OTT (ISAAC)

Fever, Thermotaxis, and Calorimetry of Malarial Fever.

BY

ISAAC OTT, M. D.,

Ex-Fellow in Biology Johns Hopkins University, Ex-President American Neurological Association, Etc.

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1. Fever.

2. Thermotaxis and Thermo-polypnœa.

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ERRATA.

In paper on "Fever."

(1) "Cardio-inhibitory" for carotido-inhibitory.

(2) "Jenner" instead of Jenna.

(3) In sentence "thermotaxic centres at base of brain neither inhibit," add "except indirectly."

In paper on "Thermo-polypnœa."

Page 9, "Polypnœa" for dyspnœa.

Page 15, Metabolism is "increased" instead of decreased.

Page 20, Fig. 8, "Increase of H. P.," in the place of decrease of H. P.

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FEVER.

BY ISAAC OTT, M.D.

BY the term fever in this paper I mean a disorder or derangement of the temperature of the body. This will include the experimental fever with high temperature and increased thermogenesis, the exceptional cases where we have high temperature with diminished thermogenesis, and the experiments where we have subnormal temperature and a thermogenesis increased equal to a similar period on the food-day, as in Exp. 4.

Senator first studied thoroughly experimental fever with the calorimeter. He concluded that in the first stage of fever the discharge of heat is rather diminished than increased, so that at this period it is probable there is an abnormal retention. As the febrile process progressed towards its height, fluctuations exhibited themselves in the quantity of heat liberated which resembled those observed in the discharge of carbonic acid and aqueous vapor, but it could not be determined whether the amount of heat given off during the whole course of the fever was greater or less than the quantity of heat given off during the same period of apyrexia. Dr. Burdon Sanderson, in a commentary on this statement, remarks that in judging of the significance of the fact last stated it must be borne in mind that the normal with which the febrile thermogenesis is here compared is that of inanition. In the dog, when on adequate diet, the production of heat is at least fifty per cent. more

active. If therefore we were to take the animal in the ordinary condition of nourishment as our standard of comparison, we should find the heat production in fever very considerably diminished. Senator's experiments upon dogs were made as follows: each animal was placed for a sufficient time on horseflesh, which was increased or diminished until the body weight and daily discharge of nitrogen in urea and the "insensible" loss became severally constant. The diet was then continued as before until nitrogen equilibrium was once more established. This having been accomplished, fever was induced by the subcutaneous injection of perfectly fresh pus, and determinations of the same kind as had been previously made were repeated under exactly similar conditions as regards nutrition during a second period of forty-eight hours. Each experiment therefore comprised forty-eight hour periods of observation, separated from each other by an interval of several days, during which periods the production of heat, the changes of bodily weight, the daily quantities of urine and urea excreted, and respiratory and cutaneous discharges of carbonic acid and water, were determined. The carbonic acid determinations and the calorimetric observations, however, only related to limited periods of measurement each lasting an hour, repeated once or twice during the day. In only one series of calorimetric observations was the heat production measured for four hours, of which three were consecutive and the fourth separated by a four hours' interval. The calorimetric observations should have been made more frequently during the day to be of marked value.

Prof. Wood has made a number of experiments, running over about three-fourths of a day for four consecutive days. He mainly used dogs, and usually produced fever by the injection of putrid blood into the veins. The blood was injected at the end of the second day, which was the first hunger day, and he studied the fever for two consecutive days. In the pyæmic fever of dogs the H. P. was usually in excess of H. P. of fasting dogs, but less than that which could have been produced by high feeding. Usually the production of animal heat rose in the febrile state with the

temperature and with the stage of fever, but sometimes H. P. became very excessive, although the temperature of the body remained near the normal limit. In rabbits with pyæmic fever, H. P. seemed to be even greater than in health. His experiments were well calculated to determine the increase of H. P. in fever, but would have been more accurate if exactly similar periods of observations were compared on normal and fever days, on account of the hourly changes in H. P. due to rhythm.

Finkler[1] has made a most exhaustive study of experimental fever. He measured the oxygen consumed and the carbonic acid given off, and compared these with a time-unit and the weight of the animal. From his experiments the law is deduced that the consumption of oxygen is greater during the fever elevation of temperature than takes place in animals not feverish under like conditions of food and surrounding temperature. He also thinks that in fever there is increase of carbonic acid given off due to increased production. When the oxidation passes through the three phases of increase, continuance at a height and decrease, it corresponds only in a general way to elevation, continuance at a height, and decrease of temperature. Finkler arrived at the conclusion that fever is a neurosis, mainly a disease of the nervous system regulating the temperature. Pflüger's theory to explain the regulation of heat is as follows: An automatic centre which presides over the production of heat and another centre which acts upon the automatic centre as an inhibitory apparatus, and on its side stands in connection with the temperature nerves of the skin and is set into activity through the action of heat, so that coldness in general is not an irritant. When the excitation of the inhibitory centre slackens, then the automatic centre enters into activity, so that coldness of the skin corresponds to lessened formation of heat. Finkler explains the action of these centres in fever as follows: Intense increased oxidation destroys the substance generating fever. The chilly feeling and contraction of the capillaries

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[1] Pflüger's Archiv., 1882.

denotes increased heat production, that in the first stage of fever a stronger excitation of the automatic centre takes place, because the nerves of the inhibitory centre are in a more or less paralytic state. In the second stage of fever, when the temperature of fever is constant, the relations of the two centres are changed. The production of heat remains as in previous stage, increased to about the same extent. In the decrease of the fever oxidation sinks below normal.

A rhythm of H.P. and H.D.exists in fever,hence all calorimetric observations should be made at the same time of day on successive days; the length of time the animal remains in the calorimeter each day should be the same; the calorimeter in observations on successive days should be nearly at the same temperature and the external temperature should be about a degree above that of the calorimeter. To produce experimental fever there are several agents which may be used. Thus solutions of hæmoglobin, albumose, peptone, fibrin-ferment, neurine, sour milk, papayotin, sulphate of ammonium and large quantities of water when injected cause experimental fever. I selected putrid blood, as it gives a fever lasting for a considerable period. My experiments were made upon rabbits and cats. In one series hourly observations were taken every six hours during the day and night, on the four successive days, the first day food being withheld as on the successive days. At the end of the second day putrid blood was injected subcutaneously or by the jugular vein, or in both ways. In another series observations were made for the first three hours, then at the sixth, eighth and twenty-fourth hour at similar periods of the successive days. I did not permit the animal to remain in the calorimeter over three hours at longest, as I feared the condition of the animal would become abnormal, although it is true the abnormality would probably be the same in each period of successive days. The calorimeter used was d'Arsonval's, and with each degree of temperature the air is above that of the calorimeter, the error was .025 F. The air was aspirated through the hollow coil, lying in the water chamber by

means of Voit's respiration apparatus, and the amount drawn through the calorimeter given in litres. The amount of heat given to or taken from the air was not calculated, as it is small and would not have changed the result. Any one who wishes to can make the calculations, as the data are given, and satisfy himself on that point. In Exp. I., the normal average temperature on the second day, or hunger day, was 102° F., and on the first fever day the average temperature was 104° F., and H. P. was decreased 7.75 thermal units; on second fever day the average temperature was 103.7, and the decrease of H. P. was 5.0 thermal units. H. D. was decreased on the first fever day 8.0 units, and on second day 6.0 units. There was on second fever day in the morning period an increase of 2.0 units of H. P. over the same period of hunger day.

In Exp. 2, the average normal temperature on hunger day was 102.3° D., and on first fever day the temperature was 103.8°, with an increase of H. P. of 1.5 units and of H. D. of 1.3 units. On the second fever day the average temperature was 103.6°, and H. P. was decreased 2.5 and H. D. 2.7 units.

In Exp. 3, on hunger day the average temperature was 102.4°, and on first fever day 101.7, H. P. was decreased 4.2 and H. D. 6.8 units. On second fever day the temperature was 97.5° F., and H. P. was decreased 8.2 and H. D. 6.5 units.

In Exp. 4 the temperature on hunger day was 101.4, and on first fever day 101.4, with an increase of H. P. 1.2 and of H. D. 2.0 units.

On second fever day the temperature was 99°, with a decrease of H. P. 0.5 and H. D. .03 units.

In Exp. 5, the average temperature on hunger day was 101.7°, and on first fever day a temperature 102.8, with an increase of H. P. 1.0 and of H. D. a decrease of 5.0 units.

In Exp. 7, the normal temperature was 100.6, and on first fever day the temperature was 100.9, whilst H. P. was decreased 4. and H. D. 1.0 units.

In Exp. 8, the normal temperature was 100.7, and on first fever day a temperature of 102.2, with an increase of H. P. 1.2 and of H. D. 2.1 units.

On second fever day an average temperature 102.8°, with a decrease of 4.2 of H. P. and 4.0 of H. D. in units.

In Exp. 9, on hunger day an average temperature of 100.5 and on first fever day a temperature 102.6, with an increase of H. P. 5.1 and H. D. 3.0 units.

On second fever day, H. P. was increased 3.0 and H. D. decreased 3 units, whilst the average temperature was 102.7.

In the following table these experiments are summarized so that the increase or decrease of H. P. is given on the first and second fever days.

+ means increase, — decreased production.

	1st fever day. Increase and decrease of units of H. P. compared with the 2d normal day.	*2d fever day.* Increase and decrease of units of H. P. compared with the 2d normal day.
Exp. 1	— 7.75	— 5.0
" 2	+ 1.15	— 2.5
" 3	— 4.0	— 8.2
" 4	+ 1.2	— .50
" 5	+ 1.0	
" 7	— 4.0	
" 8	+ 1.2	— 4.2
" 9	+ 5.1	+ 2.4

By an examination of this table it is seen that five show increased heat production, whilst three indicate a decrease, on the first day.

On the second day H. P. was decreased in all except one. This is partly to be explained by food being withheld on the 1st day of the experiment.

As regards H. D. in four experiments, it was increased, and in four decreased. On second fever day it was diminished in all. At only one period of the experiments did the fever increment equal the H. P. of the first day of experiment. If, however, as in Exp. 10, on the first hunger day the H. P. and H. D. are taken for an hour, and then two drops of putrid blood are directly injected, H. P. will be increased during the next four successive hours and H. D. will also be found to be increased for the next two hours.

If Senator's experiments are taken and tabulated in a similar manner, we will have the following table. + means increased H. P., — indicates decreased H. P.

Seveu days.	*1st day.*	*2d day.*	*3d day.*
Observation 1	— 0.86	+ .8	
" 2	— 0.28	— 1.75	
" 3	— 2.73	— 2.65	0
" 4	+ .92	+ 1.62	— .81
" 5	— .34	+ 2.55	
" 6	+ 1.28	— .89	
" 7	A.M. — .06 P.M. + 1.34	A.M. — .99 P.M. + 2.44	A.M. — .94 P.M. — 1.49

A glance at the table will show that it would be impossible to draw any conclusions from them, either as to increment or decrement of H. P., a conclusion to which he also came. However, they seemed to show that primarily in fever H. P. is lessened. His results are due to using blood subcutaneously, which gave him a slight fever, and not continuing his observations long enough.

If Prof. Woods' results are tabulated in a similar way, they will be found as follows:

+ means increased H. P., — decreased H. P., compared with the second day.

	H. P. 1st fever day.	*H. P. 2d fever day.*
Exp. 110	+ 26	+ 31
" 111	+ 2	+ 5
" 112	— 6	+ 8
" 113	— 3	+ 18
" 114		+ 37
" 116	+ 3	

An examination of Prof. Wood's results show on the first fever day an increase of H. P. in three experiments, and a decrease of H. P. in two. On second fever day there is an increase in five.

These increments are much greater than those found by me, and are partly due to observations made at dissimilar parts of the day, without regard to the diurnal rhythm.

My animals were deprived of food twelve hours before any observation had been started. His were fed during the first day, and in a few on the second day. The amount of fever as measured by the thermometer was about the same in the experiments of Dr. Wood and in mine.

All these experiments tend to the same conclusion, that experimental fever is accompanied by an increased production of heat as a rule.

Exceptionally production is decreased.

In Fig. 1 (Exp. 9) is a delineation of the access of fever, it having been studied during the first three hours and at intervals afterward. It shows that after injection per jugular of two drops of putrid blood, the heat production rises rapidly and attains its height some hours before the fever curve attains its height. At the same time the curve of H. D. is lagging behind the curve of H. P., although following it in its upward ascent. After a while the H. P. curve falls temporarily beneath the curve of H. D. and the temperature curve falls. It will be seen normally and during the fever in the curve of H. P. that it exhibits fluctuations, a fact pointed out by Senator. The fluctuations of H. P. are greater in fever. I believe the fluctuations are due to the action of external agencies upon the thermotaxic, thermogenetic and thermolytic apparatus, which are playing at see-saw, at one time making H. P. greater than H. D., at another making H. D. greater than H. P.

In Fig. 2 (Exp. 1) there is an illustration of a high temperature, although H. P. and H. D. have fallen below normal of the hunger day or second day. In Exp. 4, we see that during three-fourths of the last fever day the temperature is below normal, and at the last observation H. P. is five units greater than those of same period on hunger day. The question arises how is Fig. 2 to be explained?

Dr. Donald McAlister has given an explanation of this. Suppose a tall vessel containing water, the level of the water representing temperature. Let two pipes be connected with this vessel, one conveying water, the other carrying it off. Let the inlet and exit tubes be each provided with a stop-cock, and let the two stop-cocks be

connected by a rigid link which insures that they always turn together and by the same amount. If to start with, the inflow and outflow are equal, then however I move the linked stop-cocks, the height of the water will be the same. Now remove the rigid link and connect the stop cocks by a spiral spring. If now you move the inflow stop-cock so as to increase the flow, the outflow one will not at once follow, and, the balance being broken, the level of water will rise. But shortly the elasticity of the spring comes into activity, the outflow is equal to the inflow and the rise will cease, but the new high level will be maintained. Every movement of either stop-cock will affect the level, which will fluctuate accordingly, but its height at any moment will not be an index of the amount of inflow at that moment, The inflow may be slight while the level is high. If now you substitute H. P. for inflow and H. D. for outflow, and the rigid link will represent the healthy thermotaxic mechanism, then when this is weakened or relaxed or broken the steadiness of the normal level is impossible.

Fig. 2 amply sustains this explanation. I have tried to determine what part of the thermal apparatus is the most essential for the development of fever. The skull of rabbits, under ether, has been trephined and part of the vault broken away, then all the cortex accessible destroyed with a blunt probe without disturbing the basal ganglia. After the animal recovered from the ether and shock, putrid blood was injected by the jugular, and still fever ensued. Recently Dr. Sawadowski has published a note proving that after removal of the corpora striata in dogs, putrid blood per jugular could not cause fever. He also demonstrated that antipyrin exerted its action through the corpora striata, for upon their removal no antipyretic effect was noticed. I have made a series of experiments upon this subject, and generally noted that after extirpation of the anterior ends of the corpora striata and the injection of putrid blood, a rise of temperature. If the striate bodies are completely extirpated, there is usually no rise by putrid blood. However, I have been fortunate enough in one experiment (14) to obtain a rise of half a degree, after removal of the striate

bodies, by injections of putrid blood. Notwithstanding the shock by removal of these bodies, the other basal centres will still respond to the septic poison. This rise is not due to simple extirpation of corpus striatum, for after the operation the temperature falls in rabbits for several hours.

It now remains to consider how far these facts are supported by clinical experience. Liebermeister sought to determine the H. D. in man by placing fevered persons in cold baths and noting the amount of heat given to the water. He calculated the amount of cooling which the water would undergo without the patient during the same time the patient was in it. This method is liable to many errors, which he sought to overcome in part. The loss of heat to the air and from the lungs could not be noted. He arrived at the conclusion that when baths of the same temperature are employed "without exception the loss of heat in the fever patient is greater than in the well person. The recent experiments of Fredericque and Quinquad prove that the cold bath itself increases H. P. and necessarily H. D. Prof. Leyden attempted the solution of the problem in a different manner upon patients affected with relapsing typhoid, and pneumonia. To determine the surface loss of heat a water calorimeter was employed, which was constructed on the same principle as the one usually employed in calorimetric work, except there was no provision for the continuous passage of a current of air. The apparatus consisted of a copper chamber,in which the limb was contained. It was two feet long and one foot wide. It was surrounded by a cylinder of zinc of corresponding form, but from three to four inches wide. The outer wall of the water chamber was protected from abstraction of heat by a thick padding of non-conducting material enclosed in a wooden case. The water was agitated by means of a special apparatus. The open end of the chamber was lined by an annular cushion of india-rubber, which, when the limb was introduced, occupied the space between its surface and that of the copper, so as to close the chamber air-tight. The leg of the patient was introduced into the apparatus, and the rubber cap covered the knee. When an observation was to be

made the calorimeter was warmed to the air temperature of the room, and each experiment lasted two hours. The leg was placed on a wooden support, so as not to touch the copper, and clothed with a blanket of the same thickness as the opposite leg. He found in a healthy person the mean rise of temperature in the apparatus, and compared his fever observations with it. He arrived at the conclusion, first that the discharge of heat is increased in fever whether the temperature is constant, falls, or rises. Consequently it is certain that the production of heat is increased. In high fever the quantity of heat given off is from half as much again as the normal to twice as much. The most rapid discharge of heat takes place in the critical stage when the temperature is rapidly sinking. It may then be twice or even three times as great as normal. This rapid critical dissipation takes place with profuse sweating.

Senator believed that Leyden's observations proved two facts: 1st, that with the exception of the initial stage, the discharge of heat is considerably increased, although by no means constantly; second, that the activity of the discharge is not proportional to the bodily temperature, for it may be less when the temperature is high than when it is lower, it may be normal when the temperature is above normal, always attaining its maximum in the stage of defervescence with critical sweating. From Leyden's data he concludes the average loss of heat in fever to be seventy to seventy-five per cent., although his calorimetric observation on animals gave no definite result.

Senator's general conclusion on fever was that the discharge of heat is in the outset of fever, during the rigor, not increased but diminished; during the height of the fever it is on the whole increased seventy-five per cent, and considerably more during the critical defervesence.

Dr. Sanderson has also calculated the amount of heat in fever by using Frankland's heat value of the immediate principles of food—albumen, fat, and carbonic hydrates—when converted by oxidation into urea and carbonic acid. He arrives at the conclusion that less heat is produced in fever than when the man is fed up to food-limit, but very

much more heat is produced in the febrile state than when the man is kept without food. It must be remembered that Liebermeister and Leyden believe H. P. in fever is increased even beyond that of the food limit, an increase absolute.

Dr. Carl Rosenthal has recently investigated fever by means of a calorimeter somewhat similar to that used by Prof. Leyden, except the constricting band of rubber is wisely omitted. He used the arm instead of the leg. He arrives at the conclusion that the elevation of temperature in fever is mainly due to a diminution of the H. D. There takes place simultaneously a heaping up of heat produced in the normal manner through the diminution of the H. D. It is absolutely unnecessary to have an accompanying increase of H. P. The diminution of H. D. happens in the following way. The fever agent circulating in the blood acts specifically upon a vaso-motor centre, either by a direct excitation of the vaso-constrictors, a vaso-motor contraction and diminution of H. D., or the vaso-dilators have their activity reduced, by which the vaso-constrictors obtain control and thus in an indírect manner diminish H. D. Whilst he believes diminished H. D. to be the prinpal and, in the first place, the cause of the fever, he holds it secondarily to be perhaps due to an increased production, whose origin is to be sought in an increased chemical metamorphosis which is expressed by increased discharge of urea, and is caused perhaps by changes in the blood itself by the abnormal elevation of its temperature. These experiments upon an extremity are not as satisfactory as they might be. The better plan is to do as Langlois did, put the fevered child in a calorimeter completely surrounding it, and then study H. P. and H. D. of the whole body. This is the more easy, as d'Arsonval and I have constructed a calorimeter for observations upon the whole body of a man. In a hundred and eleven observations, mainly on fever of broncho-pneumonia of children, with some on varicella, Langlois found the H. P. to be increased corresponding with the rise of temperature, but the radiation of heat is not always in constant relation with the temperature. In chronic maladies with hyperthermia, there

was a diminution of the H. P., whilst in acute disease the augmentation was ten to fifteen per cent. of H. P.

If now we take the experimental data and the majority of the clinical conclusions, the result must be arrived at that fever is usually temporarily accompanied by an increased production of heat, an increase beyond that normally seen in a fasting state, but not equal to the amount produced upon a full diet. Fever cannot be due to retention of heat in my experiments, as injections of putrid blood do not elevate the arterial tension but lower it, which would cause greater dissipation. It is probable that in man during the chill the heat dissipation is temporarily lessened, and co-operates with the increased production to elevate the temperature. I wish to state here that the temperature of fever has no relation to the increased production of heat. The temperature is decided by the relation between H. P. and H. D.; they may be high or low in amount, as my curves show. All calorimetric experiments upon pyæmic fever show that H. D. is not usually decreased but increased at the time fever is generated. The researches upon albumose, peptone and neurin fever, although not accurate, support these views. In peptone fever there is a temporary fall of H. P., but the temperature rises as it does in albumose fever, but in albumose fever the H. P. does not fall but rises immediately. It is thus possible to partly differentiate an albumose from a peptone, the peptone producing a temporary decrease of H. P. before it rises, whilst an albumose causes an immediate rise of H. P. There is no reason to believe that the physical and chemical processes of fever differ from those normally going on. The thermotaxic centres at the base of the brain neither inhibit nor excite H. P.; all they do is to maintain the balance between H. P. and H. D., so as to keep the temperature at 98.4° F. The two cortical thermotaxic centres also assist. Now, in fever, these thermotaxic centres are so disordered that it is mainly the basal thermotaxic which are affected that the relation between H. P. and H. D. is so disturbed that a higher temperature results and continues. This is the part affected in fever. Neither increased pro-

duction, diminished dissipation or even high temperature are necessary to constitute a fever, but it is only a disease of thermotaxic centres and mainly the four basal thermotaxic. A similar theory has been put forth by Liebermeister, but he did not prove it, nor did he understand the mechanism or the location of these basal thermotaxic centres in the production of the temperature part of fever.

My experimental researches lead me to believe that fever is due to an agent from within or without which deranges the harmony of the thermotaxic, thermogenetic and thermolytic apparatuses, by which in the initial stage the metabolism of the tissues is usually temporarily increased and this increment is usually greater than that generated upon a restricted amount of nutriment. It is highly probable that during the chill heat dissipation is temporarily diminished, but it usually follows the fluctuations of heat production. The four basal thermotaxic centres play the most important part in the temperature-phenomena of fever. That neither increased production nor diminished dissipation are necessary to constitute fever is shown in Fig. 2, where heat production is diminished, although the temperature is elevated, and in Exp. 4, at one period the temperature is subnormal, yet the heat production is greatly increased above that seen on a similar period of the preceding day.

High temperature does not cause gravity in fever, for in nervous disorders and in relapsing fever we have high temperatures, 106° F., and no serious symptoms are present. High temperature is an indication of danger in specific fever, not the cause of it. But temperature is only a part of a specific fever, there are many other morbid processes going on, the essence of which has not been grasped. Sir William Jenna puts the facts tersely when he states: "There can be no doubt that the necessity for a healthy condition of the blood is as essential to the formation of normal secretions as a healthy state of the nervous system. But while we think there is strong evidence in favor of the primary affection of the blood and of the wide-spread and fearfully severe influence on the system generally of the very deep lesion which in many cases we can demonstrate

the blood to have experienced independently of mere admixture of excess of excrementitious matters, we by no means exclude the nervous system or any other part of the body from a share in the production of the symptoms of fever."

