XII. *On the influence of nerves and ganglions in producing animal heat. By Sir* Everard Home, *Bart. V. P. R. S. presented by the Society for the Improvement of Animal Chemistry.*

Read March 17, 1825.

In considering this subject, I shall first mention that in the most simple animal structures endowed with life, large enough to admit of dissection, brain and nerves are met with, although many such animals possess no power of preserving a temperature higher than that of the atmosphere by which they are immediately surrounded.

In the oyster and fresh water muscle the whole nervous system consists of two small rounded bodies; of these one is placed upon the œsophagus, one at the opposite end of the body of the animal; they are connected together by two lateral nerves, one on each side.

The internal structure of both these rounded bodies is the same, and resembles that of the brain in other animals, which I have already shown to be composed of small globules, surrounded by a transparent elastic gelatinous liquid: having this structure I shall consider them to represent the brain and the spinal marrow of the animal.

The temperature of the oyster does not exceed that of the surrounding water, since a small thermometer introduced between the shells when kept open by a wedge undergoes no change.

In the garden snail the nervous system resembles that of the muscle, but has also numerous nervous branches going to different parts of the body. The temperature of this species of snail, when its operculum is closed, does not exceed that of the surrounding air: this is proved by making a hole in the shell and introducing a small thermometer, in which the mercury undergoes no change.

It therefore appears that the existence of brain and nerves does not necessarily endow the animal with a power of producing heat.

In the leech, the earth worm, and all the insect tribe, the brain and spinal marrow very closely resemble that of the garden snail; but in all these tribes there is a pair of nerves running down from the spinal marrow the whole length of the body of the animal, which are united together at regular intervals by what are called ganglions, composed of nervous fibres, apparently entangled and agglutinated together; and in all such animals it was proved by Mr. Hunter, in his paper on heat, that their temperature exceeds that of the atmosphere when below 56°, although in very different proportions; the excess in the leech being only one degree, while in a hive of bees it is 26°.

As the only difference between the nervous systems of those animals that have no power of producing heat, and those that have, consists in there being ganglions, I was led to suspect that this power was derived from the ganglions with which the nerves are furnished. Their structure is shown in the splanchnic ganglion.

To ascertain how far there were sufficient grounds for this suspicion, I began to consider, whether any parts of animals possessed of an unusual temperature were devoid of nerves; the heat of the deer's horn while inclosed in its velvet in June 1824, when only one foot long, I found to be 96°, and on the 12th of July the tip of an antler was 99½; from which it was evident that these horns during their growth have a power of producing heat, independent of the direct influence of the brain or heart; and therefore it was only necessary to ascertain whether there are nerves accompanying their blood vessels, which Mr. BAUER not only ascertained to be the case, but found them equally numerous with the arteries themselves.

This discovery enabled me to institute an experiment, which at once would decide in what degree animal heat was under the influence of ganglionic nerves.

As I might be considered too partial an evidence respecting the different results arising out of such an experiment, I contented myself with superintending it, and made over the operative part to Mr. MAYO, and his associate Mr. CÆSAR HAWKINS, teachers of Anatomy in Berwick-street. The experiment was to consist in dividing all the trunks of the nerves that supplied the velvet of one horn, while those of the other horn were left entire; and see how far under these circumstances the horn would be liable to any diminution of its heat.

The first thing required was to examine into the number of such nervous trunks, and the situations in which they were to be met with. This was done in the head of a deer with antlers, after death.

The experiment was made in Richmond Park on the 21st of July, 1824, about noon, having the dissected nerves before us to direct the operation. These were found to be the frontal branch of the fifth pair, and the branch of the fifth belonging to the first division which ascends on the outer part of the orbit: this branch in the human body is joined by the trunk of the portio dura of the seventh pair, but in the deer it has no such connection.

Each of these trunks were laid bare by Mr. Mayo in the most satisfactory manner, and a probe passed under the nerve, which was then divided just where they emerge on leaving the great ganglion, which is close to the brain.

