism and heat production. Narcotics such as chloral counteract this experimental heat-stroke, and an animal kept narcotized long enough recovers from a fatal dose. It is obvious that, while narcotics might delay, they cannot stop heat-stroke when the air temperature is above body temperature and the patient cannot sweat.

Cramer's experiments show how infection and a hot atmosphere may have an accumulative effect in producing heat-stroke by each over-stimulating and exhausting adrenal action. Observations on lower organisms show that death from excessive heat is due neither to coagulation of proteins nor to want of oxygen, for the change produced by heat is reversible if not carried too far, and is not affected by increased oxygen tension. The ultra-microscope shows an augmentation in the number of granules in the living cell and a growth in their size as the temperature rises; the increasing aggregation, reversible up to a certain point, stops the reactions of life.

NOTE ON THE DIETETIC TREATMENT OF DIABETES MELLITUS.

BY

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In an article in the *BRITISH MEDICAL JOURNAL* in 1915 (March 13th) I recommended a line of treatment for certain cases of diabetes mellitus which I had found of much service in checking the glycosuria, temporarily at least. In cases uncomplicated by "acidosis" and certain other secondary affections, when the ordinary restriction of carbohydrates in the diet failed promptly to check the glycosuria, I advised complete rest, and for seven days a diet composed of a mixture of casein, cream, and water, given every two hours from 8 a.m. to 10 p.m. without any solid food. In many cases this diet promptly checked the glycosuria when other treatment had failed. At the end of the seven days a change was gradually made to a suitable solid diet, the amount of carbohydrates which the patient could tolerate being carefully noted.

During the war period, in place of the casein and cream solution I often used a diet composed chiefly of eggs and milk, given every two hours for seven days,¹ or a diet chiefly of suitable vegetables and jelly.² Both of these are more palatable, and are often useful, but not so frequently successful as the casein and cream solution. At the end of the war period the casein obtainable was often very unsatisfactory in taste and odour, and I have recently employed, with great success in many cases, the following mixture and course of treatment, which can be easily carried out. The mixture is a useful substitute for the casein and cream solution.

If "acidosis" and other serious complications can be excluded, and if an ordinary diabetic diet, with restriction of carbohydrates, fails to check the glycosuria promptly, then the patient is advised to rest on the sofa for seven days (or for a shorter period) and to take a mixture of eggs, cream, and water, prepared as follows: Three eggs are beaten up with 3 oz. of cream and a little water. More water is then added gradually until the mixture measures four pints. Of this mixture the patient takes half a pint (a tumblerful) every two hours from 8 a.m. to 10 p.m. (that is, eight times in the day). In addition he takes coffee or tea at 8 a.m. and 4 p.m., and also beef tea (warm) half a pint at 12 noon, 6 p.m., and 10 p.m. No bread, no meat, and no other foods are taken during this period.

In many cases the glycosuria is promptly checked in from four to seven days. This diet is not continued longer than seven days, and is then slowly changed to a solid diet containing only a small amount of carbohydrate food, the amount of bread and other carbohydrates which can be tolerated being carefully noted.

It is often found that not only has the glycosuria been temporarily arrested, but the power of carbohydrate