It has been observed (very rarely I think) that in meningitis, peritonitis, and certain cases of typhoid fever, that the temperature is normal or subnormal. I have shown that in the cortex of lower animals are localized thermotaxic centres, the cruciate and Sylvian, whose function it is to act in harmony with the basal thermotaxic centres to regulate the temperature of the body. In a recent paper I have also shown that in man there are very good reasons to believe in the localization of cortical thermotaxic centres. Now in meningitis the inflammation of the membranes by contiguity may so disorder the thermotaxic centres of the cortex that the temperature may become subnormal, instead of being above normal by an alteration of the harmony between the heat production and heat dissipation. In lower animals it is well known that peritoneal irritation as well as in man greatly reduces the force and frequency of the heart by reflexly stimulating the carotid-inhibitory apparatus and thus keep metabolism at a low point in the primary stage of a peritonitis. In the subnormal cases of temperature of typhoid patients it is easy to see that the disorder of the thermotaxic centres may be such that the relation of H. P. to H. D. is so arranged that the temperature becomes subnormal. An antipyretic usually temporarily produces this state of affairs in normal state. That acute observer, Dr. W. Hale White, has propounded a theory that the cause of fever in certain cases acts upon the nervous centres not directly, but indirectly through the nerves. He states that the rise of temperature noted in fever which is symptomatic of local inflammation bears no relation to the extent of the inflammatory disturbance and that the tension of the neighboring tissues plays a more important part in the production of fever than does the amount of inflammation. It is certainly the case, he states, that in abscess the temperature as a rule is highest where there is pain, and pain in abscess

means tension. Dr. White believes that the "calorific centres" of the brain are affected reflexely by the tension of the inflamed parts acting as a stimulant which takes off their normal inhibition. It has not been my experience that irritation of a sensory nerve will elevate the temperature for any length of time, except in cases of poisoning by atropin, where irritation causes a rise. I shall elaborate the mechanism of the thermotaxic centres in another paper on thermo-polypnœa.

Appended are the experiments upon which the preceding statements are based.

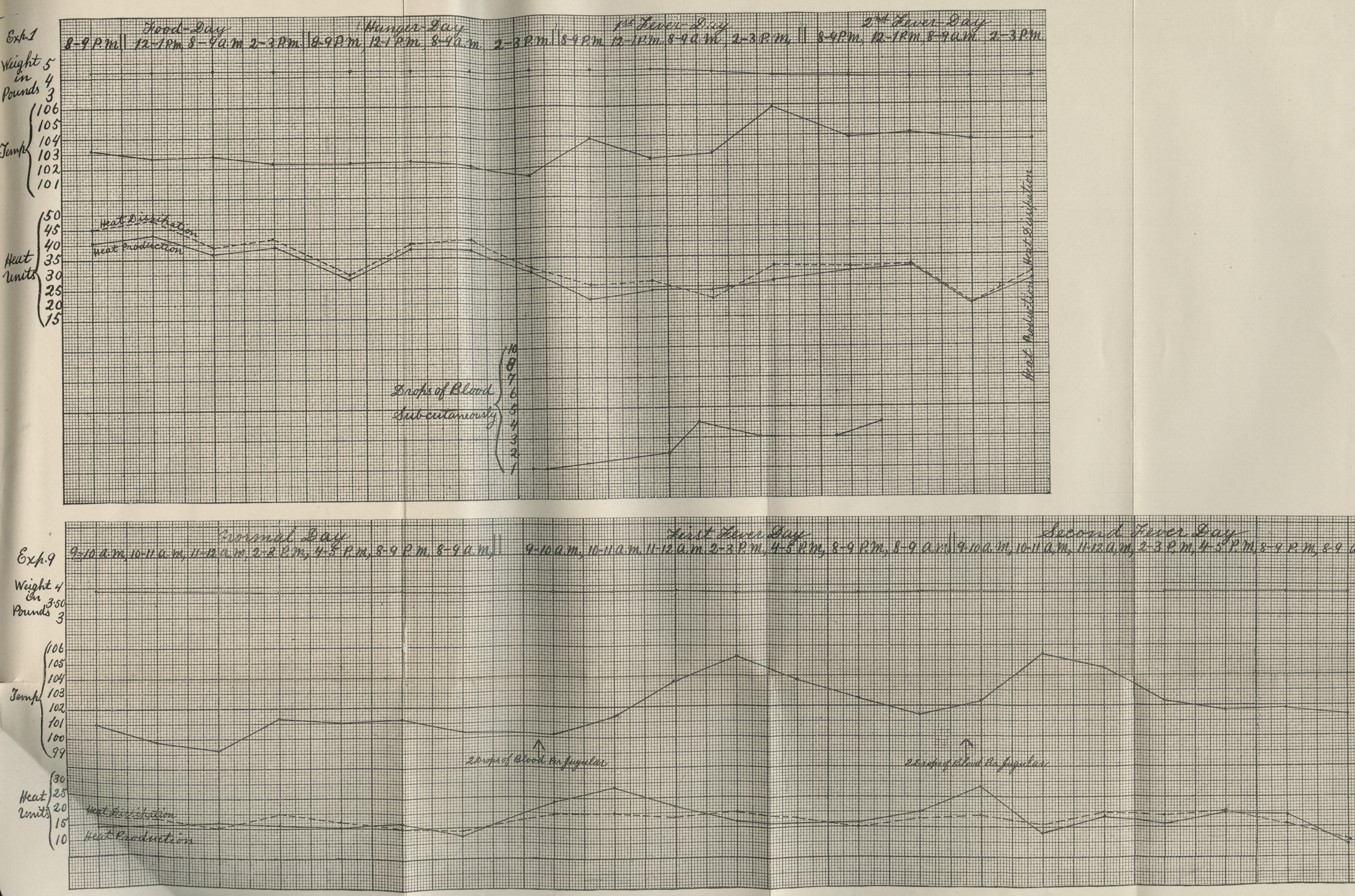
In these experiments the first day without food is called the "food day;" the second day, the "hunger day."

A. T. means air temperature.
C. T. " calorimeter temperature.
E. T. " exit tube "
R. T. " rectal "
H. D. " heat dissipation.
H. P. " heat production.
Weight " weight in pounds.
Litres " litres of air.

EXP. 1.—Cat.

Food Day.

P. M.	A. T.	C. T.	E. T.	R. T.	
8.00	74.9	72.4	24.1	103.2	Weight 4.42
9.00	74.3	73.5	24.	101.6	
		+ 1.1		— .6	
	H. P. = 40.02		H. D. = 45.89		
A. M.					Weight 4.40
12.30	75.0	73.4	23.9	102.9	
1.30	75.1	74.55	25.7	101.0	
		+ 1.15		— 1.9	
	H. P. = 39.58		H. D. = 47.97		
A. M.					Weight 4.34
8.20	73.3	72.95	24.3	102.9	
9.20	73.8	73.9	24.4	102.0	
		+ .95		— .9	
	H. P. = 36.39		H. D. = 39.63		


Exp. 1
Food-Day
Hunger-Day
1st Fever-Day
2nd Fever-Day
8-9 P.M. 12-1 P.M. 8-9 a.m. 2-3 P.M. 8-9 P.M. 12-1 P.M. 8-9 a.m. 2-3 P.M. 8-9 P.M. 12-1 P.M. 8-9 a.m. 2-3 P.M. 8-9 P.M. 12-1 P.M. 8-9 a.m. 2-3 P.M.
Weight in Pounds
5
4
3
Temp
106
105
104
103
102
101
Heat Units
50
45
40
35
30
25
20
15
Heat Dissipation
Heat Production
Drops of Blood Subcutaneously
10
9
8
7
6
5
4
3
2
1
Exp. 9
Normal Day
First Fever Day
Second Fever Day
9-10 a.m. 10-11 a.m. 11-12 a.m. 2-3 P.M. 4-5 P.M. 8-9 P.M. 8-9 a.m.
9-10 a.m. 10-11 a.m. 11-12 a.m. 2-3 P.M. 4-5 P.M. 8-9 P.M. 8-9 a.m.
9-10 a.m. 10-11 a.m. 11-12 a.m. 2-3 P.M. 4-5 P.M. 8-9 P.M. 8-9
Weight in Pounds
4
3.50
3
Temp
106
105
104
103
102
101
100
99
Heat Units
30
25
20
15
10
Heat Dissipation
Heat Production
20 drops of Blood Per Jugular
22 drops of Blood Per Jugular

P. M.					Weight 4.34
2.00	75.0	73.6	23.9	102.2	
3.00	74.6	74.6	24.5	101.3	
		+ 1.		— 1.	
	H. P. = 38.12		H. D. = 41.72		

Hunger Day.

P. M.	A. T.	C. T.	E. T.	R. T.	Weight 4.34
8.10	75.8	74.7	25.0	102.4	
9.10	75.4	75.4	24.5	102.2	
		+ .7		— .2	
	H. P. = 28.49		H. D. = 29.20		
A. M.					Weight 4.28
12.30	76.1	75.55	26.3	102.4	
1.30	78.1	76.50	26.2	102.0	
		+ .95		— .4	
	H. P. = 38.21		H. D. = 49.63		
A. M.					Weight 4.12
8.15	76.4	74.95	26.0	102.0	
9.15	77.5	75.95	25.9	101.4	
		+ 1.00		— .6	
	H. P. = 39.67		H. D. = 41.72		
P. M.					Weight 4.12
1.45	79.3	76.0	26.5	101.5	
2.45	78.7	76.75	26.2	101.4	
		.75		— .4	
	H. P. = 30.95		H. D. = 31.29		

P. M.	
3.00	1 gtt. of blood several months old, subcutaneously.
4.00	102.8
5.15	103.1

First Fever Day.

P. M.	A. T.	C. T.	E. T.	R. T.	
7.55	80.6	78.1	26 7	103.9	
8.55	79.3	78.75	26.6	102.3	
		+ .65		— 1.6	
	H. P. = 21.27		H. D. = 27.11		
A. M.					Weight 4.2
12.42	78.7	78.65	25.8	102.5	
1.42	79 5	79.3	27.0	101.8	
				.7	
	H. P. = 24.77		H. D. = 27.11		

A. M.

1.43	2 gtts. of blood several months old, subcutaneously.				
6	3 "	"	"	"	" "
8	3 "	"	"	"	" "
8.39	1 "	"	"	"	" "
8.40	75.6	75.65	25.6	103.8	
9.40	76.2	76.2	25.9	104.3	
				·5	

H. P. = 24.60 H. D. = 22.94

10.00	3 gtts. of blood several months old, subcutaneously.				
11.20				104.4	

P. M.

1.20	3 gtts. of blood several months old, subcutaneously.				Weight 3.98
2.05	78.7	76.1	26.4	105.8	
3.05	79.5	76.9	26.7	104.2	
				16.	

H. P. = 27.60 H. D. = 33.37

Second Fever Day.

P. M.

8.14	3 gtts. of blood several months old, subcutaneously.				
	A. T.	C. T.	E. T.	R. T.	Weight 3.98
8.15	81.3	77.95	27.2	103.9	
9.15	78.7	78.7	26.3	103.65	
		+ .75		— .25	

H. P. = 30.46 H. D. = 31.28

A. M.

12.45	4 gtts. of blood several months old, subcutaneously.				Weight 3.96
12.47	78.6	78.6	27.2	104.0	
1.47	80.3	79.5	28.2	104.1	
		+ .9		.1	

H. P. = 37.87 H. D. = 37.54

8.04	10 gtts. of blood several months old, subcutaneously.				Weight 3.88
8.05	77.1	77.0	25.4	103.6	
9.05	76.4	77.5	25.5	103.6	
		+ .5			

H. P. = 20.86 H. D = 20.86

11.50				104.0
P. M.				
1.54	10 gtts. of blood several months old, subcutaneously.			
1.55	77.8	77.1	26.	103.6
2.55	78.8	77.8	26.6	103.5
		+ .7		— .1
	H. P. = 28.88		H. D. = 29.20	
3 15	1 gtt. of blood several months old, per jugular.			
3.20	79.1	77.9	26.7	104.2
4.20	80.1	78.45	27.6	105.3
		.55		
	H. P. = 26.48		H. D. = 22.94	

EXP. 2.—Rabbit.

Food Day.

A. M.	A. T.	C. T.	E. T.	R. T.	Weight 5.16
8.10	69.7	68.85	22.5	102.4	
9.10	71.1	69.9	22.5	101.5	
		+ 1.05		— .9	
	H. P. = 40.05		H. D. = 43.80		
P. M.					Weight 5.16
1.45	71.6	69.8	22.5	102.0	
2.45	91.8	70.95	22.1	101.4	
		+ 1.15		— .6	
	H. P. = 45.41		H. D. = 47.97		
					Weight 5.1
7.35	71.9	71.1	22.2	102.9	
8.35	73.5	72.05	22.6	102.4	
		+ .95		— .5	
	H. P. = 37.52		H. D. = 39.63		
A. M.					Weight 4.96
12.42	72.5	72.2	22.2	102.4	
1.42	75.3	73.2	22.6	102.7	
		+ 1.0		+ .3	
	H. P. = 42.72		H. D. = 41.72		

Hunger Day.

A. M.	A. T.	C. T.	E. T.	R. T.	Weight 4.94
8.35	72.8	72.3	27.5	102.3	
9.35	74.6	73.2	27.4	102.4	
		+ .9		+ .1	
	H. P. = 37.95		H. D. = 37.54		

P. M.				Weight 4.80
1.45	76.4	73.35	102.2	
2.45	77.0	74.2	102.4	
		.85	+ .2	
	H. P. = 36.72		H. D. = 35.46	
				Weight 4.80
8.02	78.3	75.55	102.7	
9.02	78.0	76.55	102.8	
		+1.00	+ .1	
	H. P. = 40.02		H. D. = 39.63	
A. M.				Weight 4.74
1.58	78.	76.75	102.3	
2.58	78.1	77.49	102.8	
		+ . 74	+ .5	
	H. P. = 32.84		H. D. = 30.87	
3.7	1 gtt. of blood several months old, subcutaneously.			

First Fever Day.

A. M.				Weight 4.68
8.14	1 gtt. of blood several months old, subcutaneously.			
8.15	77.1	76.85	103.4	
9.15	77.9	77.8	103.7	
		.95	+ .3	
	H. P. = 40.83		H. D. = 39.63	
P. M.				Weight 4.6
1.32	1 gtt. of blood several months old, subcutaneously.			
1.33	80.1	77.95	103.9	
	79.7	78.85	103.7	
		.90	— .2	
	H. P. = 36.78		H. D. = 37.54	
7.48	3 gtts. of blood several months old, subcutaneously.			
7.50	81.0	79.5	103.8	
	78.3	80.3	103.9	
		+ .8	+ .1	
	H. P. = 33.74		H. D. = 33.37	
A. M.				
12.30	5 gtts. of blood several months old, subcutaneously.			
12.31	80.4	80.3	105.1	
1.31	81.5	81.2	104.4	
		+ .9	+ 1.3	
	H. P. = 42.53		H. D. = 37.54	

Second Fever Day.

Weight 4.40

A. M.				
8.6	5 gtts. of blood, subcutaneously.			
8.7	79.6	79.6		103.6
9.7	82.2	80.35		103.8
		·75		+ .2
	H. P. = 32.02		H. D. = 31.29	

1.56	12 gtts. of blood, subcutaneously.			
P. M.				Weight 4.30
1.58	83.1	80.10		103.6
2.58	81.1	80.9		103.8
		+ .8		+ .2
	H. P. = 34.08		H. D. = 33.37	

8.0	10 gtts. of blood injected into the peritoneal cavity.			
8.5	80.1	80.2		103.8
9.5	81.6	81.0		105.2
		+ .8		+ 1.4
	H. P. = 38.29		H. D. = 33.37	

A. M.				
1.	15 gtts. of blood into peritoneal cavity.			
				Weight 4.14
1.2	81.3	81.0		103.6
2.2	82.8	81.8		103.1
		+ .8		— .5
	H. P. = 31.66		H. D. = 33.37	

EXP. 3.—Dark-colored rabbit.

Food Day.

P. M.	A. T.	C. T.	E. T.	R. T.	
12.35	74.6	74.3	24.6	102.3	Weight 3.74 Litres of air drawn through calorimeter 124.25
1.35	75.1	75.1	24.0	101.9	
	H. P. = 31.51		H. D. = 33.37		
					Weight 3.72
8.07	74.1	73.85	24.4	102.4	Litres of air 126.62
9.07	75.4	74.5	24.6	101.8	
		+ .4		— .6	
	H. P. = 25.27		H. D. = 27.12		

A. M.					Weight 3.66
2.00	75.9	75.15	24.7	102.1	Litres 111.50
3.00	77.3	75.9	25.0	101.2	
	H. P. = 31.59		H. D. = 31.29		
					Weight 3.56
7.55	77.8	76.1	26.3	102.8	Litres 123.67
8.55	78.3	76.8	26.0	101.5	
				— 1.3	
	H. P. = 25.36		H. D. = 29.20		

Hunger Day.

P. M.					Weight 3.54
12.37	77.3	77.3	25.9	102.1	Liters 118.37
1.37	78.1	77.8	26.2	101.8	
		+ .5		— .3	
	H. P. = 19.98		H. D. = 20.86		
					Weight 3.5
8.17	72.0	71.7	23.6	101.8	
9.17	73.2	72.35	22.8	100.7	Litres 116.11
		+ .65		— 1.1	
	H. P. = 23.92		H. D. = 27.11		
A. M.					Weight 3.44
1.45	73.3	72.4	24.3	101.5	Litres 113.75
2.45	74.3	73.0	24.2	101.2	
		+ .6		— .3	
	H. P. = 24.17		H. D. = 25.03		
					Weight 3.36
7.55	74.0	73.1	24.6	101.5	Litres 106.12
8.55	75.6	73.8	24.3	100.7	
		+ .7		— .8	

9.00 1 gtt. of blood several months old, subcutaneously.

First Fever Day.

P. M.					Weight 3.32
12.35	1 gtt. of old blood, subcutaneously.				
12.36	74.2	74.18	24.1	101.0	Litres 106.05
1.36	75.7	74.80	25.1	100.8	
		+ .62		— .2	
	H. P. = 25.31		H. D. = 25.86		

Weight 3.24

8.00	5 gtt. of blood, subcutaneously.				
8.20	67.6	68.7	21.4	100.9	Litres 47.57
9.20	70 0	69.2	21.4	99.6	
		+ .5		— 1.3	
	H. P. = 17.31		H. D. = 20.86		

9.30 5 gtt. of blood 13 days old, subcutaneously.
11.20 5 gtt. of blood 13 days old, into peritoneal cavity.

12 M.				99.6	
A. M.					Weight 3.18
1.45	5 gtt. of blood 13 days old, subcutaneously.				
1.50	72.1	69.4	23.0	95.6	Litres 211.00
2.50	74.1	69.98	22.9	94.8	
		+ .58		— . 8	
	H. P. = 22.08		H. D. = 24.19		

					Weight 3.14
7.45	71.5	70.6	22.5	90.6	Litres 113.35
8.45	71.2	71.2	22.4	88.2	
		+ .6		— 2.4	
	H. P. = 18.78		H. D. = 25.03		

9.30 Animal dead.

EXP. 4.—White rabbit.

Food Day.

P. M.	A. T.	C. T.	E. T.	R. T.	
					Weight 3.58
1.44	75.1	75.1	24.0	100.9	Litres 115.37
2.44	76.8	75.7	24.9	101.7	
		+ .6		+ .8	
	H. P. = 27.40		H. D. = 25.03		

					Weight 3.5
9.20	77.0	74.55	24.8	101.3	Litres 119.87
10.20	76.2	75.15	24.7	100.9	
				— 4	
	H. P. = 23.87		H. D. = 25.03		

					Weight 3.52
A. M.					
3.00	77.3	75.9	25.0	101.0	Litres 129.70
4.00	77.3	76.35	25.3	101.1	
		+ .45		+ .1	
	H. P. = 19.06		H. D. = 18.77		

					Weight 3.50
8.55	78.3	76.8	26.0	101.8	Litres 119.82
9.55	78.5	77.35	26.3	102.0	
	H. P. =	23.52	H. D. =	22.94	

Hunger Day.

P. M.					Weight 3.42
1.37	78.1	77.8	26.2	102.1	Litres 118.44
2.37	82.8	78.35	28.2	102.2	
		+ .55		+ .1	
	H. P. =	23.22	H. D. =	22.94	
					Weight 3.34
9.17	73.2	72.35	22.8	101.4	Litres 113.55
10.17	73.0	72.8	22.8	101.0	
		+ .45		— .4	
	H. P. =	17.66	H. D. =	18.77	
A. M.					Weight 3.28
2.45	74.3	73.0	24.2	101.4	Litres 102.41
3.45	74.8	73.6	24.0	100.3	
		+ .6		— 1.1	
	H. P. =	22.03	H. D. =	25.03	
					Weight 3.28
8.55	75.6	73.8	24.3	100.8	Litres 97.38
9.55	75.5	74.3	24.3	100.7	
	H. P. =	20.59	H. D. =	20.86	

10.05 1 gtt. of blood several months old, hypodermically.
1.32 2 gtt. " " " "

First Fever Day.

P. M.					Weight 3.22
1.37	75.7	74.8	25.1	102.3	Litres 169.12
2.37	78.9	75.35	26.1	102.3	
		·55		— .0	
	H. P. =	22.94	H. D. =	22.94	
					Weight 3.14
9.15	5 gtt. of blood several months old, subcutaneously.				
9.20	70.0	69.2	21.4	100.2	Litres 94.47
10 20	71.7	69.7	21.9	100.7	
	H. P. =	22.16	H. D. =	20.86	

Weight 3.10

A. M.					
2.45	5 gtt. of blood 13 days old, subcutaneously.				
2.50	74.1	69.98	22.9	101.3	Litres 106.75
3.50	72.5	70.60	22.2	100.2	
		+ .62		+ 1.1	
	H. P. =	23.02	H. D. =	25.86	

Weight 3.10

8.44	10 gtt. of blood, 13 days old.				
8.45	71.7	71.2	22.4	102.1	Litres 103.82
9.45	74.0	71.8	23.7	100.2	
		+ .6		— 1.9	
	H. P. =	20.14	H. D. =	25.86	

Second Fever Day.

P. M.					
1.35	5 gtt. of blood 13 days old, subcutaneously.				
1.37	71.7	71.65	23.2	101.7	Litres 103.70
2.37	73.0	72.20	22.8	100.3	
		.55		— 1.4	
	H. P. =	19.34	H. D. =	22.94	

Weight 3.00

A. M.					
8.00	1 gtt. of blood 13 days old, per jugular.				
9.10	69.5	69.7	21.8	99.1	Litres 73.02
10.10	72.2	70.05	22.7	100.4	
		+ .35		+ 1.3	
	H. P. =	17.83	H. D. =	14.60	

2.35	5 gtt. of blood 13 days old, subcutaneously.				
2.40	71.3	69.7	22.5	98.4	Litres 62.62
3.40	73.2	70.25	22.6	97.5	
		+ .55		— .9	
	H. P. =	20.75	H. D. =	22.94	
8.50	73.1	71.0	22.8	97.1	Litres 105.75
9.50	74.3	71.6	23.2	97.2	
		+ .6		+ .1	
	H. P. =	25.27	H. D. =	25.03	

EXP. 5.—Fawn-colored rabbit.