That any difference in temperature of the two horns which should occur after the experiment might be registered in the most accurate manner, a hole was bored quite through each of the horns at an equal distance from the tip, just large enough freely to receive the ball of the thermometer.

An hour after the nerves were divided, which was about three o'clock of July the 21st., the temperatures were examined, and so on once a day as long as there was a material difference between them. This will appear by the following diary, only to have continued for five days.

	Atmosphere.	Unnerved Horn.	Uninjured Horn.
July 21,	66°	72°	84°
22	64	69	95
23	64	67	84
24	64	76	84
25	67	87	90

Forty-eight hours after the nerves were divided the temperature of the horn was only 3° higher than that of the atmosphere.

From the time the experiment was made the deer was kept in a small paddock with two companions. On the 26th of July it had bruised the horn so much, on which the experiment had been made, that the diary could no longer be continued, and that horn was then the hottest of the two.

Upon examination after death no union had taken place between the divided trunk, but it was evident from the recovery of its heat, that some other connection had been formed between the nerves of the horn and these of the head.

This will not appear surprising when I mention that the fallow deer, before they have antlers, shed their horns in June; and immediately after, they again begin to bud, and in the middle of August are completely hardened. Those with antlers mew in April or May, according to their keep, and at the end of August are at their full growth. So that in the space of four months all the nerves that are to supply the deer's horns of a full head have not only begun to form, and arrived at their full growth, but have ceased to exist. This rapidity of growth accounts for their recovering in five days from any check that can be given to their ready communication with one another.

Having gone thus far in my enquiry respecting animal heat, I was determined not to proceed till I had satisfactorily made out whether the placenta is furnished with nerves; and upon that discovery being made by Mr. Bauer's admirable microscopical observations, I found copious new materials to enable me to prosecute the enquiry.

The first step I took was to get my young friend, Mr. Cæsar Hawkins, to examine and describe the ganglions belonging to the nerves of the uterus, those of the nerves of the oviducts in birds and of reptiles, which were found to be more numerous than those of other organs. Mr. HAWKINS's description of them has a place in my paper on the Nerves of the Placenta in the Transactions.

The temperature of the human os tincæ in health was 99°, half a degree lower than the antler of a deer with full-head, in July; but as I knew the nerves belonging to the uterus enlarge during pregnancy, I had no doubt that the temperature of that organ would be increased at that period: in this I was confirmed by finding the oviduct of a frog ready to spawn two degrees hotter than the heart. Upon inquiring among my medical friends who practise midwifery respecting the heat of the pregnant uterus, I was told, that in turning children, they sometimes found the heat of the cavity almost greater than the hand could bear. This information made me most anxious to have its temperature ascertained by a thermometer, as I knew that water heated to 125° degrees is nearly as hot as the hand can well bear.

Upon this occasion I applied to Dr. GRANVILLE, who has upon former occasions assisted me with his knowledge on these subjects, having shown what becomes of the remains of the corpus luteum in ovarial abortions; and ascertained that the two ovaria are equally productive of male and female children, which had been denied; and till Dr. GRANVILLE took up the enquiry, remained without proof. Upon this occasion Dr. GRANVILLE gave me most cordially his assistance, and having been supplied with a proper thermometer sent me the following reports.

First report.

In a natural labour, duration three hours.

The heat of the uterus before delivery	-	108°
after delivery	-	105
Placenta	- - - -	104
The pulsations at the wrist of the mother	-	70 beats
in the navel string	- -	140

Second report.

In a labour at 7 months; child alive.

The heat of the uterus before delivery	-	100°
after delivery	- -	99
Placenta	- - - -	98
The pulsations at the wrist of the mother	-	60 beats
in the navel string	- -	110

The third report.

In a labour that lasted 38 hours. The child alive, (delivered by forceps).

Six hours before delivery in the intervals of the pains, the heat of the uterus	- -	118°
When the pains strong	- - -	120
After delivery	- - -	110
The placenta	- - - -	110
The pulsations at the wrist of the mother	-	100 beats
in the navel string	- -	120

The fourth report.

