

# PHILOSOPHICAL TRANSACTIONS.

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I. *The Croonian Lecture. On the conversion of Pus into granulations or new Flesh. By Sir Everard Home, Bart. V. P. R. S.*

Read November 5, 1818.

As this Lecture was instituted with a view to discover the principle upon which muscular motion depends, which cannot well be done till we have acquired a more correct knowledge of the structure and mode of formation of muscles; I considered that I was not greatly deviating from the direct path of this enquiry, in making the changes extravasated blood undergoes, preparatory to its being incorporated with the muscular and other structures of a living body, the subject of my last year's Lecture.

The present Lecture may be considered as a continuation of the same subject, since it is my intention to examine the changes pus undergoes in the formation of granulations or new flesh; which will be found to correspond with those that were stated to take place in the blood, so nearly, that the two fluids will be admitted to possess the same properties; and that the red colour of the globules is the principal

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characteristic mark of distinction between the one and the other.

As pus, in its first formation, has the appearance of being a transparent fluid in which globules afterwards are formed, whether the transparent fluid remains on the sore, or is removed to any other surface, as was proved by experiments made in the year 1788, and since that time laid before the public in my work upon Ulcers ; in this respect, pus might be considered to differ from blood ; but the following observations, made by Mr. BAUER, tend to prove that a similar formation of globules is met with in the serum of blood. I shall give the remarks in his own words : “ That the globules in the blood are produced in the serum, I first observed in July 1817, when I examined a small portion of human blood on a glass plate, to ascertain the real shape and size of the globules. I then found in one square of the micrometer (which was the 160,000 part of a square inch) two of these globules which were separated to a considerable distance from the rest ; they were entirely disengaged from the colouring substance, and lay in pure clear serum, which covered the whole surface of the square of the micrometer. Having placed this particular square immediately under the focus of the microscope, I attentively examined the globules for about six or eight minutes, when I perceived two extremely minute opaque spots arising in the clear serum within the same square of the micrometer, and which seemed increasing in size. In a few minutes longer, I perceived five or six more such opaque spots arising, and gradually increasing, and assuming the same form and appearance as the two original globules ; but the moisture of the serum

being nearly evaporated, I diluted it with water, when all the seven new globules, as well as the two original ones, floated in the water, and appeared of precisely the same shape and white colour; and three of the new globules were of the same size as the original ones, but the rest were smaller. When left on the glass to dry, the globules remained of the same shape and size as they were whilst floating in the serum.

“ The above experiment I have repeated a great many times with human blood, as well as with sheeps’ and calves’ blood, and the results have been always the same. When warm and fresh blood was used, the serum covering the surface of a 160,000 part of a square inch, produced from six to twelve globules, but when the serum was diluted with water, the number of globules produced was less, and they were smaller in size.

“ On the 11th of August, 1817, I poured half a pint of warm sheep’s blood into a glass vessel, and left it forty-eight hours at rest to coagulate: I then poured off the serum into another vessel, in which it remained at rest six hours; with this serum, a glass tube four inches long and three-eighths in diameter inside was filled to overflowing, and closed with a good cork, and covered with a bladder. The serum was as clear as water; and although I examined it very attentively, I could not see more than fifteen or twenty globules in the whole extent of the tube. It was kept inverted in a glass of water. At the end of seven days, upon holding the tube between my fingers, which were tolerably warm, and examining it with a double lens of considerable magnifying power, I

saw some hundreds of globules rise from the bottom, and ascend in a straight line in the centre of the tube, and when arrived within about half an inch of the upper end, they spread in all directions, and descended close to the sides of the tube; when near the bottom they re-ascended, but more rapidly than the first time, and when held longer in the warm hand, the rapidity of the motion was much increased. In two days more, I found upon examination the number of globules much greater; and on the 25th of September, 1818, the number of the globules was such as to form a sediment at the bottom of the tube of half an inch in thickness, besides a strong coat on the inside of the tube."

This experiment of Mr. Bauer's on the serum, was repeated by Mr. Faraday, at the Royal Institution, on human blood, in a tube of larger dimensions, and the serum suspended on mercury: the result was exactly the same, the number of globules was increased in ten days in the same proportion as in Mr. Bauer's experiment, and when the lower end of the tube was held in a warm hand, the same motion of the globules took place.

These experiments in proof of colourless globules forming in the serum, make this resemblance between blood and pus greater than has been generally believed.

At the conclusion of my former Lecture, I mentioned that pus, in its inspissation, has carbonic acid gas evolved, in the same manner as in the coagulation of the blood, and that I was therefore led to the opinion, that this process was the first step towards the formation of granulations; but my experiments having been made upon pus removed from the

living body, they required being repeated upon the surfaces of sores, before their results could establish the opinion I had adopted.