Food Day.

A. M.	A. T.	C. T.	E. T.	R. T.	
8.10	67.4	67.3	21.1	101.9	Weight 3.5 Litres 55.52
9.10	69.8	68.05	21.1	101.8	
H. P. = 31.00		H. D. = 31.29.		Weight 3.46	
P. M.					Litres 33.32
1.45	73.1	68.95	22.6	102.5	
2.45	74.9	69.85	24.3	101.8	
		·9		— .7	
	H. P. = 35.53		H. D. = 37.54		
P. M.					Weight 3.34
8.15	76.6	72.55	2.40	102.1	Litres 73.85
9.15	76.1	73.25	2.40	101.8	
		+ .7		— .3	
	H. P. = 28.37		H. D. = 29.20		
A. M.					Weight 3.34
12.45	73.7	74.0	23.6	102.1	Litres 120.
1.45	77.	74.65	24.7	102.1	
		+ .65		.0	
	H. P. = 27.11		H. D. = 27.11		

Hunger Day.

A. M.					
8.15	73.3	74.25	24.1	101.7	Weight 3.3 Litres 105.0
9.15	75.9	74.7	24.5	101.7	
		+ .45		.0	
	H. P. = 18.77		H. D. = 18.77		
P. M.					Weight 3.3
1.45	77.2	75.3	25.6	101.4	Litres 115.0
2.45	78.0	75.8	25.5	102.0	
		+ .5		+ .6	
	H. P. = 22.50		H. D. = 20.86		
					Weight 3.28
7.55	78.2	76.3	26.3	101.9	Litres 117.5
8.55	78.6	76.85	26.0	102.0	
		+ .55		+ .1	
	H. P. = 23.21		H. D. = 22.94		

A. M.					Weight 3.28
12.40	77.6	77.45	26.7	102.0	Litres 115 0
1.40	79.7	78.0	25.7	101.8	
		+ .55		— 2.	

H. P. = 22.4 H. D. = 22.94

2.55 1 gtt. of blood six days old, subcutaneously.
7 00 3 gtts. " " " " "

First Fever Day.

A. M.					Weight 3.08
8.20	73.5	73.4	24.3	102.0	Litres 100.0
9.20	75.3	73.8	24.4	102.3	
		+ .4			

H. P. = 17.44 H. D. = 16.68

8.30 3 gtts. of blood six days old, subcutaneously.
12.00 5 gtts. " " " " "

P. M.					Weight 3.0
1.50	76.	74.4	25.2	103.6	Litres 72.5
2.50	76.9	75.0	24.9	103.6	
		+ .6		.0	

H. P. = 25.03 H. D = 25.03

5.30 7 gtts. of blood six days old, hypodermically.
6.30 Lying on side, rolling from side to side, clonic and tonic convulsions, opisthotomos, trismus, death.

EXP. 6.—White rabbit.

Food Day.

A. M.	A. T.	C. T.	E. T.	R. T.	Weight 2.9
9.10	69.8	68.05	21.1	101.1	
10.10	69.9	68.7	21.1	101.6	Litres 140.30
		+ .65		.5	

H. P. = 28.31 H. D. = 27.11

P. M.					Weight 2.82
2.40	Animal aborted.				
2.45	74.9	69.85	24.3	101.4	Litres 93.10
3.45	77.	70.6	24.1	101.8	
		+ .75		+ .4	

H. P. = 30.36 H. D. = 31.29

9.15	76.1	73.25	24.	101.5	Weight 2.76
10.15	76.6	73.9	24.8	101.6	Litres 106.35
		+ .65		+ .1	
	H. P. =	27.34	H. D. =	27.11	
A. M.					Weight 2.72
1.45	77.	74.65	24.7	101.5	Litres 125.00
2.45	75.7	75.3	24.7	101.7	
		+ .65		+ .2	
	H. P. =	27.51	H. D. =	27.11	

Hunger Day.

A. M.					Weight 2.66
9.15	75.9	74.7	24.5	101.5	Litres 120.00
10.15	78.2	75.3	25.8	101.5	
		+ .6		.0	
	H. P. =	25.03	H. D. =	25.03	
P. M.					Weight 2.66
2.45	78.0	75.8	25.5	102.0	Litres 110.00
3.45	79.5	76.45	26.3	102.0	
		+ .65		.0	
	H. P. =	27.11	H. D. =	27.11	
8.55	78.6	76.85	26.0	101.6	Weight 2.60
9.55	77.9	77.3	25.9	101.7	Litres 100.00
		+ .45		+ .1	
	H. P. =	18.98	H. D. =	18.77	
A. M.					Weight 2.52
1.45	79.7	78.	25.7	101.7	Litres 110.00
2.45	79.1	78.4	25.7	102.1	
		.4		+ .4	
	H. P. =	17.51	H. D. =	16.68	

A. M.
2.55 1 gtt. of blood six days old, hypodermically.
7.05 3 gtt. " " " " "

First Fever Day.

A. M.					Weight 2.5
9.20	75.3	73.8	24.4	102.9	Litres 97.50
10.20	76.6	74.35	24.8	103.6	
		+ .55		+ .3	
	H. P. =	24.39	H. D. =	22.94	

12.30 5 gtt. of blood 6 days old, subcutaneously.

P. M.					Weight 2.4
3.0	76.9	75.05	25.3	103.6	Litres 100.0
4.0	77.4	75.55	25.3	104.1	
		+ .5		+ .5	
	H. P. = 21.85		H. D. = 20.86		

6.30 5 gtt. of blood 6 days old, subcutaneously.

Weight 2.34

9.15 Animal died, considerable diarrhœa preceding.

EXP. 7.—White Rabbit.

Hunger Day.

A. M.	A. T.	C. T.	E. T.	R. T.	Weight 4.94
8.55	76.3	73.3	25.2	100.2	Litres 75.00
9.55	75.0	74.1	24.2	100.3	
		+ .8		+ .1	
	H. P.=33.78		H. D.=33.37		
9.57	75.0	74.2	24.2	100.3	Litres 80.00
10.57	76.4	74.75	24.7	101.0	
		.55		.7	
	H. P. = 25.81		H. D. = 22.94		
11.00	76.4	74.8	24.7	101.0	Litres 60.00
12 00	78 0	75 4	25.7	100.6	
		+ .6		— .4	
	H. P. = 23.40		H. D. = 25.03		
P. M.					Weight 4.92
2.00	76.7	75.45	25.2	100.6	Litres 75.00
3.00	77.1	76.1	25.2	101.0	
		+ .65		+ .4	
	H. P. = 28.73		H. D. = 27.11		
					Weight 4.90
4.00	77.4	76.15	25.7	100.6	Litres 75.00
5.00	78.2	76.75	26.0	101.2	
		+ .6		+ .6	
	H. P. = 27.47		H. D. = 25.03		

A. M.					Weight 4.88
8.05	77.0	76.8	25.4	100.9	Litres 70.00
9.05	77.9	77.4	25.9	101.0	
	H. P. =	23.94	H. D. =	27.11	

First Fever Day.

					Weight 4.78
9.00	2 gtt. of blood 17 days old, per jugular.				
9.24	74.9	73.9	24.2	101.5	Litres 72.50
10.24	75.4	74.5	24.6	102.3	
		.6		+ .8	
	H. P. =	28.20	H. D. =	25.03	
					Weight 4.78
10.30	75.5	74.5	24.6	102.3	Litres 65.00
11.30	76.1	75.2	25.0	101.8	
	H. P. =	26.81	H. D. =	29.20	
					Weight 4.76
11.40	76.2	75.3	25.0	101.8	Litres 70.00
12.40	77.0	75.95	25.3	101.2	
		+ .65		— .6	
	H. P. =	24.75	H. D. =	27.11	
P. M.					Weight 4.76
2.15	77.1	75.8	25.4	100.0	Litres 67.30
3.15	78.3	76.5	25.9	99.6	
		+ .7		— .4	
	H. P. =	27,63	H. D. =	29.20	
4.10	78.8	76.7	26.5	99.9	Litres 67.50
5.10	79.1	77.1	26.4	100.3	
				+ .3	
	H. P. =	17.74	H. D. =	16.68	
8.04.	Animal dying.			99.7	

EXP. 8.—Cat.

Hunger Day.

A. M.	A. T.	C. T.	E. T.	R. T.	Weight 3.32
8.45	76.8	75.25	26.2	100.6	Litres 55.0
9.45	77.2	76.0	25.6	100.0	
		+ .75		— .6	
	H. P. =	29.64	H. D. =	31.29	

9.50	77.3	76.0	25.6	100.0	Litres 52.50
10.50	78.2	76.5	26.1	99 7	
		+ .5		— .3	
	H. P. =	20.04	H. D. =	20.86	
10.55	78.2	76.5	26.1	99.7	Litres 42.50
11.55	77.2	77.0	25.8	99.8	
		+ .5		+ .1	
	H. P. =	21.13	H. D. =	20.86	
P. M.					Weight 3.28
2.05	79.3	77.5	26.8	100.6	Litres 50.00
3.05	78.5	77.55	26.1	101.8	
		+ .5		+ 1.2	
	H. P. =	24.12	H. D. =	20.86	
					Weight 3.28
4.00	79.1	77.6	26.5	101.4	Litres 57.50
5.00	78.7	78.0	26.2	101.3	
		+ .4		— .1	
	H. P. =	16.42	H. D. =	16.68	
					Weight 3.26
8.05	79.2	78.5	27.3	102.4	Litres 45.00
9.05	79.4	78.7	26.5	101.8	
		+ .65		— .6	
	H. P. =	25.50	H. D. =	27.11	
A. M.					Weight 3.24
7.52	76.4	74.4	25.7	100.8	Litres 115.00
8.52	74.1	74.9	23.9	100.7	
		+ .5		— .1	

First Fever Day.

					Weight 3.20
9.10	2 gtt. of blood 18 days old, per jugular.				
9.15	77.2	74.95	26.1	100.2	Litres 112.50
10.15	76.2	75.5	24.7	102.0	
		+ .55		+1.8	
	H. P. =	27.7	H. D. =	22.92	
					Weight 3.2
10.20	76.5	75.55	25.1	101.8	Litres 112.50
11.20	76.4	76.0	25.5	102.4	
		.45		+ .6	
	H. P. =	20.36	H. D. =	18.77	

11.25	76.4	76.0	25.5	102.6	Litres 92.40
12.25	79.1	76.45	26.1	103.5	
		+ .45		+ .9	
	H. P. =	21.14	H. D.	18.77	
P. M.					Weight 3.18
2.00	82.4	76.8	28.0	104.3	Litres 77.50
3.00	83.5	77.6	28.7	102.1	
		+ .8		— 2.2	
	H. P.	27.51	H. D. =	33.37	
					Weight 3.18
4.00	85.2	77.95	29.2	102.8	Litres 30.00
5.00	84.4	78.7	29.0	102.1	
		+ .75			
					Weight 3.18
8.05	84.7	79.45	28.8	103.0	Litres 72.50
9.05	83.1	80.05	27.6	101.4	
		+ .6		+ 1.6	
	H. P. =	20.81	H. D. =	25.03	
A. M.					Weight 3.16
7.40	80.9	80.85	27.0	101.1	Litres 163.00
8.40	82.7	81.4	28.2	100.3	
		+ .55		— .8	
	H. P. =	20.85	H. D. =	22.94	

Second Fever Day.

A. M.					Weight 3.16
8.45	2 gtt. of blood 19 days old, per jugular.				
9.00	83.0	81.45	28.3	100.3	Litres 147.50
10.00	82.0	81.80	27.8	103.5	
		+ .45		.32	
	H. P. =	22.98	H. D. =	14.59	
					Weight 3.16
10.05	82.8	81.80	27.8	103.5	Litres 52.50
11.05	86.5	82.30	29.9	103.7	
		+ .5		+ .2	
	H. P. =	21.38	H. D. =	20.86	

11.10	86.5	82.3	29.9	103.7	Litres 142.50
P. M.					
12.10	84.4	82.78	28.9	102.3	
		+ .48		+ 1.4	
	H. P. =	16.35	H. D. =	20.02	

12.40 2 gtt. of blood 19 days old, per jugular.

					Weight 3.6
1.53	84.0	82.8	29.1	105.1	Litres 70.00
2.53	84.1	83 4	29.0	104.0	
		+ .6		+ 1.1	
	H. P. =	22.05	H. D. =	25.03	
4.00	84.8	83.4	29.5	102.9	Litres 75.00
5.00	85.2	84.0	29.8	101.3	
		+ .6		— 1.6	
	H. P. =	20.25.	H. D. =	25.03	

5.05 2 gtt. of blood 19 days old, per jugular.

					Weight 3.00
8.00	88.0	84.5	31.5	103.8	Litres 82.50
9.00	84.9	84.9	28.5	102.0	
		+ .4		— 1,8	
	H. D. =	16.68	H. P. =	12.20	
					Weight 2.98
A. M.					Litres 80.00
7.30	79.0	78.45	26.9	100.6	
8.30	80.0	78.75	26.8	102.1	
		+ .30		+ .5	
	H. D. =	12.51	H. P. =	11.28	

EXP. 9.—Cat—tortoise-shell color.

Hunger Day.

					Weight 3.98
A. M.	A. T.	C. T.	E. T.	R. T.	Litres 75.00
9.00	78.5	78.7	26.5	101.0	
10.00	78.6	79.15	26.4	99.8	
		+ .45		—.2	
	H. P. =	14.82	H. D. =	18.77	

					Weight 3.98
10.05	78.8	79.2	26.4	99.8	Litres 65.00
11.05	80.1	79.65	26.9	99.1	
		+ .45		— .7	
	H. P. =	16.47	H. D. =	18.77	
					Weight 3.9
11.08	80.1	79.65	26.9	99.1	Litres 135.00
12.08	80.7	80.05	27.2	99.2	
		+ .4		+ .1	
	H. P. =	17.00	H. D. =	16.68	
P. M.					
2.10	79.6	80.0	27.1	101.4	Litres 145.00
3.10	81.4	80.5	27.5	100.1	
		+ .5		— .13	
	H. P. =	16.66	H. D. =	20.86	
					Weight 3.9
4.10	81.5	80.6	27.7	101.0	Litres 147.50
5.10	81.9	81.0	27.9	100.5	
		+ .4		— .5	
	H. P. =	15.06	H. D.	16.68	
					Weight 3.9
8.15	79.6	80.9	28.7	101.1	Litres 127.50
9.15	82.0	81.3	27.7	102.2	
		+ .4		+ .1	
	H. P. =	17.00	H. D. =	16.68	
A. M.					Weight 3.86
8.00	77.2	74.95	25.9	100.4	Litres 125.00
9.00	74.4	75.3	23.9	99.4	
		+ .35		— 1.0	
	H. P. =	13.29	H. D. =	14.60	

First Fever Day.

A. M.					Weight 3.86
9.10	2 gtt. of blood 21 days old, per jugular.				
9.20	76.7	75.4	26.2	100.2	Litres 127.00
10.20	76.7	75.9	25.2	101.3	
		+ .5			
	H. P. =	24.70	H. D. =	20.86	

					Weight 3.80
10.30	76.9	75.9	25.2	101.4	Litres 117.50
11.30	78.1	76.4	25.9	103.8	
	H. P. =	28.42	H. D. =	20.86	
					Weight 3.80
11.45	78.1	76.4	25.9	103.8	Litres 125.00
12.45	78.2	76.85	26.0	104.9	
		+ .45		+1.1	
	H. P. =	22.24	H. D. =	18.77	
P. M.					Weight 3.76
2.10	79.6	77.0	27.0	105.2	Litres 120.00
3.10	78.1	77.5	26.0	104.1	
		+ .5		— 1.1	
	H. P. =	17.44	H. D. =	20.86	
					Weight 3.74
4.10	81.1	77.75	27.7	103.9	Litres 125.00
5.10	78.7	78.2	26.4	103.6	
	H. P. =	17.75	H. D. =	18.77	
					Weight 3.74
8.15	80.1	78.4	27.0	102.6	Litres 105.00
9.15	79.0	78.8	26.1	102.7	
		+ .4		— .1	
	H. P. =	16.99	H. D. =	16.68	
A. M.					Weight 37.0
8.05	75.6	74.25	24.7	101.6	Litres 92.50
9.05	76.5	74.7	25.0	102.2	
		+ .45		+ .6	
	H. P. =	20.61	H. D. =	18.77	

Second Fever Day.

A. M.					Weight 3.7
9.12	2 gtt. of blood twenty-two days old,				per jugular.
9.15	76.3	74.7	25.	102.2	Litres 100.00
10.15	76.8	75.15	25.2	105.4	
		+ .45		+ 3.2	
	H. P. =	28.59	H. D. =	18.77	
10.20	76.9	75.2	25.2	105.4	Litres 85.00
11.20	76.3	75.6	24.9	104.4	
		+ .4		+ 1.0	
	H. P. =	13.61	H. D. =	16.68	

11.23	76.8	75.7	25.	104.4	Litres 75.00
12.23	77.8	76.1	25.7	103.8	
		+ .5		—. 6	
	H. P. =	19.02	H. D. =	20.80	
P. M.					Weight 3.64
2.10	78.	76.15	25.9	102.3	Litres 137.00
3.10	77.6	76.6	25.4	101.7	
		+ .45		— .6	
	H. P. =	16.97	H. D. =	18.77	
4.20	78.6	76.65	26.	101.8	Litres 110.20
5.20	79.0	77.15	26.	101.7	
		+ .50		— .1	
	H. P. =	20.56	H. D. =	20.86	
8.10	77.8	77.2	25.7	101.9	Weight 3.58
9.10	78.3	77.6	25.9	102.7	Litres 120.00
		+ .4		+ .8	
	H. P. =	19.05	H. D. =	16.68	
A. M.					Weight 3.56
8.00	75.	74.85	22.6	101.1	
9.00	78.	75.1	24.6	100.7	
		+ .25		— .4	
	H. D. =	9.23	H. P. =	10.43	

EXP. 10.—Cat.

Hunger Day.

A. M.					Weight 5.6
10.10	74.4	74.4	22.	101.1	Litres 77.50
11.10	78.	75.15	26.1	100.4	
		·75		— .7	
	H. P. =	28.84	H. D. =	31.29	

11.20 2 gtt. of blood seven days old, per jugular.

11.20	78.	75.2	25.6	100.4	Litres 105.00
12.20	78.	76.0	25.8	102.3	
		+ .8		+ .9	
	H. P. =	37.55	H. D. =	33.37	

12.24	78.	76.	25.8	102.3	Litres 92.50
1.24	79.5	76.75	26.8	102.5	
		+ .75		+ .2	
	H. P.	32.21	H. D. =	31.29	
1.32	79.5	76.8	26.3	102.5	Weight 5.48
2.32	79.1	77.3	26.3	104.4	Litres 70.00
		+ .5		+ 1.9	
	H. P. =	29.50	H. D. =	20.86	
2.40	79.5	77.4	26.3	104.4	Weight 5.48
3.40	79.5	78.1	26.6	104.8	Litres 105.00
		+ .7		+ .4	
	H. P. =	31.01	H. D. =	29.20	
3.45	79.5	77.1	26.6	104.8	Litres 90.00
4.45	79.8	78.8	26.8	104.0	
		+ .7		— .8	
	H. P. =	25.56	H. D. =	29.20	

Observation arrested.

The preceding experiments have been tabulated below, that they may be more readily understood and compared.

EXP. 1.

	P.M. 8–9	A.M. 12.30–1.30	8.20–9.20	P.M. 2–3	Average Temp.	Hourly H. P.	Excess or deficit of H. P. on fever days.
H. P.	103.2	102.9	102.9	102.2 =	102.8		
	40	47	36	38			
	102.4	102.4	102.0	101.5 =	102.0		
	28	38	39	30		= 33.75	During 8–9 period, 2d fever day an excess of 2 units.
	103.9	102.5	103.8	105.8 =	104.0 =		
	121	24	24	27		= 26.00	— 7.75
	103.9	104.0	103.6	103.6 =	103.7 =		
	30	37	20	28		= 28.75	— 5.00
						Hourly H. D.	Excess or deficit of H. D. on fever days.
H. D.	45	47	39	41		= 43	
	29	39	41	31		= 35	
	27	27	22	33		= 27	— 8.0
							During 8–9 period, an increase of 2 units.
	31	37	20	29		= 29	— 6.0

EXP. 2.

	A.M. 8.10–9.10	P.M. 1.45–2.45	7.35–8.35	A.M. 12.42–1.42		Hourly H. P.	Excess or deficit of H. P. on fever days.
H. P.	102.4	102.0	102.9	102.4			
	40	45	37	42			
	102.3	102.2	102.7	102.8	=	102 3	
	37	36	40	32	=	36.2	
	103.4	103.9	103.8	104.1	=	103.8	
	40	36	33	42	=	37.7	+ 1.5
	103.6	103.6	103.8	103.6	=	103.6	
	32	34	38	31	=	33.7	— 2.5

						Hourly H. D.	Excess or deficit of H. D. on fever days.
H. D.	43	47	39	41			
	37	35	39	30	=	35.2	
	39	37	33	37	=	36.5	+ 1.3
	31	33	33	33	=	32.5	— 2.7

EXP. 3.

	P. M. 12.35–1.35	8.07–9.07	2–3	7.55–8.55		Hourly H. P.	Excess or deficit of H. P. on fever days.
H. P.	102.3	102.4	102.1	102.8	=	102.4	
	31	25	31	25	=	28 2	
	102.1	101.8	101.5	101.5	=	101.7	
	23	24	24	26	=	24.2	— 4.0
	101.0	100.9	96.8	90.6	=	97.5	
	25	17	22	18	=	20.5	— 8.2

						Hourly H. D.	Excess or deficit of H. P. on fever days.
H. D.	33	27	31	29	=	30	
	20	27	25	29	=	25.2	— 6.8
	25	20	24	25	=	23.5	— 6.5

EXP. 4.

	P. M. 1.44–2.44	9.20–10.20	3–4	8.55–9.55		Hourly H. P.	Excess or deficit of H. P. on fever days.
H. P.	100.9	101.3	101.0	101.8	=	101.2	
	27	23.2	19	25	=	23	
	102.1	101.4	101.4	100.8	=	101.4	
	23.2	17.6	22	20	=	20.7	
	102.3	100.2	101.3	102.1	=	101.4	
	22.9	22	23	20	=	21.9	+ 1.2
	101.7	99.1	98.4	97.1	=	99.0	
	19	17	20	25	=	20.2	— .5

						Hourly H. D.	Excess or deficit o H. D. on fever days.
H. D.	25	25	18	22	=	22	
	22	18	25	20	=	21	
	22	20	25	25	=	23	+ 2
	22	14	22	25	=	20.7	

EXP. 5.

	A. M. 8.10–9–10	1.45 2.45	8.15 9.15	12.45–1.45		Hourly H. P.	Excess or deficit of H. P. on fever days.
H. P.	101.9	102.5	102.1	102.1			
	31	35	28	27			
	101.7	101.4	101.9	102.0	=	101.7	
	18	22			=	20	
	102	103.6			=	102.8	
	17	25			=	21	+ 1

						Hourly H. D.	Excess or deficit on fever days.
H. D	27	31	27	27	=		
	25	27			=	26	
	22	20			=	21	— 5

EXP. 6.