In a labour that lasted 40 hours; the pelvis deformed.

The heat of the uterus was not accurately ascertained before delivery.	
after delivery - -	115°
When placenta expelled - - - -	118
The placenta itself - - -	112

The instant the child breathes, the pulsations in the chord begin to decrease in frequency till they become the same as at the wrist of the mother, and then cease.

As the balls of some thermometers are so thin, that any pressure made upon them raises the mercury, and renders the instrument inaccurate, it is necessary to remark in this place, that the thermometer employed by Dr. GRANVILLE was not capable of having its mercury raised a single degree by the greatest pressure upon the ball that could be made without risk of breaking it.

When the heart of a dog is in action, the heat in the left ventricle is 101, and is the same in the stomach, so that muscular action does not increase animal heat; and the following circumstances, mentioned in Mr. HUNTER's paper on this subject, in his work on the Animal Œconomy, proves that its increase or diminution of heat is independent of the action of the arteries. A gentleman while in a state of insensibility from an apoplectic fit, and lying in bed covered up with blankets, had his whole body at one instant become extremely hot, and then suddenly extremely cold, his pulse all the time undergoing no change.

The glow of heat brought into the cheek in the act of blushing, from whatever cause, has been generally considered to arise from the rush of blood into the smaller vessels; it must however depend on the state of the ganglionic nerves.

Although the nerves when performing their functions in health appear to have no power of producing or keeping up the heat of the animal, there is no doubt that when they are injured or diseased, heat is produced. Of this in the practice of surgery the proofs are without end.

I do not mean at present to go further into this subject, since it would lead me into discussions of some length, respecting the real cause of the increase of temperature excited by inflammation and fever; as however in the first the heat never I believe exceeds the standard heat at the heart; whereas in the second it is raised to 104° or 105°; it is reasonable to believe that the first is from affections of common nerves, the other from affections of ganglionic nerves.

As the torpedo and electrical eel were among the first animals that I ever assisted to dissect, and Mr. HUNTER's account of the structure of the electrical organs, and the wonderful supply of nerves with which they are furnished, was laid before the Royal Society in July 1773; three months after I had enlisted under his banner for the purpose of prosecuting human and comparative anatomy, it will only be considered as natural, that I cannot conclude the present communication, without stating, that the nerves of the torpedo belonging to the electric organs, however numerous, not being ganglionic, do not increase the standard heat of the animal.

As fishes have a lower standard of heat than birds, I wished for some accurate information respecting the ganglions their nerves are furnished with, to determine the proportion they bear to those in birds. I was also desirous of knowing whether there are any ganglions belonging to the nerves that supply the electrical organs of the electrical eel. Mr. Hawkins's report on both these subjects I shall give in his own words.

"My dear Sir. In the skate I find the following ganglia.

"The olfactory nerve expands into a ganglion of great size, from the lower surface of which many nerves proceed to the membrane of the nose.

"The fifth pair of nerves has a plexiform appearance, chiefly on its inferior or lower root. The lower of the two branches into which the ophthalmic nerve divides has a distinct ganglion upon it.

"The portio dura of the seventh pair of nerves forms a ganglion while passing through the cartilage of the ear.

"The eighth pair of nerves after passing through its foramina enlarges considerably, and that branch which passes along the œsophagus to the stomach forms a considerable plexus on the end of the cardiac portion.

"The spinal nerves originate by two roots, as in quadrupeds, and on the posterior root a ganglion is formed.

"The sympathetic nerve has several ganglia where the branches of the spinal nerves join it; but instead of there being a ganglion at every such junction, as in the quadruped, they are only in the proportion of one to six.

"In examining the preparations of the elecric eel and torpedo in the Hunterian Collection, no ganglia are met with in the nerves that supply the electric organs; each of these nerves arises separately from the brain, and consists of numerous fasciculi.

yours, &c.

CÆSAR HAWKINS."