Before I attempted to trace the changes met with in pus upon the surface of a sore, my first object was to become more accurately acquainted with the appearance of the surface immediately under the newly secreted pus. That this surface might be examined under the most favourable circumstances for such observation, I selected an ulcer upon the leg to which no application was made but straps of adhesive plaster, and these only changed once in the twenty-four hours; and that time was chosen for the examination, which was made by a double convex lens, magnifying about eight times. Previous to the adhesive straps being taken off, the leg was laid upon a low table, so as to be immediately under the eye, and in the position in which hæmorrhage from the small vessels was least likely to take place, and obscure the surface of the sore.

That the observations might be made with greater accuracy, I requested Mr. John Griffith, one of the pupils of St. George's Hospital, to look at the sores, as well as myself, upon every occasion on which they were examined, and no change is mentioned to have taken place that was not distinctly seen by us both. A healthy sore thus examined had the following appearance: the surface was uneven, being made up of eminences and hollows. The eminences consisted of small clusters of tortuous blood vessels, the hollows were filled with pus. After remaining exposed from five to ten minutes, the following alterations were distinctly seen to take place: a very thin pellicle covered the whole surface;

this was of so transparent a nature, that a number of small bubbles of gas were seen to make their appearance in different places; in a few minutes more, horizontal canals of different sizes, filled with red blood, taking different directions, and anastomosing with one another, were seen to form. In some places, there were red points, the terminations of perpendicular canals, that had been stopped in their course, by coming against the pellicle. There were also occasional specks of extravasation, from some of the horizontal canals bursting through the pellicle.\*

The changes just mentioned seemed to occur in a regular order of succession. First, the pellicle was formed on the surface. Secondly, the bubbles of gas made their appearance. Thirdly, the canals carrying red blood were observed: these, while filled with carbonic acid gas, were not to be distinguished from the semi-transparent jelly which surrounded them.

As it is difficult to describe appearances of this kind, and it is of importance that the fact of such appearances being met with, should be well established, I requested Mr. BAUER to make a drawing of a portion of the sore of which I have attempted a description, after it had been exposed for nearly sixteen minutes; and on the following day he made a drawing of the same portion, showing the progress that had been made, and that the canals formed on the first day, had on the second become permanent tubes, and had been covered over by a cuticle. These two drawings are annexed.

\* If, under these circumstances, the foot was put to the ground, so weak was the covering of the canals, that it instantly gave way, and the sore was covered with blood.

It is so easy for any one to bring the facts which I have stated under his own observation, that I shall leave them to speak for themselves, but it may appear to my audience, that farther evidence is required to establish the doctrine, that they are produced entirely by the coagulation of the pus, and the extrication of the carbonic acid gas. To remove every objection which it occurred to me could be made, I put the doctrine to the test of the following experiments. Immediately after the exposure of the surface of the sore, I poured water at the temperature of  $95^{\circ}$  upon it, which washed away all the pus and although the sore was left exposed in this state ten minutes longer, none of the above mentioned appearances were produced, so that the presence of pus is necessary to their taking place.

As cold water has a power of coagulating pus more rapidly than simply exposure to the atmosphere, I applied water at the temperature of  $65^{\circ}$ , to a sore, and all the appearances were produced in so much greater a degree, that I requested Mr. BAUER would make a drawing of a portion of a sore that had been exposed for fifteen minutes under common circumstances, and at the end of that period to pour upon it water at the temperature of  $65^{\circ}$ , and, in ten minutes more, begin a second drawing of the same surface, showing to how much greater an extent the appearances had taken place; by this means proving, that the degree of coagulation was the great cause of the effects that followed. These drawings are also annexed.

As a saturated solution of sal ammoniac has a greater power of coagulating pus than any substance that I am acquainted with, (and on that account, in the year 1788, I

recommended its mixture with pus as the best criterion by which pus might be detected and distinguished from other animal fluids,) I now determined to try what effect it would have with respect to the appearance of the granulations; for although in some respects it is not a fair trial, since the chemical combination of pus with this solution might destroy the natural properties of pus, and convert it into a compound of a very different kind, still that was by no means necessarily the case.

Upon pouring a saturated solution of sal ammoniac at the temperature of  $45^{\circ}$  upon the surface of a sore, the pus almost immediately became curdled, and tortuous canals were every where seen in these masses of coagulum. There was great uniformity in the tortuous canals; they were of the same size, running first in a straight direction, terminating in a spiral turn and a half, the end of which was extremely small; they were all filled with red blood. It was remarked that, although the canals themselves were in greater number, there were fewer bubbles of gas than when the cold water had been used, more having been retained in the tubes. Some of the coagula of pus were more elevated than the general surface, and large canals filled with red blood were seen superficially passing over some of them, without any smaller ones in the immediate neighbourhood. To ascertain whether there was any vascular basis with which these canals were connected, I passed a tolerably large crooked needle under one of them, bringing out the point on the opposite side, so that the canal was distinctly seen above the flat surface of the needle: I then withdrew it, and there was not the slightest degree of extravasation of blood. This was repeated on



several different sores without any appearance of blood escaping, or the person having the slightest pain; affording a sufficient proof of the canals being formed in the coagulated pus immediately on its coagulation, before any other approximation to living animal solids had taken place.