	A. M. 8.55–9.55	9.57–10.57	11–12	2–3	4–5	8.05–9.05	8.05–9.05		Hourly H. P.	Excess or deficit of H. P.
Hunger Day. H. P.	100.2	100.3	101.0	100.6	100.6	100.9	101.9	=	100.6	
	33	25	23	28	27	23	23	=	27	
	101.5	102.3	101.8	100	99.9			=	100.9	
	28	26	24	27	17			=	23	— 4

									Hourly H. D.	Excess or deficit of H. D.
H. D.	33	22	25	27	25	25	27	=	26	
	25	29	27	29	16			=	25	— 1.

EXP. 7.

	A. M. 8.45–9.45	9.50–10.50	10.55–11.55	2.05–3.05	4–5	8.05–9.05	7.52–8.52		Hourly H. P.	Excess or deficit of H. P.
Hunger Day. H. P.	100.6	100	99.7	100.6	101.4	102.4	100.6	=	100.7	
	29	20	21	24	16	25	21	=	22.2	
	100.2	102	102.6	104.3	102.8	103	101.1	=	102.2	
	27	20	21	27	29	20	20	=	23.4	+ 1.2
	100.3	103.5	103.7	105.1	102.9	103.8	100.6	=	102.8	
	22	21	16	22	20	12	11	=	18	— 4.2

									Hourly H. D.	Excess or deficit of H D.
H. D.	31	20	20	20	16	27	20	=	22	
	22	18	18	33	31	25	22	=	24.1	+ 2.1
	14	20	20	25	25	16	12	=	18	— .4

EXP. 8.

	A. M. 9-10	10.05-11.05	11.08-12.08	2.10-3.10	4.10-5.10	8.15-9.15	8-9		Hourly H. P.	Excess or deficit of H. P.
H. P.	101.	99.8	99.1	101.4	101	101.1	100.4	=	100.5	
	14	16	17	16	15	17	13	=	15.4	
	100.2	101.4	103.8	105.2	103.9	102.6	101.6	=	102.6	
	24	28	22	17	17	16	20	=	20.5	+ 5.1
	102.2	105.4	101.4	102.3	101.8	101.9	101.1	=	102.7	
	28	13	19	16	20	19	9	=	17.8	+ 2.4

									Hourly H.P.	Excess or deficit of H. D.
H. D.	18	18	16	20	16	16	14	=	16.8	
	20	20	18	20	18	16	18	=	17.1	+ 3
	18	16	20	18	20	16	10	=	16.5	— 3

EXP. 10.—Cat.

First Hunger Day.

A. M.	A. T.	C. T.	E. T.	R. T.	
10.10	70.	74.4	22.1	101.1	Weight 5.6
11.10	78.	75.15	26.1	100.4	Litres 77.5
	H. P. = 28.84		H. D. = 31.29		
11.19	2 gtt. of putrid blood seven days old, per jugular.				
11.20	78.	75.2	25.6	100.4	Litres 105.0
12.20	78.	76.0	25.8	102.3	
	H. P. = 37.55		H. D. = 33.37		
12.24	78.	76.	25.8	102.3	Litres 92.50
12.24	79.5	76.75	26.8	102.5	
	H. P. = 32.21		H. D. = 31.29		
1.32	79.5	76.8	26.3	102.5	Weight 5.48
2.32	79.1	77.3	26.2	104.4	Litres 70.0
	H. P. = 29.50		H. D. = 20.86		
2.40	79.5	77.4	26.3	104.4	Litres 106.0
3.40	79.5	78.1	26.6	104.8	
	H. P. = 31.01		H. D. = 29.20		
3.45	79.5	78.1	26.6	104.8	Litres 90.0
4.45	79 8	78.8	26.8	104.0	
	H. P. = 25.56		H. D. = 29.20		

EXP. 11.—Rabbit. Cortex cerebri removed.

P. M.		R. T.
3.34		101.8
3.35	2 gtt. of putrid blood, per jugular.	
4.05		101.6
5.20		105.4
5.55		102.4
7.00		101.6

Second Day.

A. M.		
8.45		103.0
8.47	1 gtt. of blood, per jugular.	
9.10		102.8
9.33		103.0
10.07		103.4
11.35		104.1
12.07		103.0

Upon autopsy, a large part of the cortex was found to be destroyed.

EXP. 12.—Rabbit. Cortex removed.

P. M.		R. T.
1.24		103.7
1.45	2 gtt. of putrid blood, per jugular.	
1.54		106.1
2.42		105.7
4.00		106.0

At autopsy, a large part of cortex cerebri destroyed.

EXP. 13.—Rabbit. Anterior end of corpora striata destroyed.

P. M.		R. T.
1.40		104.8
2.15	¼ gtt. of putrid blood, per jugular.	
2.45	½ gtt. " " "	105.1
2.47		106.3
4.15		105.3
5.00		105.2
6.20		104.8

EXP. 14.—Rabbit. Corpora striata removed.

P. M.		R. T.
4.45		103.4
5.35	¼ gtt. of putrid blood, per jugular	103.6
6.00		103.8
6 20		103.6
6.50	½ gtt. of putrid blood, per jugular	103.9
7.05		103.6
7.25		102.9
7.45		102.0
8.10		102.4

EXP. 15.—Rabbit. Anterior ends of corpora striata removed.

P. M.		R. T.
12.45		103.2
1.42	¼ gtt. of putrid blood, per jugular.	
2.10		103.4
3.00		105.2
3.25		106.4
4.10		106.6
		106.2

EXP. 16.—Rabbit. Corpora striata removed.

A. M.		R. T.
11.50		103.8
12.40	¼ gtt. of putrid blood, per jugular	102.8
1.05		102.1

EXP. 17.—Rabbit. Corpora striata removed.

P. M.		R. T.
5.42		103.9
5.49	1 gtt. of putrid blood, per jugular.	
6.15		102.8
6.45		102.6
8.10		100.8

THE THERMO-POLYPNŒIC CENTRE AND THERMOTAXIS.[1]

By ISAAC OTT, M.D.

IN a paper recently published by Prof. Richet on what he calls a new function of the medulla oblongata, he states that in dogs exposed to a temperature of 86° F., with the elevation of the body heat of the animal the number of the respirations suddenly increased 350-400 per minute, a form of respiration which the author calls polypnœa. He shows by numerous experiments that it is not the want of oxygen which causes polypnœa, for it is necessary that the animal be not in need of breathing, but in a state of apnœa, for polypnœa to occur. An excess of carbon dioxide in the blood interferes with polypnœa. An animal pants to cool himself, whilst a man perspires under the same conditions. The role of polypnœa is to regulate the temperature of the body exclusively, as was seen in the experiment upon two dogs exposed to an equally high temperature, one of which was curarized or otherwise so manipulated as to interfere with polypnœa; the temperature of the curarized dog ran to 110° F., while that of the other did not go higher than 103° F. This new function of the nervous system Richet calls thermo-polypnœa—a reflex function, he states, ordinarily, but when it is insufficient central it regulates temperature by an exhalation of vapor from the skin or from the lungs. Section of both vagi did not alter the course of the phenomena. The application of heat to the bodies of animals has been studied by many observers. Ackermann[2] arrived at the conclusion that not only the skin of animals but also the lungs are used as an apparatus to regulate the body-temperature, the skin acting in a more gross manner, the respiratory mechanism being used in bringing about the minor variations. He also states that

[1] Read before the New York Neurological Society, January meeting.

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the frequency of the respirations is caused neither by the want of oxygen nor excess of carbonic acid in the blood, but alone in the increase of the temperature of the whole organism, a heat dyspnœa. When the temperature of the animal is high, artificial respirations have no effect on the frequency of the respirations, not even when, in consequence of the inflations, the venous blood is bright red; while at a lower temperature artificial respirations can greatly reduce or even bring to a standstill the movements of the respiratory apparatus. Dr. Goldstein,[3] who also has greatly extended the experiments upon this subject in Fick's laboratory, asks, "Is the increased temperature of the blood a new cause adding itself to the stimulus for the respiratory centre normally present in the blood, or is it an influence diminishing the resistance." He also inquires if it acts on the cerebral convolutions primarily and through these on the respiratory centres, or does it act on the skin first, or on the pulmonary endings of the vague first, or, finally, does it act directly on the nerve centres which govern the respiratory movements. He arrived at the conclusion that the heat acted on the blood, elevating its temperature, and the heated blood acted directly on the respiratory centre, causing the increase of respiratory movements.

Dr. Sihler,[4] at Johns Hopkins University has also made a number of experiments upon this subject, and arrived at the conclusion that the animal cannot be made apnœic, that cutting the pneumogastrics does not prevent the increase in the respiratory rhythm, nor does opium, although Richet found chloral to do so.

He does not fully agree with Goldstein that the cause is in the blood acting directly upon the respiratory centres, but holds that the increased respiration following exposure of the animal is due to two causes, skin stimulation and warmed blood; of these, skin stimulation is the more powerful. That apnœa can be produced if the spinal cord is cut,

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[2] Deutsche Archiv. f. klinische Medicin, 1867

[3] Arbeiten aus den physiologischen Laboratorium der Würzburger Hochschule, 1872.

[4] Journal of Physiology, vol. ii., No. 3.

thus removing greatly the skin stimuli, and that the direct action on the respiratory centres of the hotter blood of the heated animal is probably not, or not only, due to its temperature but to its greater venosity. Gad and Mertschinsky have also investigated the subject, and they believe that increased temperature of the blood stimulates the respiratory centres or increases their excitability.

The latest writer upon hyperthermia due to external heat is Vincent.[5] He proves what has been surmised before, that the blood of an animal dying of excess of heat contains a poison which causes convulsions, stupor and death in guinea pigs, sparrows and frogs. Comparative experiments with normal blood on the same kind of animals were without effect.

The experiments upon which this paper is founded were made upon rabbits and cats. They were etherized, bound down, their skulls trephined, and the cortex broken up with a blunt probe, so as to prevent any perception of pain during the whole of the experiment. With the polygraph of Marey was connected a T canula, which was bound in the trachea. Through this arrangement the number of respirations were written on the smoked drum of a kymographion of Ludwig. To study the effect of heat on the normal animal, a sheet-iron box lined with wood and large enough to accommodate Czermak's holder, upon which the rabbit lay, was heated by a Busen burner beneath. A thin layer of water was kept on the bottom of the box to prevent the wood from being charred. The top of the box was partly closed by a woolen covering, although not enough to prevent a full interchange of air in the box. The temperature of the box was usually 100° F., but at times was higher and lower. A thermometer hanging in the box noted its temperature. After the normal respiratory movement of the animal was noted, he was placed in the box about five minutes, when the curve again was taken and the rectal temperature noted. The observations were taken every five, ten, or fifteen minutes, according to the circumstances which I wished to study.

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[5] Recherches experimentales sur l'Hyperthermie. Par le Dr. H. Vincent, 1887.

When the cortex alone was removed, heat still caused a great increase of respiration. If, however, the corpus striatum and the parts between it and the optic thalami were removed, then the respirations at first began to fall instead of rising, but at high rectal temperature rose to a little above normal. If, however, a puncture was made by a blunt "seeker" into the tissues between the corpora striata and the optic thalami, then no increase of respiration ensued, except a small amount on high elevation of rectal temperature just before the respirations began to fall. In Fig. 1 are represented the curves of temperature and respiration with cortex removed. In Fig. 2 are shown the curves of temperature and respiration when corpora striata and parts between them and optic thalami are removed. In the first figure the curve of temperature and respiration ascend together, till the rectal temperature reaches a high point, when the respiration curve begins to descend and continues to do so till death ensues, this lethal temperature point being about 111° F., a fact shown by several observers. In the second figure the temperature curve rises as in Fig. 1, but more abruptly, whilst the respiration curve begins to descend, and only at limits of temperature approaching the death-point does it rise to normal or a little above it. If the animal is breathing rapidly, and a probe be thrust into the tissues of the brain between the corpora striata and optic thalami, then the respiration is reduced greatly, and remains so, no matter what the internal temperature of the animal. If, with a pair of electrodes insulated to near their point with sealing-wax and attached by a wire to an upright on the rabbit-holder to steady them, an induction current is sent through them for about three minutes, then the respirations in the animal with his cortex removed are doubled or trebled in number.

In Fig. 3 the line marked 1 is normal, and during the 2d, 3d, and 4th curves the current is acting on the centre to produce polypnœa, which is shown in the curve marked 5. The current was so weak as scarcely to be perceptible to the tongue, and the electrodes were pushed to a point lying just over the parts between the corpora striata and

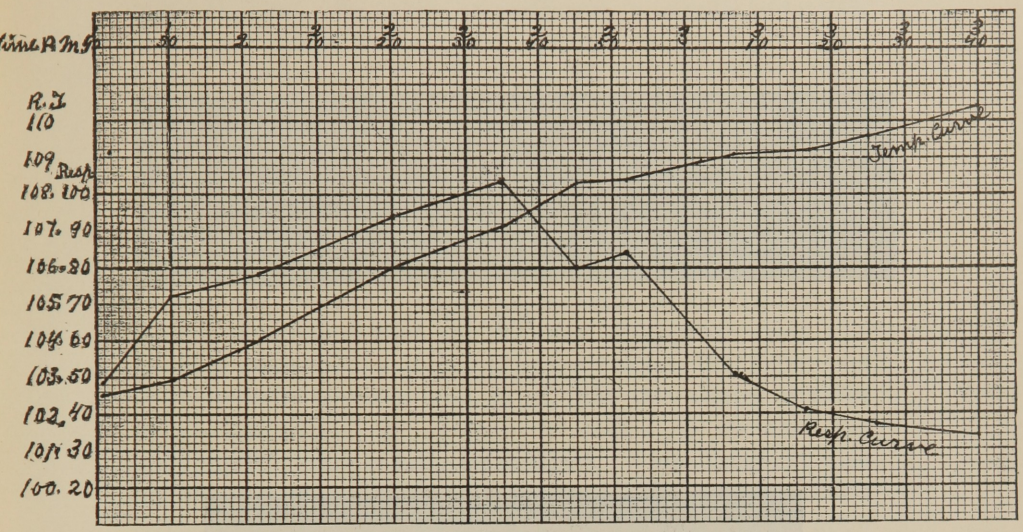
Time P.M.
R.T.
110
109
Resp.
108. 100
107. 90
106. 80
105 70
104. 60
103. 50
102. 40
101. 30
100. 20
Temp. Curve
Resp. Curve

Fig. 1.

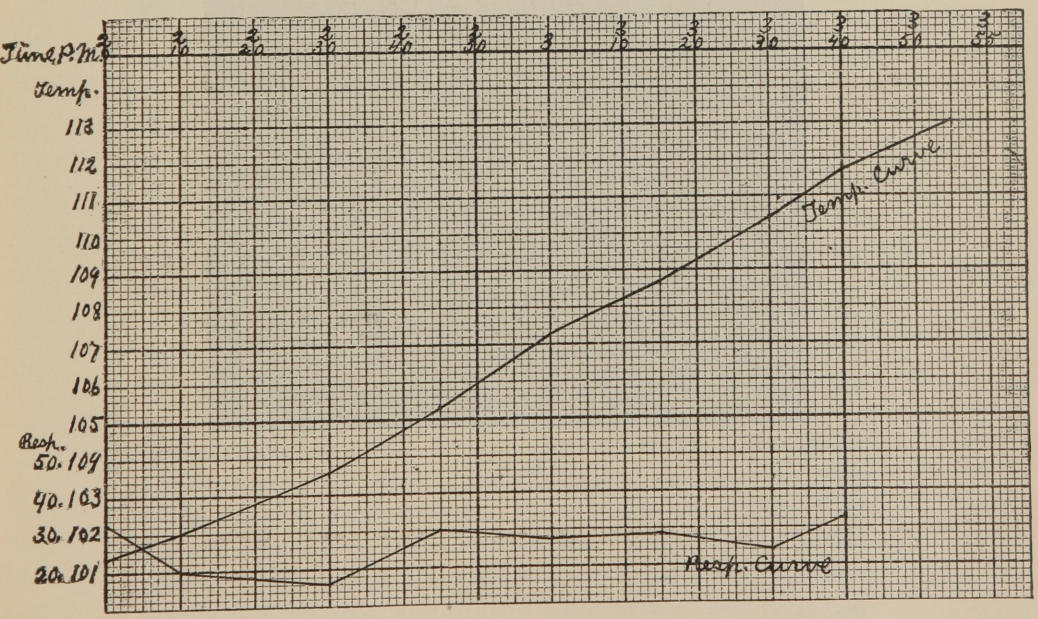
Time P.M.
Temp.
113
112
111
110
109
108
107
106
105
Resp.
50. 104
40. 103
30. 102
20. 101
Temp. Curve
Resp. Curve

Fig 2.

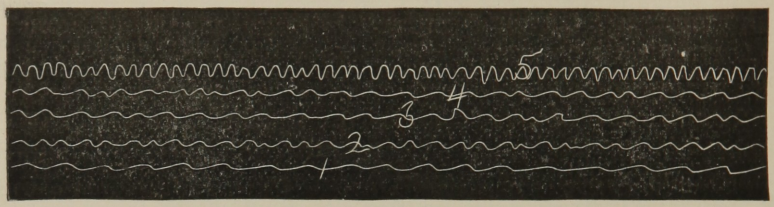

Fig. 3.

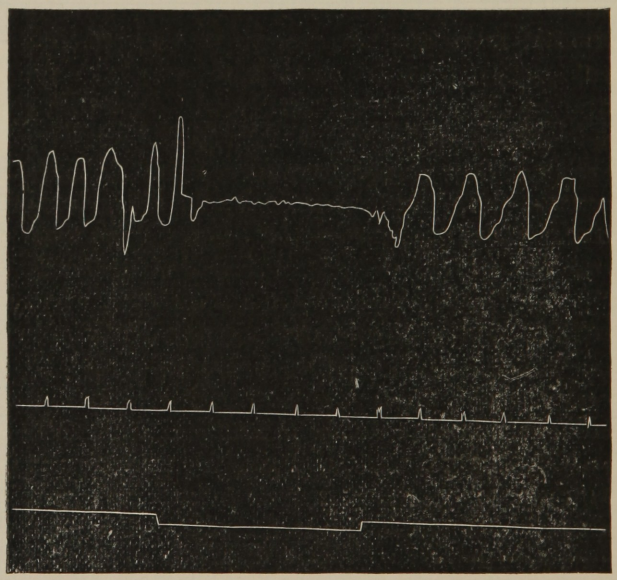

Fig. 4.

optic thalami. In some experiments a single induction shock per second was sent through the centre above mentioned, and arrest of the chest in expiration obtained. This is seen in Fig. 4, which is to be read from right to left.

To establish a centre, three things are necessary: 1st, that its abolition causes the phenomena to disappear; 2d, that irritation—mechanical, chemical, or electrical—causes the phenomena to be present; 3d, that the part of the nervous system exhibiting these peculiarities is circumscribed in extent. If now I apply these tests to the polypnœic centre, it is found that the function disappears when this point is destroyed, and that it appears when the same part is electrically irritated, and, third, that this centre or point is circumscribed in extent. It seems to me that the polypnœic centre is fully established. This discovery also shows that in lower animals external heat acts in a reflex manner upon the polypnœic centre, and not directly upon the respiratory centre, as has been held by Richet and others; that the sensory nerves send impulses into the polypnœic centre, which acting as a reflex centre, sends other impulses which are carried to the respiratory centre in the medulla oblongata and causes rapid respiration. These facts lead us to think that fever in man excites rapid breathing in a similar manner; that heat is the best external stimulant to rouse, through the polypnœic centres, the centre of respiration in cases of poisoning or drowning. I have twice seen the best effects in cases of opium poisoning, where the respirations were about six per minute, by the immersion of the feet into water of a high temperature.

If we examine the respiratory apparatus, it is found that the nervous mechanism is as follows: 1st, a main centre in the medulla oblongata; 2d, Christiani's expiration centre; and, 3d, Martin and Booker's inspiration centre in the posterior bodies of the corpora quadrigemina; 4th, Christiani's inspiration centre in the thalami at the anterior edge of the corpora quadrigemina. It occupies the centre of the thalami exactly in their median line, and, if I may be permitted, a fifth centre, the polypnœic. It might be observed that both Christiani and Martin have established their cen-

tres solely by irritations; no effect of extirpation of these points has been shown. I mention this fact to show that observers capable of forming a judgment believe the fact of irritation sufficient to establish centres, not that I doubt their experiments or their conclusions.

Christiani states that the optic, auditory, sensory nerves of the skin, and certain fibres of the vagus, stand in relation with the thalamic inspiration centre. The inhibitory nerves, according to him, in connection with these centres are the other fibres of the vagus not mentioned above, the nerves conveying painful sensations, and especially the trigeminus.

Having shown that a polypnœic centre exists, it remains to determine why after its removal the number of respirations fall from a high temperature. When I cut the trigemini within the skull, they still fell; when I removed the thalami they also fell; when I removed the corpora quadrigemina, there was also a decrease of the number; the same ensued when only the pons and medulla oblongata were left. If, however, the pneumogastrics were divided, then hardly any fall ensued. I noted, in a few experiments where only the pons and medulla were present, that with the vagi intact a temporary rapidity of respiration soon followed by a fall. In one case, where the dividing line between the pons and medulla was nearly reached, no fall ensued, and the increase at the start lasted. This increase, however, was not over about ten or eleven in number of respiration per quarter minute.

In the Weigert treatment of phthisis, by air heated from 212°–482° F. and inhaled, the respirations are found to be diminished, although the temperature of the body rises one to two degrees for an hour and then subsides.

Here the superheated air calls into activity the inhibitory fibres of the vagi, thus diminishing the activity of the respiratory centre. In irritations of the polypnœic centre by the electric current, I have frequently seen convulsions ensue, although the cortex had been removed. When a rabbit is heated up and polypnœa occurs, plunging the rabbit into ice-water brings the respiration to normal, although

the respirations are very deep. But this return to normal lasts only fifteen seconds, when the respirations again ascend nearly to their original rapidity and then gradually descend. If ten grains of antipyrin are given subcutaneously, and the animal heated, polypnœe does not take place; but if polypnœa is first thoroughly established, and eight grains of antipyrin are injected by the jugular, it takes about fifteen minutes for the breathing to return to normal. Injection of putrid blood, causing septic fever, seemed to partially prevent polypnœa; for, when the animal was heated up, the respirations did not attain their maximum frequency. Clipping off the fur and covering the animal with mucilage did not prevent dyspnœa, but it took a longer time than usual to heat him up. Here the mucilage acts as an irritant of the sensory nerves and diminishes heat production. It would seem that when heat is applied to the skin that two influences of an antagonistic nature are set up—one to arouse the polypnœic centre, and through it the respiratory, into increased activity; the other, through the respiration and inhibiting fibres of the vagus and probably through the nerves of the skin, a depression of the number of respirations. However, the impulses sent into the polypnœic centre preponderate and mask the antagonistic ones.

These experiments proved that after the removal of the polypnœic centre the fall of respiration frequency by the rise of temperature was due mainly to an irritation of the inhibitory fibres running through the vagus to inhibit the main respiratory centre. These facts still further substantiate the existence of the polypnœic centre. With five centres concerned in the respiratory mechanism, it may be permissible to consider the relation of the thermo-polypnœic centre to the six thermotaxic centres regulating the temperature of the body. As already noted, the polypnœic centre is active in the regulation of the temperature of the body. The thermo-polypnœic centre acts reflexly, but it is ever active. The moment high temperature affects the sensory nerves of the skin this centre signals the medullary respiratory centre to go to work and cool down the body by throwing off heat to counterbalance that thrown on.