From Mr. HAWKINS's examination the ganglions in the skate do not amount to one-sixth part of those in the bird, and the standard heat of this fish is low in proportion; the thermometer in the stomach being only 40°, in the rectum 38°, while the surrounding water was 36°.

EXPLANATION OF PLATE XVII.

In which is exhibited the external and internal appearance of the great splanchnic ganglion.

Fig. 1. The ganglion in situ upon the aorta; natural size.

Fig. 2. The ganglion enclosed in its outer or dura matral covering; magnified two diameters.

Fig. 3. A longitudinal section; magnified in the same degree.

Fig. 4. A small portion from which the outer or dura matral covering has been removed, but is still inclosed in the inner or pia matral coat; magnified six diameters.

Fig. 5. A longitudinal section; magnified in the same degree.

Fig. 6. A very small portion of the internal substance of the ganglion; magnified twenty diameters, to show that it consists of fasciculi of globular fibres from $\frac{1}{3000}$ to $\frac{1}{4000}$ part of an inch in diameter, similar to those in the brain, connected together by a transparent elastic jelly: this jelly

is so much less readily soluble in distilled water than that met with in the brain, that after eight days maceration in it, the fasciculi are not so readily separated as those of the brain are in two.

Fig. 7. A portion of a single globular fibre in its natural or contracted state, only $\frac{1}{400}$ part of an inch long.

Fig. 8. The same portion of fibre extended by means of the great elasticity of the jelly which connects the globules to more than double its former length.

Natural size

Fig. 1.

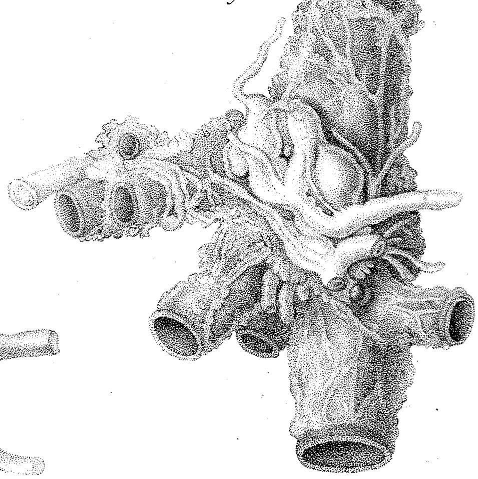

Fig. 2.

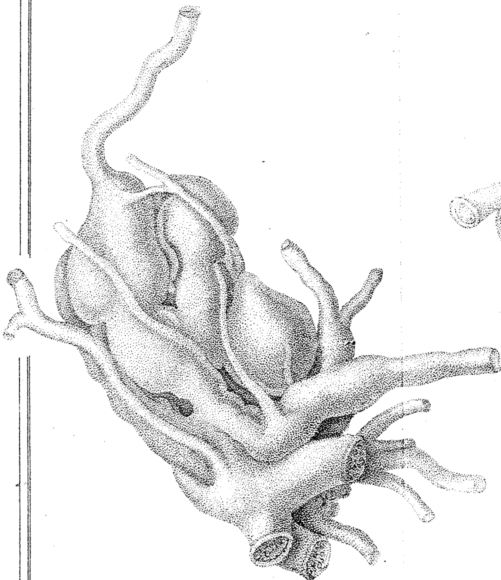

Fig. 3

x. 2.