The readiness with which the blood displaces the carbonic acid gas contained in these canals, may be explained by the great disposition the blood has to absorb this particular gas, which forms so large a proportion of its component parts.

I shall not take up the time of the Society with a farther detail of experiments, although many more were made, as the results were uniformly the same.

If I have succeeded in establishing the object of this Lecture, which is, that the coagulated pus is rendered tubular by the extrication of its carbonic acid gas, and that these tubes or canals are immediately filled with red blood, and thus connected with the general circulation, there will be little difficulty in making out the succeeding changes, by means of which the coagulated pus afterwards becomes organized; since Mr. Bauer's drawings, laid before the Society last year, trace the thin covering of the canals in the coagulated blood to the thick arterial coats met with in the testicle after the coagulum had remained a month in that situation; and it is the arteries which build up all the different structures in the body, as well in the restoration of parts, as in their original formation.

The farther prosecution of this enquiry belongs to the science of Surgery; but as the explanation which I have given of the process employed in the regeneration of parts is, I

believe, entirely different from that which is generally received, I have been desirous that an account of that process should, in the first instance, be laid before the Royal Society.

#### DESCRIPTION OF PLATE I.

Two views of a small portion of a superficial sore on the leg, close to its edge, magnified 10 diameters.

Fig. 1. The appearance the surface put on after it had been exposed by the removal of the dressings for 10 minutes, none of the parts represented having been visible at the time the sore was first exposed, as it was covered with a thin core of pus. The appearances since produced are the canals carrying red blood; the red points, which are terminations of perpendicular canals; and the bubbles of carbonic acid gas. The greater part of the margin is covered with a film of inspissated pus which is become cuticle.

Fig. 2. The appearance the same surface put on the subsequent day at the same hour, after exposure for the same time; showing the progress of the healing process, particularly the rapidity with which the sore is covered by cuticle.

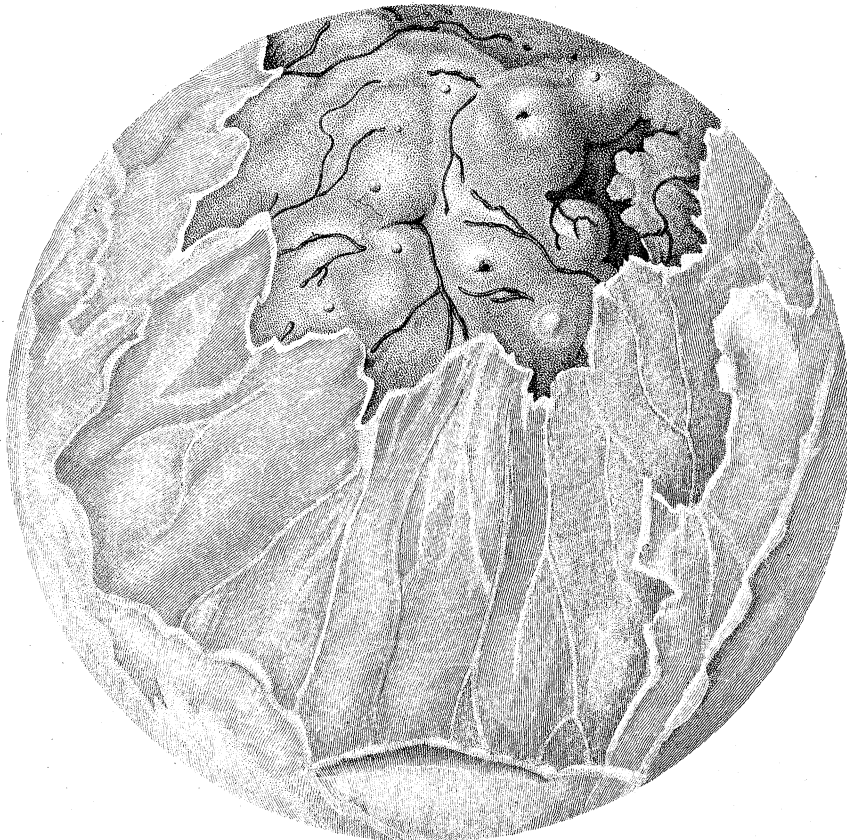
#### DESCRIPTION OF PLATE II.

Two views of a small portion of a superficial sore on the leg, magnified 10 diameters.

Fig. 1. The surface represented under exactly the same circumstances as in Pl. I. Fig. 1.

Fig. 2. The same surface represented 10 minutes after cold spring water had been poured over it for a few minutes, to show the increase in the number of canals.

*Fig. 1.*



*Fig. 2.*

*Fig. 1.*



*Fig. 2.*