As I have already stated elsewhere, the thermotaxic centres located in the cortex are the cruciate and Sylvian and the four basal centres at the base of the brain are also thermotaxic. I have lately made some experiments to determine whether the polypnœic centre and the thermotaxic centre in the gray matter at the most anterior part of the third ventricle are one and the same or different centres. In puncturing the thermotaxic centre at this point, I have frequently obtained polypnœa, with a rise of temperature. In fact the location of these centres is precisely in the same spot, so that I am convinced they are one; in other words, this thermotaxic centre manifests its activity by polypnœa. How the other basal thermotaxic centres stand in relation to the thermolytic centres, which are the respiratory, vaso-motor, and sudorific, is not yet determined. Danilewsky[6] found that electric irritation of the caudate nuclei had a direct action on the vaso-motor centre, causing sometimes an elevation of arterial tension, at other times a depression; sometimes an acceleration of pulse, at other times a slowing. In another place I have put upon record some experiments to prove that the corpora quadrigemina contain a centre regulating the spinal sweat centres. It is highly probable that part of the basal thermotaxic centres, through an irritation of the sensory nerves, send reflex impulses down the the cord, regulating the spinal thermogenic centres instead of directly inhibiting metabolism.

Some years ago I made experiments with cats, the soles of whose feet were devoid of pigment. They were etherized, the spinal cord bared by trephining, and then divided or at times destroyed *in toto* by a wire thrust between the two trephined openings. Then the animal was heated. It was found, when the spinal cord was divided between the sixth and seventh cervical vertebræ, the right cervical sympathetic divided above the first rib, and the left sciatic cut, that upon heating the right posterior extremity it became more red than the left posterior extremity. Destruction of the cord at this point caused the soles of the feet of

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[6] Pflüger Archiv, Bd. xi., p. 128.

the posterior extremities in the above experiment to be the same in color. These experiments proved that the spinal cord alone has vaso-dilator centres which are called into activity by heat. Now, vaso-dilation and vaso-constriction are means to regulate the temperature of the body. Heat can also excite directly the spinal sudorific centres. Now, sections of the spinal cord or, according to my experiments, of the lateral column alone, are followed, according to the surrounding temperature, by a fall or rise of body temperature.

Ugolino Mosso has shown in curarized animals that strychnia elevates the temperature probably by stimulating the spinal thermogenic centres. Atropin acts in a similar manner, also being accompanied by increased production of heat. Now, it is probable that after section of the lateral columns of the spinal cord the influences of part of the thermotaxic centres have been removed, and the temperature rises and falls according to the external temperature. In this case the vaso-motor fibres have been cut and the blood-vessels are dilated. If, however, a section is made above the main vaso-motor centre, then the regulation of the temperature is much better; the temperature frequently rises. In fact, so able an observer as Heidenhain believed the vaso-motor system to be mainly sufficient for the regulation of the temperature, thus rejecting the idea of thermotaxic centres. Jürgensen found that within the first seven to eight days of extra-uterine infantile life that the body temperature moved within wide limits, and independent of the time of day.

In the case of monsters born without any brain excepting medulla and pons, heat regulation exists, how accurately no one has thermometrically determined. Here the vaso-motor system suffices to carry on the necessary thermotaxis, for no great excess of heat or cold is allowed to test the thermotaxis of infants.

It has also been noted that irritation of the cortex centres was accompanied by a fall of temperature, and their excision by a rise of temperature. Dr. Girard, of Geneva, has recently made some experiments on the same subject,

and finds the Sylvian in the same area, but states that Schreiber found a similar state of affairs after injury to the pons, cerebellum, and peduncles. Now, it happens that I have repeatedly punctured the pons variolii and obtained a rise of a few degrees of temperature for a couple of hours. This is not due to destruction or irritation of a thermotaxic centre here, but is the same phenomenon seen in many parts of the brain, and is due to injury of an afferent nerve of the thermotaxic centres. Now, with the Sylvian and cruciate centres this rise of temperature is not for a few hours, but continues for days, up to the death of the animal. Hence this objection of Dr. Girard's falls to the ground, especially as injuries to any part of the brain are frequently accompanied by a temporary rise of temperature. It seems to me that the Sylvian and cruciate centres are limited in their extent, no other part of the cortex causing a similar state of affairs; that their irritation is followed by a depression of temperature, their excision by a rise of temperature, and compared with the motor centres in the same animals are quite as well circumscribed. Further unilateral excision of these centres is followed by a greater elevation of the temperature on one side of the body than on the other, probably due to a decussation of fibres. All researches go to show that in man more highly specialized thermotaxic centres exist. The cortical thermotaxic areas in man will have to be worked out from pathological observations, for the human cortex attains so high a degree of development that the localization of the thermic points in animals cannot be transferred.

Taking up these four basal thermotaxic centres, Dr. Girard has found a similar disturbance in the temperature curve after their injury by a probe, as I have already demonstrated. He however believes that they are not so circumscribed as I have stated. I have again made calorimetric observations lasting a whole day upon fasting rabbits, both before and after injury of the thermotaxic centres. Usually I selected the hours between seven and twelve A. M. for the normal series, whilst the afternoon hours showed the effect of lesions of one of these basal thermo-

taxic centres upon temperature, H. P. and H. D. The calorimeter error was so reduced that the instrument only varied $\frac{1}{1000}$ of a degree F. per hour for every degree the temperature of the air exceeded that of the calorimeter. A little carpet and sawdust was introduced into the instrument for the animal to sit upon, so as to gradually accustom him to the surrounding copper walls, which absorb heat more rapidly than the animal is accustomed to in the air. The calorimeter used was d'Arsonval's, which has been modified by the addition of an agitator[7] which could be worked without opening the instrument or hardly disturbing the sawdust.

These hourly calorimetric observations brought out plainly the fact that normally there was no necessary relation between temperature and H.P., that the H. P. is constantly fluctuating up and down with the H. D. This was shown much more readily in man, whose temperature did not alter much in the calorimeter, yet whose H. P. fluctuated considerably. Insults to the basal centres with either small or large probes or hollow tubes, proved that these injuries neither excite nor inhibit H. P. as a necessary consequence, but simply disturb the relation between H. P. and H. D., frequently causing increased temperature, which is also at times accompanied by H. P. temporarily increased more than H. D. This temporary increase of H. P. had no necessary relation to the temperature increase, for the temperature may rise and H. P. be diminished (Fig. 5), or the temperature may fall and the H. P. be increased (Fig. 6). In my hourly observations on septic fever the rise of temperature in the beginning was usually accompanied by a H. P. increased more than H. D. for a few hours; yet the fever had no necessary relation to the H. P., for in exceptional cases H. P. was diminished and the fever continued as usual. These facts go to prove that these six thermotaxic centres have no necessary relation to the H. P., either to increase or diminish it; all they do is to preside over the relation of H. P. to H. D. and preserve the normal temper-

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[7] New York Medical Journal, March, 1889.

ature at a fixed point. If these centres are injured by probes or tubes, large or small, or by septic poisons, albuminoids, peptones, papayotin, or neurin, then they lose their regulating power, and the relation between H. P. and H. D. is changed, and the temperature usually increases, although exceptionally may decrease. As I have proved that it is upon the basal thermotaxic centres that the fever poison mainly acts, it follows that the great interest to determine whether H. P. is increased or diminished in fever is not of so much account; for usually in the setting up of fever, heat production is increased temporarily more than heat dissipation; there is no necessary relation between heat production and the fever, or even the temperature. The vital part affected in fever, as regards the temperature section of it, is a disorder of the thermotaxic centres, which means a disorder of the relation between heat production and heat dissipation. Liebermeister, in 1875, in his "Pathologie des Fiebers," had a clearer conception and was nearer to the true explanation of fever than all subsequent experimentalists. In the same way, when antipyretics are given to an animal, and the heat production, heat dissipation, and temperature are studied for some hours before and after the drug, it is found that the depression of temperature is often accompanied by a temporary decrease of heat production (Fig. 7); but this decrement of heat production has no necessary relation to the fall of temperature; for I have often seen the temperature fall and the heat production increase (Fig. 8), or even the temperature increase and the H. P. fall (Fig. 9).

Prof. Chittenden, of Yale, has studied the effects of quinine and antipyrin upon rabbits who have fasted three days, and noted during the whole day the amount of carbonic acid exhaled both before and after the antipyrin. He arrived at the conclusion that quinine exercises at most only a very slight depressing influence upon body temperature, and has but a minimum effect upon the production of carbonic acid. Antipyrin in therapeutic doses has no special influence upon the production or elimination of carbonic acid. Lately he has found antipyrin to diminish urea and

uric acid. Kummagawa has recently studied the effect of antipyretics upon the nitrogenous tissue changes. He brought dogs to a nitrogen equilibrium by means of a definite amount of food, and then in addition to their daily diet gave them antipyretics for days, and studied the amount of nitrogen in the urine and feces. All the antipyretics except quinine increased the amount of change in nitrogenous tissues. He found that antifebrin, in doses of .08–.11 gr. per kilogramme of body-weight, exercised no marked influence; but in doses of .16–.19 grains caused an increased action upon the decomposition of albumen tissues of 31–36 per cent. The increased excretion of nitrogen on the antifebrin days was completely balanced by the decrease of nitrogen in the period after the stoppage of antifebrin. Antipyrin in large doses, 51 grammes in 16 days, caused no change in the albumen bearing tissues, although the uric acid was increased two-thirds beyond normal. Thallin, in doses of .014–.14 grains per kilogramme of body-weight, caused an increase of change in the albumen tissues (about seven per cent).

Quinine, in doses of .02–.04 grains per kilogramme, decreased the change in albumen tissues 9–16 per cent. and decreased the uric acid 13–50 per cent.

All the antipyretics except quinine increase the changes in albumen-tissues. Quinine decreases the albumen changes and the excretion of uric acid.

With antipyrin Prof. Chittenden found an increased excretion of urea, whilst it had a special inhibitory influence upon uric acid.

Now, with antipyrin and antifebrin, other experimentalists have found directly opposite results—some that metabolism is decreased, others that it is decreased. Now, one factor, an important one to my mind, has not been taken into account, and that is the changes in external temperature. It is quite evident that on a cold day more heat is dissipated than on a warmer day, hence more metabolism must ensue. Now, I believe that no results can be drawn of much accuracy unless the animals can be kept at the same external temperature. Further, I have shown that

antipyrin acts on a thermotaxic centre whose function is polypnœa; and Sawadowski has seen no fall of temperature after removal of the corpus striatum from a dose of antipyrin.

All these researches lead me to believe that the antipyretics do not act on metabolism, but on the thermotaxic centres, whose function it is to maintain the balance between heat production and heat dissipation, so that hyperpyrexia may not continue.

My calorimeter experiments with antipyrin gave the same antagonistic results, sometimes showing increased heat production, at other times decreased production, but usually immediately after the drug a temporary decrease of temperature, heat production, and heat dissipation.

I will now return to the circumscription of the basal thermotaxic centres, the only point upon which Dr. Girard and I differ. The centre between the thalamus and the corpus striatum and the centre at the anterior inner end of the thalami have been electrically irritated and found to be accompanied often by a rise of temperature. The caudate nucleus has also been electrically irritated and often attended by a rise of temperature. The rise of the temperature, when the parts between corpus striatum and optic thalamus have been mechanically insulted, is usually 105.5° F., which lasts three days; whilst the gray matter beneath the corpus striatum under similar treatment has a temperature of 105° F., which also lasts about three days. Now, punctures by a probe; a fine one may be made in the neighborhood of these centres, but the rise is not as great as at the points mentioned and falls greatly next day, as I have often seen, and which Girard's temperatutres also prove. The thalmic thermotaxic centre is usually accompanied by a temperature curve totally different from the others; it agrees with these in being rapid in its ascent, but instead of lasting three days it lasts about three hours, and attains the colossal height of 109½° F., and returns to normal in about six hours. Dr. Girard has never probed this centre, for he never attained in all his experiments a temperature over 106.8° about this

centre. A puncture an eighth of an inch behind this centre will be followed often by a temperature of 105°, which remains sometimes till next day or falls rapidly back to normal. Now, the whole thermal apparatus is so very sensitive that a puncture anywhere in it may be accompanied by a temporary rise of temperature, and a puncture in the neighborhood of a thermotaxic centre may so disorder it that it may be accompanied by a low rise of temperature, which may last till next day. I see no reason to doubt

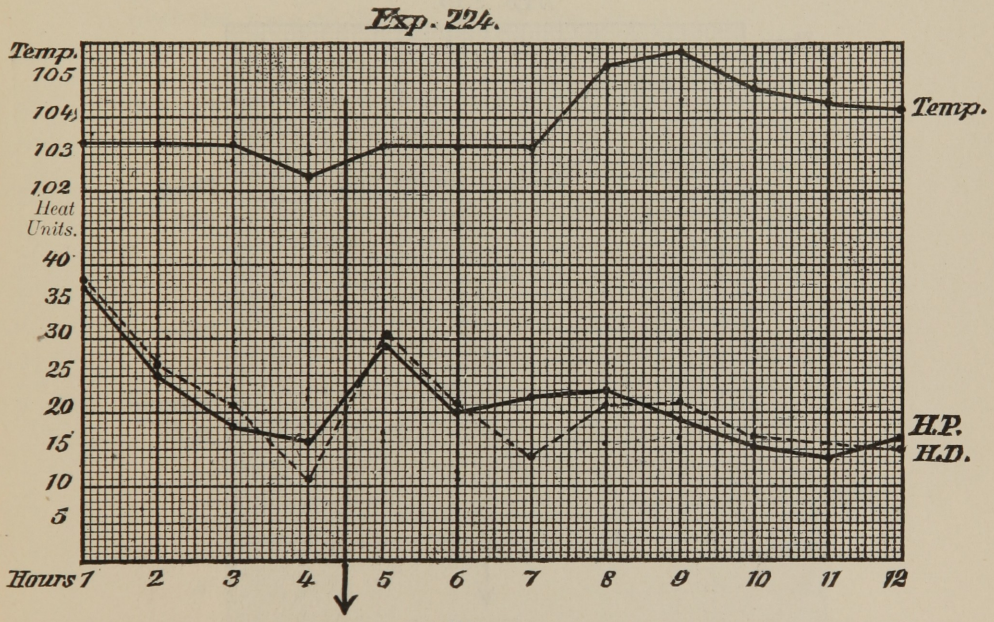

Fig. 5.

Puncture into thermotaxic centre about the gray matter at most anterior part of third ventricle.

that the thalamic is not circumscribed. As to the caudate nucleus, it takes twenty-four to forty-eight hours for its lesion to attain a temperature of 107°, which is the highest temperature accompanying this injury.

No other thermotaxic centre in the brain is like it in that respect, all the other five being rapid risers. The rise of temperature after insults to caudate nucleus is accompanied by an augmented absorption of oxygen, excretion of carbonic acid and urea, according to Messrs. Sachs and

Aronsohn. The great difference in these basal thermotaxic centres, with regard to their accompanying temperature curves as to rapid and slow rise of temperature, their short and long duration make it self-evident that we are dealing with different centres.

It has been thought that the fibres coming from the cortical thermotaxic centres might be injured and concerned in this rise of temperatuae about the basal thermotaxic cen-

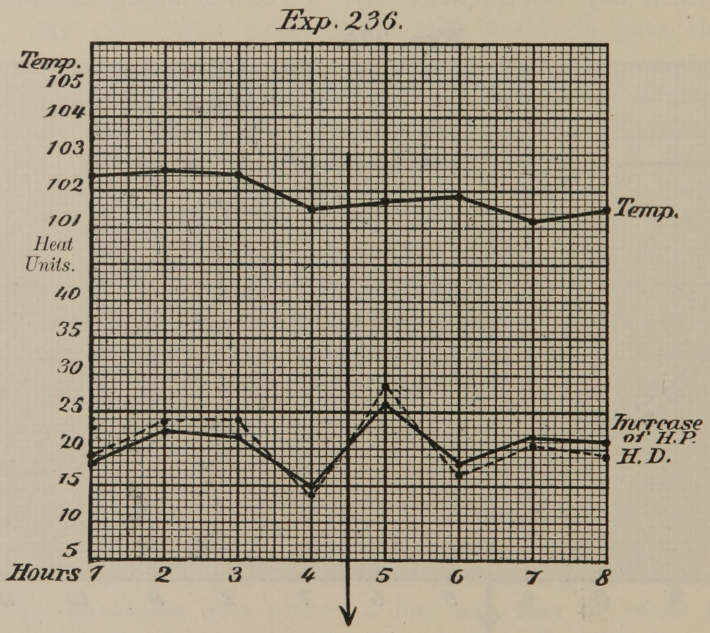

Fig. 6.

tres; but the manner of the rise and the duration of the temperature excludes this view. For instance, the temperature curve after injury of caudate nucleus, and after lesion of the cruciate cortex centre above it, are totally different. Neither for the same reason can the temperature variations, by insults to centres behind or beneath it, be ascribed to the caudate nucleus. It makes a great difference whether you select the point where a lesion with probe is accompanied by the highest temperature, or to a point in the neigh-

borhood where you have temperatures lower and not lasting as long as those made nearer the thermotaxic centre. All opinion is that the sensory fibres stand in a very close relation with these thermotaxic centres, in order to regulate the relation between H. P. and H. D. The relation of the sensory nerves to the polypnœic centre, which is a regulator of heat, also confirms this view.

If these centres were not circumscribed, then usually a probe should cause about the same rise of temperature all over the base of the brain, and this rise should continue

Exp. 225.

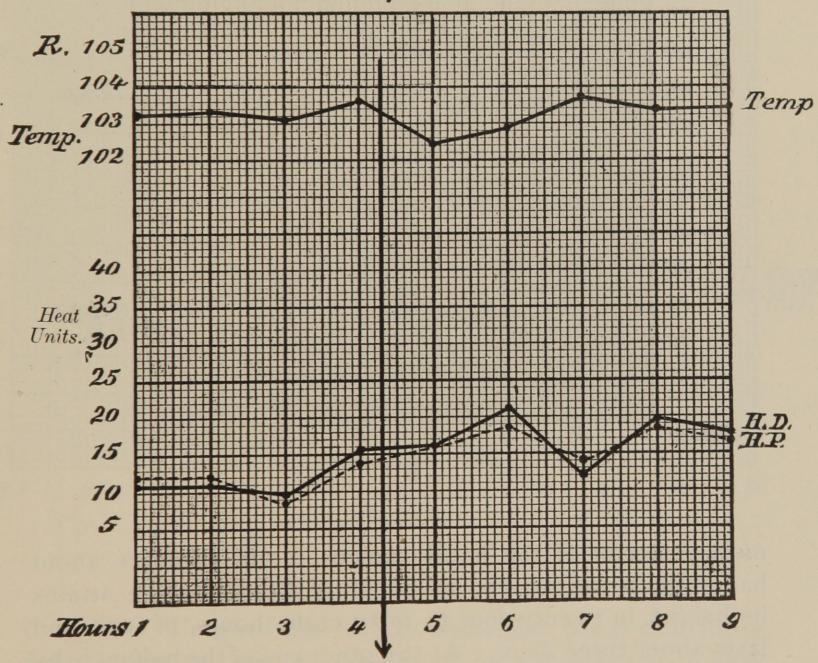

Fig. 7.

about the same length of time. But, as a fact, the probe causes temperature curves not equal in height or duration, and this I regard as a strong argument in favor of circumscribed centres. The real question is where do you usually obtain the highest temperature, and how wide is this area? The point at issue is not a mere rise of temperature of small

amount and short in duration. The difficulty which Dr. Girard erects is that he has a series of small rises, about 105° F., in nearly all his observations upon the first day and less upon the second day; that there cannot be points where lesions are accompanied by temperatures much higher and this point be circumscribed. If a line be drawn from the most anterior thermotaxic centre to the

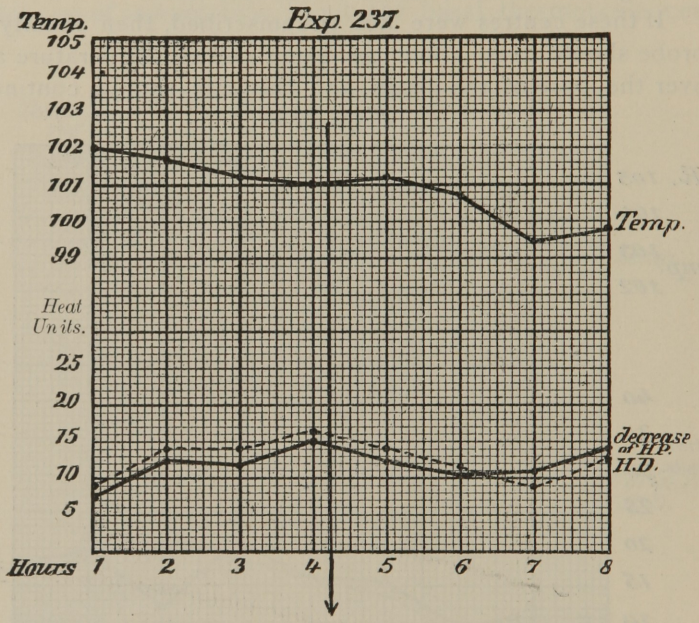

Fig. 8.

most posterior of the basal centres, it will measure about half an inch; at one end by puncture a temperature attains its height, in twenty-four to forty-eight hours, of 107°, and lasts about three days. At the other end of the half inch, by puncture a temperature of 109½° is attained in three hours, and lasts but a short time, returning to normal in four or five hours. Between these two points are two other centres which when punctured are associated with temperatures of 105°–105.5, rapidly reached and continued about three days. Temperature is as sensitive to lesion about these thermotaxic basal centres as arterial tension to irritations of distant parts;

but these changes in arterial pressure do not prove that no chief vaso-motor centre exists. I should like to state here that whilst a rise of temperature is often attained by insults to these centres at the base of the brain, it by no means follows that it always does; for I have often seen the reverse happen with the same sized probe, under the same external circumstances, and about in the same situation in

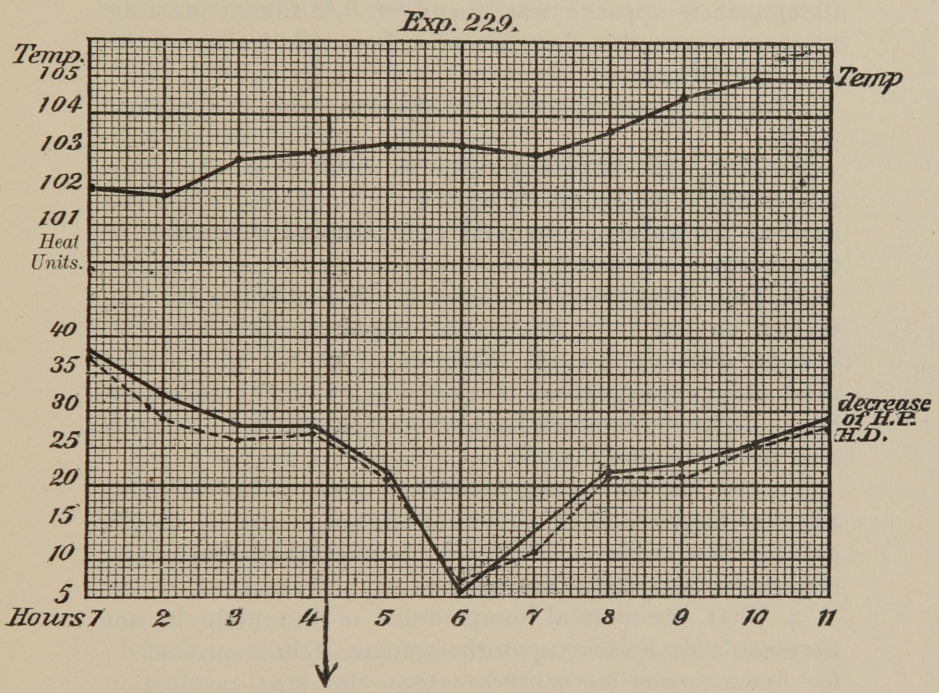

Fig. 9.

the brain. I regard this fact an important proof that these centres preside over the relation of heat production to heat dissipation; and if this relation is disordered so that the temperature falls, it shows that the thermotaxic centres are not necessarily connected directly with heat production.