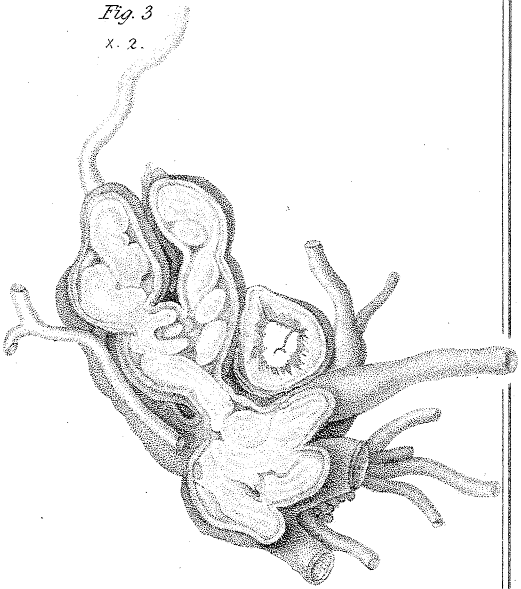

Fig. 6

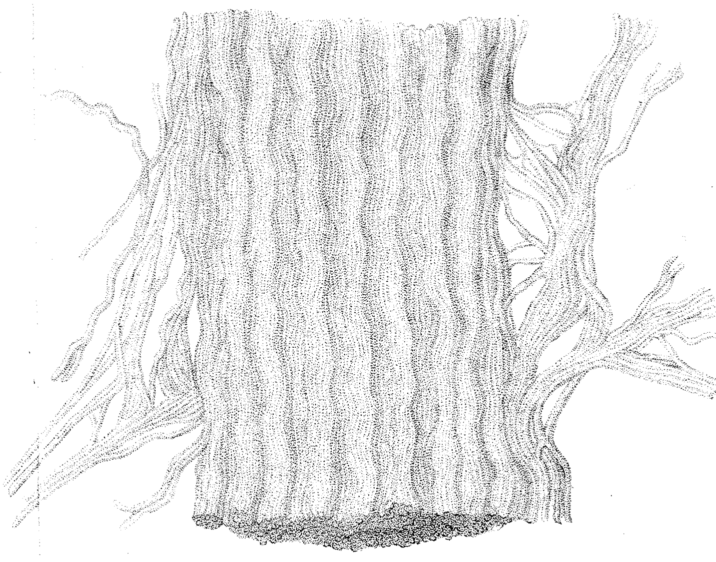

Fig. 4.

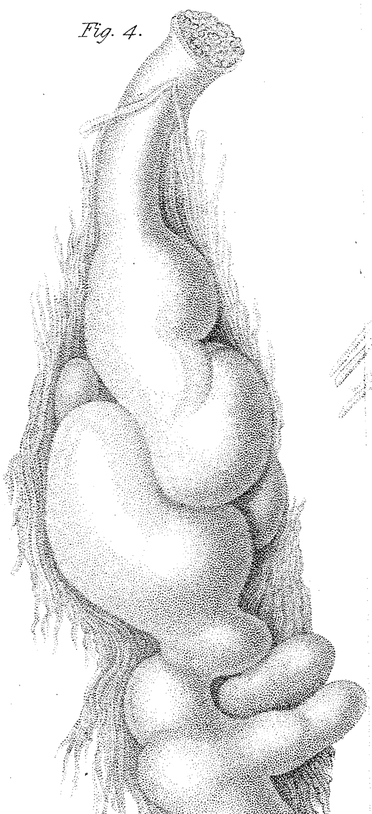

Fig. 5

x. 6.

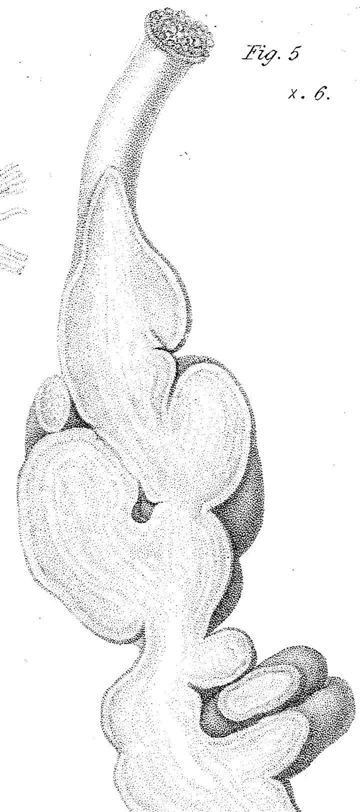

Fig. 7.

Fig. 8.

Franz. Bauer del.t

J.s Basire sculp.t