My calorimetric experiments upon the thermotaxic centres, when continued for several hours, showed sometimes increased production, at other times a decreased production of heat.

Usually there was a temporary elevation of heat production shortly after the injury. At the late Congress, Dr. Ferrier alluded to these thermotaxic centres as probably concerned in trophic work, and inferred that there must be several to preside over the tissues of the body. I have frequently seen great wasting of the body in large and well-developed rabbits after injury of the caudate nucleus, although their appetite was excellent. A similar wasting has been reported in the case of a boy with lesion of the corpus striatum.

The following are the conclusions from the experiments:

1. That the thermotaxic centre situated in the gray matter at the most anterior part of the third ventricle is the same as the thermo-polypnœic; polypnœa is a function of this thermotaxic centre.

2. That this centre acts reflexly, so that when heat is thrown on the body the sensory impulses excited by the heat are conveyed to this thermotaxic centre, which stirs up a thermolytic centre, the respiratory one to throw off heat. It stands between heat production on one side and heat dissipation on the other.

3. That the fall of the number of respirations by heat, after the removal of the above-mentioned centre, is due to an excitation of fibres running in the vagi which inhibit the respiratory centre.

4. That the normal temperature of the body is not necessarily dependent upon the amount of heat produced; for human calorimetry shows that the heat production varies, but the temperature remains nearly the same. The relation of heat production to heat dissipation decides the temperature which is regulated by the thermotaxic centres.

5. The cortical centres, the cruciate (Eulenberg and Landois) and the Sylvian are thermotaxic.

6. The four basal thermotaxic centres are situated as follows: one in the caudate nucleus(Sachs and Aronsohn), one in the gray matter beneath the corpus striatum, one in the gray matter about the most anterior part of the third

ventricle, and still another in the gray matter at the anterior inner end of the optic thalamus.

7. That these six thermotaxic neither inhibit, except indirectly, nor excite heat production, but are thermotaxic, that is, regulating the relation of heat production to heat dissipation. That the thermolytic centres are the vaso-motor, respiratory, and sudorific; that the thermolytic respiratory centre stands in relation to one of the basal thermotaxic centres; that the thermolytic vaso-motor centre probably stands in part in relation to the thermotaxic centre, the caudate nucleus. The thermogenic centres are situated mainly in the spinal cord.

8. The thermotaxic centres are more circumscribed than Dr. Girard, of Geneva, believes.

9. That in fever neither increased production nor decreased dissipation, nor high temperature are necessary, but that fever is mainly a disease of thermotaxis, a disorder of the four basal thermotaxic centres. It is true that in septic fever, in its initial stage, heat production usually runs temporarily ahead of heat dissipation, but exceptionally both are immediately diminished.

10. That the antipyretics, as a rule, neither inhibit nor excite metabolism in a direct manner, but act upon the thermotaxic centres disordered by fever, to restore order or normal thermotaxis. Usually temporarily an antipyretic is accompanied by a diminished heat production and heat dissipation.

The number of experiments upon which this paper is founded is eighty-seven, part of which are given.

R. means number of respirations.
R. T. " rectal temperature.
C. T. " calorimeter temperature.
A. T. " air temperature.
E. T. " exit tube temperature (Centigrade).
M. " meter, amount in litres.
B. T. " temperature of hot box.
Lab. T. " temperature of laboratory.
H. D. " heat dissipation.
H. P. " heat production.

When the thermotaxic centres were punctured, I used a probe two millimetres in width and one in thickness. The tube used in operations upon the basal thermotaxic centres was two millimetres in diameter.

EXP. 165.—Rabbit. Cortex partly destroyed.

P. M.	RESP.	R. T.	B. T.	L. T.
2.12	20	103.5	100	74
2.18	37	103.5		
2.25	45	103.5		
2.35	58	104.2		
2.54	66	105.8	102	
3.15	43	107.8		
3.27	43	109.7	102	
3.35	30	110.4		

EXP. 166.—Rabbit. Cortex destroyed.

TIME, P M.		RESP.	R. T.	B. T.	LAB. T.
1.42	Put in warm box.	49	102.6	104	80
1.50		73	103.	100	
2.4		78	104.	100	
2.20		94	106 1	100	
2.35		103	107.1	102	
2.46		81	108.4	104	
2.52		84	108.4	100	
3.7		50	109.2	102	
3.16		41	109.2	100	
3.27		38	110.2	104	

EXP. 168.—Rabbit. Cortex removed.

P. M.		RESP.
1.50		26
1 55	Electrodes upon the space between corpora striata and optic thalami.	
1.57		42
2.32	Electrodes as above	27
2.34		54

EXP. 175.—Rabbit. Cortex removed.

P. M.		RESP.
2.21	Electrodes as in Exp. 168	20
2.24		54
2.30		20

EXP. 170.—Rabbit. Cortex and corpora striata removed, also the parts at anterior end of 3d ventricle.

P. M.	RESP.	R. T.	B. T.	LAB. T.
2.10	14	99.4	101	76
2.17	11	99.0	101	
2.37	11	100.	97	
2.48	15	102.	102	
3.7	22	102.3	104	
3.20	28	104.4	106	
3.33	21	106.4	104	
3.39	20	109.1		
4.7	Died.	110.8		

EXP. 171.—Rabbit. Cortex removed and also corpora striata, with parts between them and optic thalami.

P. M.		RESP.	R. T.	B. T.	LAB. T.
1.55	Put in box.	17	103.2	110	84
2.		15	103.4	105	
2 5		15	104.3	100	
2.18		15	104.3	106	
2.27		18	105.2	106	
2 37		17	106.1	106	
2.47		23	107.0	102	
3.2		26	108.1	106	
3.18		24	109.2	100	
3.33		25	110.2	104	

EXP. 162.—Rabbit. Polypnœic centre removed.

P. M.	RESP.	R. T.	B. T.	LAB. T.
2.00	31	101.4	102	78
2.10	20	102.	100	
2.30	18	103.8	100	
2.45	30	105.2	100	
3.0	28	107.4	100	
3.15	29	108.8	100	
3.30	34	110.4	102	
3.40	33	111.8	100	
3.55	Dying.	113.		

EXP. 172.—Rabbit. Cortex destroyed, polypnœic centre destroyed on both sides.

P. M.	RESP.	R. T.	B. T.	LAB. T.
1.50	14	102.2	105	78
1.51	12	102.	100	
2.10	14	102.4	98	
2.20	13	104.	102	
2.37	14	106.	100	
2.53	17	108.1	102	
3.8	17	110.1	104	
3.12	17	110.3	104	

EXP. 177.—Rabbit. Cortex removed; a puncture made into the anterior end of the gray matter about the 3d ventricle.

P. M.		RESP.	R. T.	B. T.	LAB. T.
1.35	Put in box.	13	$103\frac{8}{5}$	100	26
1.38		12	$103\frac{1}{5}$	100	
1.42		19	$103\frac{1}{5}$		
1.51		19			
2.8		15	104.0	104	
2.22		16	105.2	106	
2.40		31	107.1	108	
2 42		19	107	108	
2.50		19	107	108	
3.6		19	108	108	

Autopsy: polypnœic centre partly destroyed.

EXP. 181.—Rabbit. Cortex removed, corpora striata only destroyed.

P. M.	RESP.	R. T.	B. T.
3.30	17	104^{1}	100
3.33	36		
3.38	66	$107\frac{1}{5}$	116

EXP. 182.——A section made between pons and medulla oblongata at lower border of pons.

2.1	25	104	108	78
2.5	31	$104\frac{4}{5}$	108	
2.15	33	105.1	110	
2.32	30	108	112	
2.42	32	109	110	
3.5 Dying.	33	$111\frac{3}{5}$	110	

EXP. 183.—Rabbit. Transverse section through the crura cerebri, leaving corpora quadrigemina intact.

P. M.		RESP.	R. T.	B. T.	LAB. T.
3.27	Put in box.	22	$105\frac{2}{5}$		80
3.32		19	$105\frac{4}{5}$	108	
3.48		19	106.1	104	
4.1		22	107	106	
4.26		26	109 1	104	
4.55		28	111	106	

EXP. 184.—Rabbit. Transverse section through the pons; convulsions in left posterior leg.

P. M.		RESP.	R. T.	B. T.	LAB. T.
1.31		15	$103\frac{2}{5}$		72
1.32		14		94	
1.37		11	$103\frac{2}{5}$	94	
1.52		12	101^{2}	96	
2.10		15	107	100	
2.20	Dying; respiratory movements, all inspiratory.....		$108\frac{4}{5}$	102	

EXP. 186—Rabbit. Section just behind corpora quadrigemina, leaving pons and medulla intact.

P. M.	RESP.	R. T.	B. T.	LAB. T.
2.35	18	$102\frac{3}{5}$	98	68
2.43	21	$101\frac{4}{5}$	98	
2.54	17	$103\frac{3}{5}$	98	
3.6	16	$105\frac{1}{5}$	100	
3.17	15	107	102	
3.26	16	$107\frac{4}{5}$	104	
3.35	22	$109\frac{1}{10}$	100	

EXP. 188.—Rabbit. Section transversely at anterior edge of corpora quadrigemina down to the base of brain, carotids previously ligated.

P. M.	RESP.	R. T.	B. T.	LAB. T.
2.	14	$100\frac{1}{5}$	104	64
2.5	14	$100\frac{1}{5}$	102	
2.15	16	$100\frac{3}{5}$	102	
2.24	16	$101\frac{4}{5}$	102	
3.16	18	$108\frac{2}{5}$	106	
3.22	22	109.1	106	

EXP. 192.—Rabbit. Carotids ligated, trigemini divided, transverse section just behind the polypnœic centre.

P. M.	RESP.	R. T.	B. T.	LAB. T.
4.7	25	$102\frac{3}{5}$	100	72
4.10	Put in box.			
4.17	18	$102\frac{4}{5}$	102	
4.25	17	$103\frac{2}{5}$	100	
4.33	14	104	100	
4.47	15	105	100	
5.13	16	109	112	
5.26	20	$109\frac{4}{5}$	98	

EXP. 195.—Rabbit. Vagi cut, cortex destroyed, polypnœic centre cut off by a transverse section at anterior part of optic thalami.

P. M.	RESP.	R. T.	B. T.	LAB. T.
1.15	12	$101\frac{1}{5}$	92	70
1.22	12	$102\frac{2}{5}$	98	
1.30	12	$101\frac{4}{5}$	102	
1.49	12	$102\frac{3}{5}$	102	
2.1	12	103	100	
2.34	12	$106\frac{4}{5}$	98	
3.12	16	$110\frac{2}{5}$	100	

EXP. 196—Rabbit. Cortex, vagi cut; polypnœic centre removed by a transverse section.

P. M.	RESP.	R. T.	B. T.	LAB. T.
3.40	16	$104\frac{4}{5}$	100	66
3.45	$15\frac{1}{2}$		98	
3.52	$16\frac{1}{2}$	$104\frac{1}{5}$	98	
4.1	19	$105\frac{3}{5}$	98	
4.14	23	$106\frac{4}{5}$	98	
4.30	22	109^{1}	98	

EXP. 238.—Rabbit.

P. M.	R. T.
12.20	102.2
12.30 Transverse section through the middle of the pons.	
1.10	$99\frac{3}{5}$
1.40	99 6
2.5	99.4
2.34	99.8
3.5	100.6
3.47	101.2

EXP. 239.—Rabbit.

P. M.		R.	R. T.	BOX T.
1.55	10 grs. of antipyrin subcutaneously..	17	103.3	80
3.		12	101.3	94
3.17		25	101.8	102
3.35		31	103.4	109
3.55		31	105.6	111
4.10		37	108.1	111
4.30	Died.			

EXP. 240 —Rabbit.

P. M.	R.	R. T.	BOX T.
1.40	10 grs. of antipyrin subcutaneously.		
2.20	5 grs. of antipyrin subcutaneously.		
2.3	120	101.1	86
2.4	150	102	86
3.	28	103.2	92
3.15	19	104.6	98
3.35	20	107·7	106
3.45	21	109.8	104
	Died.		

EXP. 242.—Rabbit.

P. M.		R. T.
12.34		100.4
1.40	Transverse section of brain at posterior end of optic thalami.	
2.5		101 5
3.12		100 5
4.20		99.2

EXP. 246.—Rabbit; heated up.

P. M.		R.	R. T.
2.		95	103 4
2.15	8 grains of antipyrin by the jugular. The animal is removed from the heated box and lies on the table.		
2.16		98	
2.17		92	
2.18		93	
2.19		96	
2.22		92	
2.23		82	
2.24		69	
2.26		62	

2.39	32
2.31	33
2.32	21
2.33	11
2.42	6
2.47	7

EXP. 243.—Rabbit.

P. M.	R.	R. T.	B. T.
1.30	4 gtts. of blood subcutaneously.		
3.55	7	102.5	102
4.	7	102.5	
4.12	17	102.9	
4.20	34	103.8	104
4.30	49	104 4	
4 40	57	106.	
4.55	58	106.5	
5.	56	108.	
5.10	36	109.	
5.15	30	110	
5.25	29	110.4	108

EXP. 245.—Rabbit.

P. M.		R.	R. T.
3.		24	103.7
3.29.45		85	106.
3.30	Dropped into ice water and kept in	23	
3.30.15		40	
3.30.30		44	
3.30.45		48	
3.31.45		56	
3.32.45		71	
3.35.0		31	

EXP. 244.—Rabbit. Hair closely clipped over the whole body.

		R.	R. T.	B. T.
12.00 M.			102.2	
P. M.				
12.10	Covered with mucilage.			
1.5		7	98 6	100
1.12		7	97.2	
1.21		7	96.6	96
1.33		7	96.6	102
1.43		6	96.8	104
2.10		7	98.8	100
3.15		8	101.2	102
3.30		60	102.2	108
3.45		78	102.8	104
4.		53	105.2	
4.23		30	108.	

EXP. 202.—Rabbit. Carotids tied, cortex lifted up, thalamic bared, and a hollow tube two millimetres in diameter pushed down into the anterior ends of both thalami.

P. M.	R. T.
3.45	$102\frac{4}{5}$
3.46 Operation performed.	
3.56	$102\frac{4}{5}$
4.17	102
4.45	102.1
5.	102.1
6.	$103\frac{3}{5}$
7.30	$104\frac{4}{5}$
9.30	$104\frac{4}{5}$
2d day.	
8 A. M.	$101\frac{2}{5}$

EXP. 203.—Rabbit. Cortex lifted up, anterior end of right thalamus tubed, carotids tied, runs to left.

P. M.	R. T.
2.	$103\frac{4}{5}$
2.10 Operation performed.	
2.40	$103\frac{3}{5}$
3.3	$103\frac{4}{5}$
3.30	$103\frac{1}{5}$
3.44	$103\frac{3}{5}$
4.29	$103\frac{3}{5}$
4.58	$103\frac{3}{5}$
6.45	$103\frac{2}{5}$
9.30	102
2d day.	
8 A. M.	93.2

EXP. 204.—Rabbit.

P. M.	R. T.
1.20	102
1.30 Right optic thalamus punctured about its middle.	
2.7	$101\frac{8}{5}$
2.40	$101\frac{4}{5}$

P. M.	R. T.
3.15	$102\frac{1}{5}$
3.30	$101\frac{9}{10}$
4.	$102\frac{2}{5}$
4.30	$102\frac{1}{5}$
5.	$102\frac{1}{5}$
6.	103
8.	$101\frac{2}{5}$

EXP. 205.—Rabbit. Cortex lifted up.

P. M.	R. T.
1.45	$103\frac{3}{5}$
1.50 Right optic thalamus tubed about its middle.	
2.17	$102\frac{1}{5}$
2.44	$101\frac{1}{5}$
3.18	101
3.35	$100\frac{4}{5}$
4.	$101\frac{3}{5}$
4.30	$101\frac{3}{5}$
5.	$101\frac{2}{5}$
6.	$101\frac{3}{5}$
8.	$98\frac{2}{5}$

EXP. 206.—Rabbit. Carotids tied, cortex lifted.

P. M.	R. T.
1.30	103
1.35 Optic thalamus punctured about its middle.	
1.57	$101\frac{1}{5}$
2.35	$102\frac{1}{5}$
3.3	$101\frac{3}{5}$
3.20	101.2
3.39	$101\frac{2}{5}$
4.14	$101\frac{2}{5}$
Ligature removed from the carotids.	
4.30	$100\frac{9}{10}$
4.445	$100\frac{1}{5}$
5.45	101
8.	102
9.	100.9

EXP. 207.—Rabbit. Carotids tied.

P. M.	R. T.
2.20	$103\frac{3}{5}$
2.30 Right optic thalamus tubed about its middle, cortex lifted up.	
2.58	102
3.14	$102\frac{1}{5}$
3.35	$102\frac{3}{5}$
3.59	$103\frac{1}{5}$
4.45	$103\frac{1}{5}$
5.	$102\frac{4}{5}$
5.40	101
8.	101

EXP. 208.—Rabbit.

P. M.	R. T.
4.25	103
4.30 Thalamic, thermotaxic centre had a tube two millimetres through it.	
4.45	$102\frac{1}{5}$
5.	$102\frac{2}{5}$
5.15	$102\frac{1}{5}$
5.37	$102\frac{1}{5}$
6.45	$102\frac{4}{5}$
8.	103
9.30	$103\frac{4}{5}$

EXP. 209.—Rabbit.

P. M.	R. T.
1.30	103
1.35 Thalamic thermotaxic centre destroyed.	
2.8	$101\frac{1}{5}$
2.32	101
2.56	101
3.21	$101\frac{1}{5}$
3.40	$101\frac{4}{5}$
3.59	$101\frac{4}{5}$
4.20	102
4.40	$102\frac{3}{5}$
5.45	$103\frac{2}{5}$
6.45	$104\frac{2}{5}$
8.40	$101\frac{4}{5}$

2d day.

8 A. M. 103

EXP. 210.—Rabbit.

P. M.		R. T.
1.40		$103\frac{1}{5}$
1.45	Thermotaxic centre at anterior inner end of gray matter of 3d ventricle tubed in part; respirations 240 per minute; thermo-polypnœa.	
2.13		$100\frac{4}{5}$
2.36		$100\frac{3}{5}$
3.1		$100\frac{2}{5}$
3.32		$100\frac{4}{5}$
3.50		$99\frac{3}{5}$
4.08		99.9
4.27		99.8
4.45		99.8
5.50		$99\frac{3}{5}$
6.50		100
8.40		$101\frac{1}{5}$

2d day.

8 A. M. ..... $102\frac{5}{8}$

EXP. 211.—Rabbit.

P. M.		R. T.
11.20		101.1
11.25	The gray matter of the 3d ventricle at its most anterior part had a tube two millimetres in diameter driven through it; corpus striatum slightly injured.	
11.30		$99\frac{3}{5}$
11.45		$99\frac{3}{5}$
12.27		101
1.12		$100\frac{1}{5}$
1.33		$99\frac{2}{5}$
1.59		$99\frac{1}{5}$
2.32		$98\frac{4}{5}$
2.53		$98\frac{4}{5}$
3.34		$98\frac{3}{5}$
6.10		100
9.20		$101\frac{1}{5}$

2d day.

8 A. M. ..... $101\frac{4}{5}$

EXP. 212.—Rabbit.

P. M.		R. T.
11.35		103
11.40	The gray matter of the 3d ventricle at its most anterior part had a tube pressed through it; corpus striatum partly injured.	
11.54		100
11.35		102
1.15		$103\frac{4}{5}$
1.37		$104\frac{1}{5}$
2.05		$104\frac{2}{5}$
2.37		$103\frac{3}{5}$
2.57		$101\frac{4}{5}$
4.35		$102\frac{3}{5}$
9.20		$104\frac{3}{5}$
8 A. M., 2d day—convulsions		98

EXP. 213.—Rabbit.

P. M.		R. T.
12.40		103
12.50	Caudate nucleus cleanly sucked out.	
1.20		$102\frac{2}{5}$
1.40		$102\frac{2}{5}$
2.10		$102\frac{3}{5}$
3.18		$101\frac{4}{5}$
3.41		$102\frac{1}{5}$
4.39		$102\frac{3}{5}$
6.20		102.9
9.30		102.2
8 A. M., 2d day		103

EXP. 214.—Rabbit.

P. M.		R. T.
1.		$103\frac{3}{5}$
1.10	Tissue beneath corpus striatum broken up.	
1.22		102

P. M.	R. T.
1.44	102
2.13	$101\frac{4}{5}$
2.45	$101\frac{4}{5}$
3.7	$101\frac{2}{5}$
3.22	$101\frac{1}{5}$
4.35	102
6.25	102.9
9.20	$103\frac{3}{5}$
8 A. M., 2d day	$103\frac{2}{5}$

EXP. 216.—Rabbit; fasted 3 days, allowed water; wt. 3.86 lbs.

TIME.	A. T.	C. T.	E. T.	R. T.	METER.
7.30	66.6	66.6	$18\frac{2}{5}$	101.1	95,544 litres.
8.30	68.5	67.0	19	101.8	96,385 "
		4		—.3	

H. D. = 16.68. H. P. = 15.82. Wt. 3.74 lbs.

8.35	69.1	67.	19	101.8	96,385	"
9.35	70.	67.4	$19\frac{4}{5}$	102.4	96,995	"
		.4		.6		

H. D. = 16.68. H. P. = 18.54. Wt. 3.74 lbs.

9.41	70.	67.4	$19\frac{4}{5}$	102.4	96,995	"
10.41	70.1	67.8	$19\frac{3}{5}$	101.8	97,365	"
		.4		—.6		

H. D. = 16.68. H. P. = 14.84. Wt. 3.70 lbs.

10.52	70.1	67.8	$19\frac{3}{5}$	101.8	97,365	"
11.52	71.1	68.18	$19\frac{4}{5}$	101.8	97,772.5	"
				.0		

12 M. Puncture by a tube two millimetres through the gray matter at the most anterior end of the 3d ventricle.

12.17	72.6	68.18	20	101.	97,725	litres.
12.17	72.0	68.4	20	102.4	98,295	"
		+ .22		+ 1.4		

H. D. = 9.178. H. P. = 13.46. Wt. 3.70 lbs.

1.21	72.	68.4	20	102.4	98,295	"
2.21	73.1	68.75	20	103.8	98,610	"
		+ .35		1.4		

H.P. = 14.60. H. P. = 18.89. Wt. 3.70 lbs.

2.25	73.1	68.75	20.	103.8	98,610	"
3.25	74.5	69.2	20.4	104.6	99,050	"
		+ .45				

H. D. = 18.77. H. P. = 21.21. Wt. 3.68 lbs.

3.30	74.5	69.2	20.4	104.6	99,050	"
4.30	74.5	69.5	20.6	104.6	99,710	"
		.3		— .0		

H. D. = 12.51. H. P. = 13.12. Wt. 3.68 lbs.

4.35	74.5	69.5	$20\frac{3}{5}$	$104\frac{3}{5}$	99,710	"
5.35	71.8	69.9	$20\frac{4}{5}$	$104\frac{3}{5}$	101,019	"
		.4				

H. D. = 16.68. H. P. = 17.29. Wt. 3.68 lbs.

5.42	71.8	69.9	$20\frac{4}{5}$	$104\frac{3}{5}$	101,019	"
6.42	71.4	70.3	$21\frac{1}{5}$	$104\frac{4}{5}$	102,218	"
		.4		$+\frac{1}{5}$		

H. D. = 16.68. H. P. = 17.29.

EXP. 217.—Rabbit; fasted 3 days.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.17	70.7	70.7	21.2	101.1	
8.17	71.4	71.4	21.4	101.8	1,122
	.7				

H. D. = 29.20. H. P. = 18.25. Wt. 3.82 lbs.

8.20	71.4	71.4	21.4	101.8	
9.20	76.1	71.9	21.8	101.8	945
		.5			

H. D. = 10.86. H. P. = 20.86. Wt. 3.°2 lbs.

9.25	76.1	71.9	21.8	101.8	
10.25	73.6	72.4	22.	102.2	1,015
		.5		+ .4	

H. D. = 20.86. H. P. = 24.06. Wt. 3.82 lbs.

10.32	73.6	72.4	22.	102.2	
11.32	74.8	72.9	22.4	101.9	1,015
		·5		— ·3	

H. D. = 20.86. H. P. = 19.91.

11.40 A. M. A tube two millimetres in diameter was pushed through the anterior inner end of optic thalamus.

Wt. 3.82 lbs.

12.	75.	72.9	22.6	101.2	
1.	76.3	73.4	22.4	99.6	1,055

H. D. = 20.86. H. P. = 15.79. Wt. 3.78 lbs.

1.7	76.3	73.4	22.4	99.6	
2.7	73.1	73.8	22.8	99.8	1,230
		.4		+ .2	

H. D. = 16.68. H. P. = 17.31. Wt. 3.78 lbs.

2.15	74.1	73.8	22.8	99.8	
3.15	75.2	74.2	23.0	101.2	1,060
				1.4	

H. D. = 16.68. H. P. = 17.20. Wt. 3.76 lbs.

3.22	75.2	74.2	23.	101.2	
4.22	77.3	74.8	23.4	102.4	1,080

H. D. = 25.03. H. P. = 28.75. Wt. 3.74 lbs.

4.25	75.3	74.8	23.4	102.4	
5.25	77.7	75.35	23.8	104.1	1,034
		·55		+ 1.9	

H. D. = 22.94. H. P. = 28.83.

EXP. 218.—Rabbit; fasted 2½ days; wt. 4.62 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.16	72.2	70.5	20.2	102.0	
8.16	73.7	70.90	20.4	101.8	1,141

H. D. = 16.68. H. P. = 15.92. Wt. 4.62 lbs.

8.24	73.7	70.9	20.4	101.8	
9.24	73.6	71.15	20.8	102.2	985
		.25		.4	

H. D. = 10.43. H. P. = 11.19. Wt. 4.62 lbs.

9.29	73.6	71.15	20.8	102.2	
10.29	73.9	71.4	21.2	102.6	945
		.25		+ .4	

H. D. = 10.43. H. P. = 11.19. Wt. 4.62 lbs.

10.38	73.9	71.4	21.2	102.6	
11.38	74.8	71.88	21.4	102.3	950
		.48		— .3	

H. D. = 20.02. H. P. = 17.82.

12 M. Caudate nucleus in greater part sucked out.

Wt. 4.52 lbs.

12.5	75.3	71.7	21.4	101.4	
1.5	76.05	72.1	21.8	102.6	1,116
		.4		1.2	

H. D. = 16.68. H. P. = 21.18. Wt. 4.48 lbs.

1.15	76.05	72.1	21.8	102.2	
2.15	74.8	72.5	22.2	103.1	2,454
		.4		+ .9	

H. D. = 16.68. H. P. = 20.02. Wt. 4.46 lbs.

2.20	74.8	72.5	22.2	103.1	
3.20	75.6	73.1	22.2	102.8	2,730
		.6		— .3	

H. D. = 24.03. H. P. = 25.24. Wt. 4.46 lbs.

3.25	75.6	73.1	22.2	102.8	
4.25	74.5	73.5	22.2	102.6	2,690
		.4		.2	

H. D. = 16.68. H. P. = 15.94.

4.30	74.5	73.5	22.2	102.6	
5.30	77.	74.	22.8	102.4	2,690
		.5		— .2	

H. D. = 20.86. H. P. = 20.12.

EXP. 219.—Rabbit; fasted 2½ days; wt. 3.60 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.15	71.7	71.2	21.0	102.	
8.15	74.2	71.8	21.3	100.8	1,210
		.6		— 1.2	

H. D. = 25.03. H. P. = 21.45. Wt. 3.56 lbs.

8.25	74.1	71.8	21.3	100.8	
9.25	73.5	72.15	21.4	100.2	1,040
		.35		— .6	

H. D. = 14.60. H. P. = 12.83. Wt. 3.56 lbs.

9.34	73.5	72.15	21.4	100.2	
10.34	74.	72.5	21.4	100.4	1,365
				.2	

H. D. = 14.60. H. P. = 15.19.

10.40	74.	72.5	21.4	100.4	
11.40	74.6	72.9	22.2	100.4	1,095
		.4			

H. D. = 16.68. H. P. = 16.68.

11.45. A blunt probe thrust through the gray matter about the most anterior end of the 3d ventricle.

Wt. 3.42 lbs.

12.	74.6	72.9	22.2	99.6	
1.	73.6	73.0	22.2	101.	1,100
		.1		1.4	

H. D. = 4.17. H. P. = 8.14. Wt. 3.40 lbs.

1.3	73.6	73.0	22.2	101.0	
2.3	75.9	73.35	22.4	101.6	1,046
		.35		+ .6	

H. D. = 14.60. H. P. = 16.29. Wt. 3.36 lbs.

2.6	75.9	73.35	22.4	101.6	
3.6	75.4	73.7	22.6	101.8	1,145
		.35		.2	

H. D. = 14.60. H. P. = 15.15. Wt. 3.34 lbs.

3.11	75.4	73.7	22.6	101.8	
4.11	76.0	74.1	22.8	102.	950
		.4		+ .2	

H. D. = 16.68. H. P. = 17.23. Wt. 3.32 lbs.

4.14	76.3	74.1	22.8	102.	
5.14	75.3	74.4	23.0	102.4	705
		.3		+ .4	

H. D. = 12.51. H. P. = 13.51.

5.18	75.3	74.4	23.	101.6	
6.18	75.5	74.8	23.2	102.0	572
		.4		+ .4	

H. D. = 16.68. H. P. = 17.78.

EXP. 220.—Rabbit; fasting 3 days; wt. 4.24 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.54	70.45	70.45	20.	101.2	
8.54	72.7	70.95	20.3	100.6	1,214
		.5		— .4	

H. D. = 20.86. H. P. = 19.46. Wt. 4 lbs.

9.2	72.7	71.95	20.6	100.6	
10.2	72.1	72.2	20.8	100.6	2,140
		.25		.0	

H. D. = 10.43. H. P. = 10.43. Wt. 4 lbs.

10.10	72.1	71.2	20.8	100.6	
11.10	74.3	71.5	21.2	100.4	1,555
		.3		— .2	
11.15	74.3	71.5	21.2	100.4	
12.15	75.7	72.0	21.4	100.4	1,210
		.5			

H. D. = 20.86. H. P. = 20.86.

12.20 Corpus striatum destroyed.
Wt. 3.98 lbs.

12.30	74.7	71.95	21.4	99.4	
1.30	72.7	72.1	21.7	100.	500
		.15		+ .6	

H. D. = 6.25. H. P. = 6.45. Wt. 3.98 lbs.

1.35	72.7	72.1	21.7	100.	
2.35	77.0	71.35	21.8	100.4	1,515
		+ .25		+ .4	

H. D. = 10.43. H. P. = 11.75. Wt. 4.98 lbs.

2.40	75.5	72.35	21.8	100.4	
3.40	76.8	72.65	22.0	100.4	127
		.30		.0	

H. D. = 12.51. H. P. = 12.51. Wt. 3.96 lbs.

3.45	76.8	72.65	22.	100.4	
4.45	76.7	83.	22.2	100.4	1,463
		.35			

H. D. = 14.60. H. P. = 14.60. Wt. 3.96 lbs.

4.49	76.7	73.0	22.1	100.4	
5.49	74.55	73.3	22.6	100.8	846
		.3		+ .4	

H. D. = 12.51. H. P. = 13.83.

EXP. 221.—Rabbit; fasted 3 days.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.20	74.0	67.9	20.5	102.2	
8.20	72.1	68.75	20.4	102.2	1,119
		.85			

H. D. = 35.45. H. P. = 35.45. Wt. 3.84 lbs.

8.27	72.1	68.75	20.4	102.2	
9.27	71.3	69.55	20.8	101.8	1,215
		.80		—. 4	

H. D. = 33.37. H. P. = 32.10. Wt. 3.84 lbs.

9.34	71.3	69.55	20.8	101.8	
10.34	72.	70.1	21.2	101.9	1,213
				+.1	

H. D. = 22.94. H. P. = 23.25. Wt. 3.84 lbs.

10.43	72.	70.1	21.1	101.8	
11.43	73.6	70.7	21.4	102.1	1,187
		.6		.7	

H. D. = 25.06. H. P. = 27.29.

11.50. Gray matter beneath corpus striatum destroyed with probe.

Wt. 3.83 lbs.

12.10	73.4	70.7	21.6	101.2	
1.10	71.6	71.1	21.6	101.6	1,215
		.4		+ .4	

H. D. = 16.68. H. P. = 17.95. Wt. 3.76 lbs.

1.14	71.6	71.15	21.6	101.6	
2.14	73.2	71.70	21.8	101.2	1,300
		.55		— .4	

H. D. = 22.94. H. P. = 21.70. Wt. 3.76 lbs.

2.19	73.2	61.70	21.7	101.2	
3.19	72.2	72.1	22.	100.8	2,755
		.40		— .4	

H. D. = 16.68. H. P. = 15.44. Wt. 4.64 lbs.

3.20	73.0	72.1	22.	100.6	
4.20	75.5	72.5	22.4	101.2	1,095
		.4		.6	

H. D. = 16.68. H. P. = 18.99. Wt. 3.64 lbs.

4.36	75.5	72.5	22.4	101.2	
5.26	76.9	72.9	22.7	101.4	1,795
				+ .2	

H. D. = 16.68. H. P. = 17.30.

EXP. 224.—Rabbit; fasted 2 days; wt. 4.28.

7.21	72.	71.9	21.2	102.0	
8.21	77.6	72.4	21.8	102.0	979
		.5		.0	

H. D. = 20.86. H. P. = 20.86. Wt. 4.28 lbs.

8.24	77.8	72.4	21.8	102.0	
9.24	75.2	72.8	22.2	102.0	1,082
		.4			

H. D. = 16.86. H. P. = 16.86. Wt. 4.28 lbs.

9.30	75.2	72.8	22.7	102.0	
10.30	65.4	73.2	22.4	102.0	1,348
		.4			

H. D. = 16.68. H. P. = 16.68. Wt. 4.26 lbs.

10.34	75.4	73.2	22.4	102.0	
11.34	76.4	73.9	22.6	101.6	2,525
		.6		.4	

H. D. = 25.03. H. P. = 23.62. Wt. 4.24 lbs.

11.40	76.4	73.8	22.9	101.6	
12.40	76.2	74.1	22.8	102.0	1,715
		.3		+ .4	

H. D. = 12.51. H. P. = 13.90.

1.20. Puncture into thalamus at its anterior inner end.

2.7	76.0	73.9	22.8	102.4	
3.7	76.5	74.3	23.0	102.8	1,055
		.4		+ .4	

H. D. = 16.68. H. P. = 18.08. Wt. 4.20 lbs.

3.12	76.5	74.3	23.0	101.8	
4.12	75.0	74.7	23.2	102.9	940
		.4		.0	

H. D. = 16.68. H. P. = 16.68. Wt. 4.20 lbs.

4.15	75.0	74.7	23.2	102.8	
5.15	77.2	75.1	23.4	103.0	1,065
		.4		+ .2	

Wt. 4.20 lbs.

5.19	77.2	75.1	23.2	103.0	
6.19	76.	75.5	23.4	102.6	1,224
		.3		— .4	

H. D. = 12.51. H. P. = 11.12.

EXP. 224.—Rabbit; fasted 12 hours; wt. 4.62 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.19	71.4	71.4	21.	103.4	
8.19	73.1	70.3	21.6	103.4	1,111

H. D. = 37.54. H. P. = 37.54. Wt. 4.50 lbs.

8.23	73.1	72.3	21.4	103.4	
9.23	76.8	72.9	22.0	10.32	1,055
		.6		—.2	

H. D. = 25.03. H. P. = 24.29. Wt. 4.48 lbs.

9.28	76.8	72.9	22.0	103.2	
10.28	76.6	73.4	22.4	102.6	890
		.5		—. 6	

H. D. = 20.86. H. P. = 18.63.

10.35	76.6	73.4	22.4	102.6	
11.35	75.5	73.65	22.4	104.2	1,130
		+ .25		+ 1.6	

H. D. = 10.43. H. P. = 17.56.

11.45. Puncture into the gray matter at the most anterior end of the 3d ventricle.

				103.8	
12.				104.1	
12.10				103.6	
12.29	77.4	73.45	22.4	103.4	995
1.29	65.2	74.2	22.8		
		.75		— .2	

H. D. = 31.29. H. P. = 30.56. Wt. 4.44 lbs.

1.35	76.2	74.2	22.2	103.4	
2.35	75.8	74.7	23.0	103.6	645
		.5		+ .2	

H. D. = 20.86. H. P. = 20.50. Wt. 4.40 lbs.

2.44	75.8	74.7	33.0	103.6	
3.44	75.2	75.05	23.2	105.6	600
		+ 35		2.0	

H. D. = 14.60. H. P. = 22.00. Wt. 4.30 lbs.

3.49	75.2	75.05	23.2	105.3	
4.49	77.2	75.55	23.8	105.8	225
		.50		+ .5	

H. D. = 20.86. H. P. = 22.68. Wt. 4.24 lbs.

4.59	77.2	75.55	23.8	105.8	
5.59	76.15	76.1	24.0	104.8	1,075
		1.55		—.9	

H. D. = 22.94. H. P. = 19.78. Wt. 4.24 lbs.

6.3	76.8	76.1	24.0	104.9	
7.3	81.7	76.5	24.4	104.6	1,589
		.4		— .3	

H. D. = 16.68. H. P. 15.63.

7.6	80.8	76.5	24.4	104.6	
8.6	78.2	76.9	24.6	104.4	1,226
		.4			

H. D. = 15.28. H. P. = 14.58.

8.12	77.8	76.9	24.6	104.4	
9.12	77.9	77.3	34.6	104.6	675
		.4		+ .2	

H. D. = 15.28. H. P. = 15.97.

EXP. 225.—Rabbit; fasted 12 hours; wt. 3.68 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.15	77.3	71.1	20.4	103.2	
8.15	73.7	71.4	20.8	103.4	1,300
		.3		+ .2	

H. D. = 12.51. H. P. = 13.12. Wt. 3.68 lbs.

8.21	73.7	71.4	20.8	103.4	
9.21	73.1	71.7	21.2	103.2	715
		.2		— .2	

H. D. = 12.51. H. P. = 11.96. Wt. 3.68 lbs.

9.29	73.1	71.7	21.2	103.2	
10.29	74.9	71.9	21.6	103.5	505
		.2		+ .3	

H. D. = 8.34. H. P. = 9.26. Wt. 3.68 lbs.

10.36	74.9	71.9	21.6	103 5	
11.36	74.5	72.25	21.8	103.8	595
		.35		+ .3	

H. D. = 14.60. H. P. = 15.51.

11.45. Two punctures near the thalamic thermotaxic centre. Wt 3 68 lbs.

12.40	77.4	72.05	22.	102.8	
1.40	76.9	72.45	12.	102.9	823
		.40		+ .1	

H. D. = 16.68. H. P. = 16.98. Wt. 3 66 lbs.

1.43	76.9	72.45	22.	102.9	
2.43	76.	72.9	22.1	103.9	767
		.45		+ .1	

H. D. = 18.77. H. P. = 21.80. Wt. 3.64 lbs.

2.56	76.	72.9	22.1	103.9	
3.50	75 9	73 25	22.6	103.4	755
		.35		— .5	

H. D. = 14.60. H. P. = 13.19.

3.56	75.1	73.25	22.6	103.5	
4.56	75.7	73.7	22.8	103.4	620
		.45		.0	
5.0	76.7	73.7	22.8	103.4	
7 0	75.6	74.1	22.8	103.5	665
		.4		+ .1	

H. D. = 16.68. H. P. = 16.98.

EXP. 226.—Rabbit; fasted 12 days; wt. 4.6 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.37	78.	67.2	19.	101.9	
8.37	70.2	67.8	19.6	102.3	1,025
		.6			

H. D. = 25.13. H. P. = 26.84. Wt. 4.6 lbs.

8.45	70.2	67.8	19.6	102.5	
8.45	70.7	68.6	20.2	102.7	610
		.8		.2	

H. D. = 33.37. H. P. = 34.13. Wt. 4.2 lbs.

9.53	70.7	68.6	20.2	102.7	
10.53	70.	69.2	20.4	102.8	1,150
		.6		+ .1	

H. D. = 25.03. H. P. = 25.37. Wt. 4 lbs.

10.59	71.0	69.2	20.4	102.8	
11 5	71.7	69.7	20.6	101.7	715
		.5		— .1	

H. D. = 20.76. H. P. = 20.53. Wt. 3.98 lbs.

12.6	71.7	69.7	20.6	101-7	
1.6	75.5	70.15	21.9	102.5	455
		.45		+ .8	

1.15. Puncture into anterior inner end of caudate nucleus.

2.0	75.3	70.1	22.1	102.3	
3.0	75.7	70.65	21.1	102.8	390
				+ .5	

H. D. = 22.94. H. P. = 24.56. Wt. 3.94 lbs.

3.5	75.7	76.65	21.1	162.8	
4.5	73.1	71.2	21.2	103.1	390
		.55		— .7	

H. D. = 22.94. H. P. = 20 66. Wt. 3.94 lbs.

4.12	73.1	71.2	21.2	103.1	
7.12	73 0	71.6	21.6	103.5	765
		.4		+ .4	

H. D. = 16.68. H. P. = 17.98. Wt. 3 94 lbs.

5.20	73.0	71.6	21 6	103.5	
6.20	78.0	72 05	21.2	103.6	495
		.45		+ .1	

H. D. = 18.77. H. P. = 18.09. Wt. 3.94 lbs.

9.24	74.5	72.05	22.1	103.6	
7.24	74 4	72.5	22.4	103.5	475
		.45		— .1	

H. D. = 18.77. H. P. = 17.45.

EXP. 227.—Rabbit; fasted 12 hours; wt. 3.84 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
7.50	70.4	70.4	20.9	101.2	
8.50	72.65	71.0	21.1	101.7	755
		.6		+ .5	

H. D. = 25.03. H. P. = 23.44. Wt. 3.84 lbs.

8.55	72.65	71.0	21 1	100.7	
9.55	73.3	71.35	21.2	100 8	1,000
		.35		+ .1	

H. D. = 14.60. H. P. = 14 91.

9.59	73.3	71.35	21.2	100.8	
10.59	73.4	71 8	21 3	101.0	840
		.45		.2	

H. D. = 18.77. H. P. = 18.40. Wt. 3.84 lbs.

11.4	63.4	71.8	21.3	101.0	
12.0	74.0	72.3	22.0	101.1	730
		.5		+ .1	

H. D. = 20.86. H. P. = 21.17.

12.9. 10 grains of antipyrin subcutaneously.

Wt. 3.84 lbs.

12 10	24.0	72.32	22.0	101.1	
1.10	74.2	72.75	22.1	100.6	535
		+ .43		— .5	

H. D. = 17.93. H. P. = 16.34. Wt. 3.84 lbs.

1.15	74.2	72.75	22.1	100.6	
2.15	74.4	73.2	22.5	100.4	685
		.45		— .2	

H. D. = 18.77. H. P. = 19.08.

EXP. 229.—Rabbit; fasted 12 hours; wt. 5.8 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
6.50	66.9	66.9	18.8	102.01	
7.50	67 8	67.8	19.6	101.9	495
		.9		— .1	

H. D. = 29.20. H. P. = 33.44 Wt. 5.4 lbs.

9.8	69.1	68.5	20.0	102.8	
10.8	69.2	69.1	20.2	103.0	500
		.6		+ .2	

H. D. = 25.03. H. P. = 26.42. Wt. 5.2 lbs.

10.15	69.2	69.1	20.2	103.0	
11.15	69.9	69.75	20.6	103.1	425
		+ .65		+ .1	

H. D. = 27.11. H, P. = 27.59.

11.20. 5 grains of antipyrin subcutaneously.
Wt. 5 lbs.

11.25	69.9	69.75	20.6	103.1	
12.25	70.4	702.5	20.9	103.1	459
		.60		.0	

H. D. = 20.86. H. P. = 20.86. Wt. 5 lbs.

12.31	70.4	70.25	20.9	103.1	
1.31	72.5	70.4	21.4	103.0	421
		.15		— .1	

H. D. = 6.25. H. P. = 5.77. Wt. 5 lbs.

1.35	82.5	70.4	21.4	103.	
2.35	71.8	71.7	21.8	103.3	780
		.3		+ .3	

H. D. = 12.51. H. P. = 13.75. Wt. 5 lbs.

2.40	71.8	71.7	21.8	103.3	
3.40	72.8	72.25	22.0	104.3	1,153
		.55			

Wt. 5 lbs.

3.46	72.9	72.25	22.0	104.3	
4.46	73.2	72.75	22.2	105.0	1,800
		.50		+ 7.	

H. D. = 20.86. H. P. = 23.76. Wt. 5 lbs.

4.53	73.2	72.75	22.2	105	
5.53	73.35	83.35	22.3	105	1,915
		.60		.0	

H. D. = 25.03. H. P. = 25.03. Wt. 4.54 lbs.

5.58	73.35	73.35	22.3	105.	
6.58	74.	74 00	23.0	105.1	996
		+ .65		+ .1	

H. D. = 27.11. H. P. = 27.59.

EXP. 230.—Rabbit; fasted 3½ days; same animal as in Exp. 229; wt. 4.78 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
8.15	68	67.9	18.3	102.3	
9.15	74	68.6	19.3	102.0	1,273
		+ .7		—. 3	

H. D. = 29.20. H. P. = 28.26.

9.19	74	68.6	19.3	102.0	
10.19	72	69.2	19.4	101.8	1,227
		.6		— .2	

H. D. = 25.03. H. P. = 24.39. Wt. 4.76 lbs.

10.35	72	69.2	19.4	101.8	
11.25	74	69.6	20.0	102.1	1,360
		.4		+ .7	

H. D. = 16.68. H. P. = 18.64.

11.31	74	69.6	20.	102.1	
12.31	72	70.25	20.5	102.1	1,275
		.65		.0	

H. D. = 27.11. H. P. = 27.11.

12.32. Rabbit received 5 grains of antipyrin subcutaneously.

12.35	72	70.25	20.5	102.1	
1.35	73	70.50	20.9	102.2	110
		.25		+ .2	

H. D. = 10.43. H. P. = 11.23. Wt. 4.74 lbs.

1.40	73	70.5	20.9	102.3	
2.40	75	71.0	21.1	102.8	1,100
		.5		+ .5	

H. D. = 20.86. H. P. = 22.82.

2.46	75	71.0	21.1	202.8	
3.46	72	71.6	21.3	103.5	741
		.6		+ .7	

H. D. = 25.03. H. P. = 27.78.

3.51	72	71.6	21.3	103.5	
4.51	72	72.5	22.0	103.4	354
		.9		— .1	

H. D. = 37.54. H. P. = 37.16.

EXP. 236—Rabbit; fasted 3 days; wt. 3.30 lbs.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
8.12	74	72.3	72.52	102.6	
9.12	74	72.7	72.88	102.5	897
		.4		.1	

H. D. = 19.32. H. P. = 19.04. Wt. 3.30 lbs.

9.21	74	72.7	72.98	102.5	
10.21	74	73.2	73.50	102.3	1,030
		.5		.2	

H. D. = 24.15. H. P. = 23.60. Wt. 3.30 lbs.

10.30	74	73.2	73.50	102.3	
11.30	74	73.7	73.78	101.6	1,055
		.5		— .7	

H. D. = 24.15. H. P. = 22.12. Wt. 3.30 lbs.

11.40	74	74.7	73.28	101.6	
12.40	73	74.	74.28	101.7	270
		·3		+ .1	

H. D. = 1J.49. H. P. = 14.76.

12.45. 10 grains of antipyrin.

Wt. 3.30 lbs.

2.48	73.	74.	74.28	101.7	
3.48	78.5	74.6	74.16	100 8	2,040
		.6		— .9	

H. D. = 28.98. H. P. = 26.52. Wt. 3.38 lbs.

1.56	78.5	74.6	73.24	100.8	
2.56	75.	74.95	75.4	101.1	1,040
		·35		+ ·3	

H. D. = 16.90. H. P. = 18.53 Wt. 3.28 lbs.

3.3	75.5	74.95	74.56	101.1	
4.3	76.0	75.4	76 12	101.3	1,065
		+ .45		+ .2	

H. D. = 21.73. H. P. = 22.54. Wt. 3.28 lbs.

4.10	76.	75.4	76.12	101.3	
5.10	75.5	75.8	76.48	102.6	1,111
				·3	

H. D. = 19.42. H. P. = 20.13.

EXP. 237.—Rabbit; fasted 3 days; wt. 2.90.

A. M.	A. T.	C. T.	E. T.	R. T.	LITRES.
8.24	71	72.1	72.34	102.0	
9.24	72	71.3	72.88	101.7	809
		.2		— .3	

H. D. = 9.6. H. P. = 8.94. Wt. 2.80 lbs.

9 30	72	72.3	73.06	101.7	
10.30	72	72.6	73.42	101.2	948
		·3		·5	

H. D. = 14.49. H. P. = 13.33. Wt. 2.78 lbs

10.37	72	72.6	73 42	101.2	
11.37	73	72.9	73.50	101.	830
		+ .3		— .2	

H. D. = 14.49. H. P. = 14.03. Wt. 2.78 lbs.

11.48	72	72.9	73.50	101.	
12.58	76	73.25	74.28	100.9	
		.35		— .1	

H. D. = 16.90. H. P. = 16.67.

1.5. 10 grains of antipyrin subcutaneously.

Wt. 2.74 lbs.

1.11	76.5	73.2	74.16	101.2	
2.11	74.0	73.5	74.28	100.9	
		3.3		.3	

Convulsive effect of antipyrin present.

H. D. = 14.49. H. P. = 13.81. Wt. 2.72 lbs.

2.18	74	73.5	74.25	100.9	
3.18	76	73.75	74.28	99.6	1,245
		.25		— .3	

H. D. = 12.07. H. P. = 11.40. Wt. 2 72 lbs.

3.26	76	73.75	74.28	99.6	
4.26	76	73.95	64.68	99.9	1,165
		.20		+ .3	

H. D. = 9.66. H. P. = 10.33. Wt. 2.72 lbs.

4.33	76	73 95	74.68	99.9	
5.33	76	64.225	74.86	100 2	1,026
		.275		+ .3	

H D. = 13.28. H P = 13 95.

CALORIMETRY OF MALARIAL FEVER.

In the preceeding pages it is brought out for the first time that in septic fever the heat production and heat dissipation may be diminished during the whole course of the fever. Usually septic fever in its initial stage is accompanied by an increased production heat. Now it is easy to definitely settle the question as to the increase or decrease of heat production in fever, and I have studied the calorimetry of malarial paroxysms during the cold, hot, and sweating stages. The instrument which I have designed is constructed as follows.

It is composed of two cylinders of galvanized iron—one smaller than the other and enclosed within it (Fig. 1). The space in which the man lies upon a mattress is six feet long and two feet in diameter. Air is conveyed to him through the tube H, (to which is attached at its inner end a coiled leaden tube through which the air enters the instrument) and traverses the whole length of the apparatus and enters the hollow tube of lead at P, and finally emerges at B, having given off its heat to the water between the two cylinders. The meter, M, is run by the water-wheel, N, which aspirates the water through the whole apparatus by means of a hose, R, connecting it with the lead tube at B. The space between the cylinders is filled with about four hundred and eighty-four pounds of water. This water is kept thoroughly mixed by means of the agitator, O, which has two arms. These arms are pushing the water back and forth thirty times a minute, the motion being caused by water running the motor, X, which, by means of the wheel, Z, and the eccentric, drives the agitator. The thermometer, A, gives the temperature of the water, and on account of the thorough mixing of the water by the agitator, gives the accurate record of the temperature of the water throughout the apparatus. The thermometer is pushed farther down than is represented in the figure ; it usually lies aside of the tube H. The air-tube, B, also has a thermometer to denote the temperature of the air as it is heated up by the man. The thermometer at B is graduated into tenths, while the thermometer at A is graduated into fiftieths, but they are so far apart that one one-hundreth of a degree Fahrenheit can be read. The temperature of the mouth was taken by a thermometer giving tenths, but I

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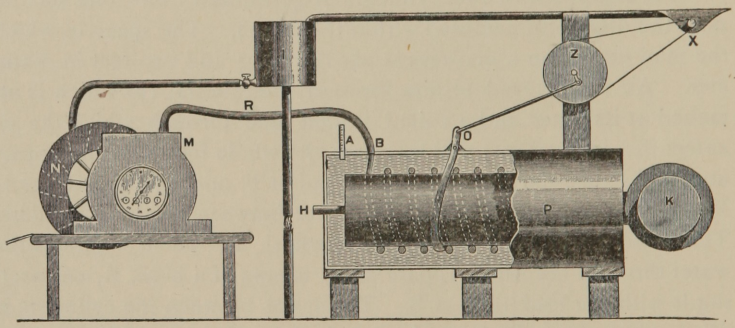
expect to use one so graduated that I can read fiftieths. The rectal temperature would have been preferable on account of accuracy. The bucket, I, receives the water from the motor, X, and so conveys it to the water-wheel, N, that it runs the meter as an aspirator. The meter is filled with water, and belongs to Voit's little respiration apparatus. The quantity of air aspirated an hour is five to six thousand litres, which is sufficient for respiratory purposes. The instrument is made air-tight by means of the door, K, which is clamped by eight powerful iron clamps. The inner edge of the door is lined with rubber. The whole apparatus is enclosed in over six inches of saw-dust, the door, K, having against it a saw-dust mattress. The interior of the instrument is lighted by an electric light of one-candle power, by which a paper can be read.



With these arrangements, excepting light, and a mattress inside the instrument I have tested the apparatus. As the apparatus necessary for the hydrogen test was not available, I used absolute alcohol. The different physicists who have burned a gramme of alcohol have obtained the following various numbers : Thus Rumford obtained 6,195 ; DuLong, 6,962 ; Andrews, 6,850 ; and Favre and Silbermann, 7,183.6. These numbers mean so many gramme-calories, and the number 7,183, is supposed to be the most accurate. In their experiments, in order to allow for the loss of heat due to radiation, a preliminary experiment was made with the body whose heat was sought, the only object of which was to ascertain approximately the increase of temperature of the cooling water. If this increase be 10°, for example, the temperature of the water calorimeter was reduced one-half this number—that is to say, 5° below the temperature of the atmosphere. By this method the

water of the calorimeter receives as much heat from the atmosphere during the first part of the experiment as it loses by radiation during the second part. This procedure is called Rumford's compensation. In the human calorimeter the air tube must be of considerable size for the air to enter, and necessarily permits of considerable loss of heat by the air constantly traversing the instrument. I have tested my calorimeter before and after the performance of the experiments. I give here a test with alcohol :

Time.	A. T.	C. T.	E. T.	Metres.
1.24	83°	74·20°	75·5°	758,274
2.24	82·3°	74·61°	75·8°	762,650
	82·6°	·41	75·6°	3,376

577·42=number of heat units required to raise the calorimeter 1° F.

577·42 × ·41 rise in calorimeter temperature = 236·74 heat units.

Alcohol burned = 9·235 grammes × 7, 183 number of gramme-calories by burning a gramme of alcohol = 66·33 kilo-calories. As one kilo-calorie is equal to 3·96 heat units, then 66·33 × 3.96 = 262·66.

V = 3,376 litres of air pumped through the calorimeter.

t = 75·6° — 32° = 43·6 number of degrees the air is heated above 32°.

V + (v × 43·6 × ·002035, co-efficient of expansion) = 3,376.

V + ·0887260V = 3,376.

1·0887260V = 3,376.

V = 3,376 ÷ 1·088 = 3102,9.

W = V × ·00285, weight of litre of air at 32° F.

W = 3102,9 × ·00285 = 8·84 lbs.

Q = W × t × specific heat.

Q = 8·843 × 7° × ·2374 specific heat of air = 14·69, number of heat units given to the calorimeter by the air.

Then 236·74 — 14·69 = 222·05, number of heat units obtained in burning the alcohol.

But the alcohol burned produced 262·66 heat units, and of these 222·05 have been recovered ; then 262·66 — 222·05 = 40.61 =loss of heat units or error of the calorimeter. Then the percentage of error is 40·61 ÷ 262 = 15·5. In other words, all results by the calorimeter must have 15·5 per cent. added to them, that they may be accurate. In this paper I have made the percentage of error 16

per cent., as the mean of several experiments showed this to be the average error of the instrument. The constancy of the error made the apparatus one of precision for scientific work.

In my experiments upon man the calculation was made in the same manner. The specific heat of the body was taken to be 0.83.

In estimating the moisture I used Voit's little respiration apparatus, taking the moisture of the air of the room and deducting it from the moisture of the air coming from the calorimeter. Now, according, to Helmholtz, 1,000 grammes of water require 582 calories in evaporation from the lungs and skin ; then one gramme of water from the lungs requires $\frac{291}{500}$ calories $= 2 \cdot 304$ heat units to vaporize it.

The glass bulbs were filled partly with sulphuric acid, and weighed upon a delicate balance before and after the absorption of moisture from the air.

By placing a pully outside the calorimeter and attaching to a leather rope a fourteen pound weight, the man within the instrument was able to excise. The leather band entered one of the air holes of the instrument. In this manner it was found out : 1. That a man weighing one hundred and ninety-two pounds, during the afternoon produced 410 heat units per hour on an average and not 512 as calculated by oxidation changes and the amount of egesta. 2. Of the whole amount of heat dissipated, about 14 per cent. is thrown off by the lungs. 3. The elevation of about five tons an hour a foot high doubles the hourly heat production.

The study of the calorimetry of malarial fever has never been attempted, except by a study of the changes in the leg or arm. Langlois attempted by an air calorimeter to study the heat production in pneumonia of children, but the instrument is by its construction so inaccurate, that it will give only very gross changes.

The instrument used in the study of the malarial paroxysm is accurate in its workings as has been already detailed. Through the great kindness of Dr. J. F. Berg, of Plainfield N. J., I was able to study upon the person of Mr. W. W. Schenk, the first accurate calorimetry of malarial paroxysms. Mr. S—— was 5 feet 9½ inches in height, aged twenty-nine, a farmer, and the chill he had was the fourth one. During the course of this tertian intermittant fever, he was taking no medicine. He ate a very light breakfast at 7.30 A M. At 8 A.M. his temperature was 98, at 9.30 A.M., 99.2, felt catching

pains in the nape of the neck ; at 10.18 A.M. he entered the calorimeter, temperature, 100.1. While in the calorimeter he had chills running up and down his back, his hands felt cold, and he had a general sense of chilliness. Upon leaving the instrument, 11.18 A.M., his pulse was 84, temperature, 101.85 ; 10.35 A.M., thirsty, feels badly, looks pale, bones and head aches, has a pinched and and anxious look ; pulse, 92. At 11.47 A.M., again entered the calorimeter, temperature, 101.4, left the instrument at 12.48 P.M., temperature, 102.0 ; pulse, 112 ; complains of heat while in instrument, face flushed, hands moist. At 1.15 P.M. ate a fair dinner. At 1.40 P.M , pulse, 84 ; temperature, 100.6 ; headache, face flushed, some perspiration. 2 P.M., temperature, 100.2, entered calorimeter ; 3 P M., left it, pulse, 84 ; inside of calorimeter moist from perspiration, he noted the musty odor for the first time in the instrument. 8 P.M., temperature, 98.2 ; feels quite good ; had four movements of bowels, supposed to be due to water not accustomed to.

Second day.—7.30 A.M., ate a good breakfast, entered calorimeter at 9.53 A.M., temperature, 99.0 ; left instrument at 10.53 A.M., temperature, 99⅔ ; pulse, 84 ; at 11.22 A.M. entered calorimeter, temperature, 99.25. At 12.22 P.M. left it, temperature, 99.25 ; had another movement of bowels, took a whiskey before dining at 1 P.M.

At 1.35 P.M. again entered the calorimeter, temperature, 99.2 ; left it at 2.35 P.M., temperature, 99.7 ; pulse, 92 ; felt good, and left for home on Saturday.

On following Sunday had a light chill. No chills since. One week since the last chill he again entered the calorimeter for a test of his normal heat production. He was well, and ate heartily. On the previous day he was engaged in very laborious work.

By means of the electric light (which gives a very uniform heat) of one candle power, he was able to read the morning news while his heat production was being taken. It was found by burning absolute alcohol, that with the electric light, the error was 2.8 per cent. which was to be deducted from the amount of heat production registered by the calorimeter.

From a study of Fig. 2 it is found that during the initial stage or chill-period of a malarial paroxysm, the dissipation is not as great as at other times, and the heat production is enormously increased. After the fever reached its height, the previous great rise of heat production was succeeded by a great fall, according to the law of

compensation. Here high temperature is not an index of a correspondingly high production of heat.

In the stage of defervescence, heat dissipation is greatly increased and heat production does not regain its original height. It is only during the sweating stage that the excess of moisture comes over in the sulphuric acid bulbs on the fever-day. If the heat production on the chill day and on the succeeding day is compared with that of the normal day, it will be found to be on the chill-day 79.3 heat units in excess, and on the succeeding day 9.6 heat units in deficit. This is a much greater increase than that seen in the septic fever of animals.

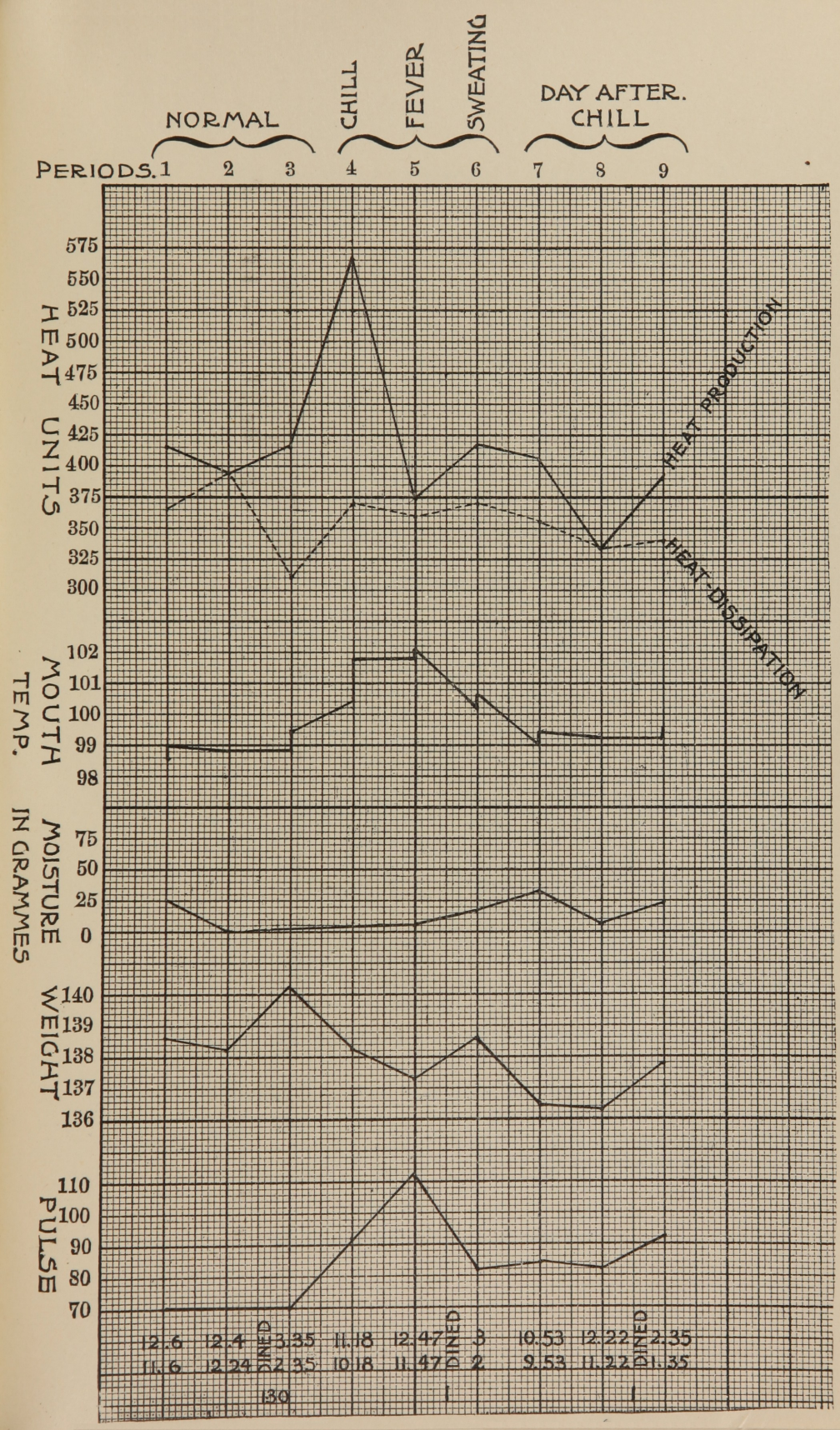
These observations show how fever in man is originated, that is, usually heat production runs rapidly ahead of heat dissipation, which is partly lessened, and the temperature is elevated. On the next day after the malarial paroxysm there was a slight fever, and the heat production on the average was lower than on the preceding day.

There is every reason to believe that in a continued fever this increase of heat production does not usually last many days, but that the fever continues because of an alteration between heat production and heat dissipation, without regard to an increased or diminished heat production. These observations confirm the theory supported in the preceding articles, which is a modified theory of Liebermeister's. The theory of Traube, that fever causes a vaso-motor spasm; that of Marey, that a vaso-paralysis exists; or the more recent view of Rosenthal, that of heat retention—all these theories contain only a germ of truth, that is, during the chill and fever there is a lessened dissipation of heat when compared with the sweating stage. Appended are the calorimetrical results upon which Fig. 2 is founded.

"Chill" Day.

A. T. = Air temperature.
C. T. = Calorimeter temperature.
E. T. = Temperature of exit air tube.
M. T. = Temperature of mouth tube.
Litres = Amount of air aspirated through the calorimeter.

A. M.	A. T.	C. T.	E. T.	M. T.	Meter
10.18	73.3	67.70	20 6	101.1	Litres 51.37
11.18	72.8	68.38	21.1	101.85	Weight $138\frac{9}{50}$
		68		1.75	


NORMAL
CHILL
FEVER
SWEATING
DAY AFTER. CHILL
PERIODS. 1 2 3 4 5 6 7 8 9
HEAT UNITS
575
550
525
500
475
450
425
400
375
350
325
300
HEAT PRODUCTION
HEAT-DISSIPATION
MOUTH TEMP.
102
101
100
99
98
MOISTURE IN GRAMMES
75
50
25
0
WEIGHT
140
139
138
137
136
PULSE
110
100
90
80
70
12.6 12.4 DINED 3.35 11.18 12.47 DINED 3 10.53 12.22 DINED 2.35
11.6 12.24 2.35 10.18 11.47 2 9.53 11.22 1.35
130 1 1

H. D.=369.1 H. P.=569.8

A. M.	A. T.	C. T.	E. T.	M. T.	Meter
11.47	73.1	68.36	21	101.85	Litres 5040
12.47	74.0	69.01	21.6	102.00	Weight 137.$\frac{29}{50}$
		+.65		.15	

H. D.=354.0 H. P.=371.1

P. M.					Meter
2	75.3	68.95	21.6	100.2	Litres 4792
3	73.9	69.57	21.8	100.6	Weight 138$\frac{40}{50}$
		+.62			

H. D.=373.1 H. P.=419.2

Day After the Chill.

A. M.	A. T.	C. T.	E. T.	M. T.	Meter
9.53	73.7	69.14	21.2	99.0	Litres 5453
10.53	75.3	69.69	22.2	99.4	Weight 136$\frac{40}{50}$
		55		4	

H. D.=355.4 H. P.=400.8

A. M.					Meter
11.22	74.3	69.68	21.8	99.25	Litres 5150
12.22	75.2	70.29	22.2	99.25	Weight 136$\frac{31}{50}$
		61			

H. D.=335.8 H. P.=335.8

P. M.					Meter
1.35	77.8	70.22	22.2	99.2	Litres 5215
2.35	75.8	71.75	22.4	99.7	Weight 137$\frac{44}{50}$
		53		5	

H. D.=338.7 H. P.=395.9

Normal Day—One Week After He had a Chill.

A. M.	A. T.	C. T.	E. T.	M. T.	
11.6	71.0	65.60	19.0	98.05	Litres 5251
12.6	72.2	66.20	20.2	98.85	Weight 138.58
		.60		.35	

H. D.=373.8 H. P.=414.0

P. M.					
12.24	72.2	66.16	20.0	98.85	Litres 5004
1.24	72.0	67.78	20.4	98.85	Weight 138.44
		.62		0	

H. D. = 342.88 As no electric light add 16% = 54.86
H. D. = 397.74
H. P. = 397.74 No moisture came over.

P. M.					
2.35	73.4	66.86	20.6	98.5	Litres 4873
3.35	74.1	67.34	21.0	99.4	Weight 140.12
		.48		.9	

H. D. = 264.82 No electric light, add 16% = 42.37
H. D. = 307.19
H. P. = 411.19 No moisture came over.