brane, where, according to Schwann, they appear again to proceed from single primary cells.

It follows from what has been stated, that it is equally unwarrantable to regard the primary cells universally as epithelium cells, as the latter as globules of pus. On this latter head the author makes particular allusion to Gluge's recent researches into Bright's disease of the kidney (Casper's *Wochenschrift*, 1837, p. 601), where the primary cells in question, enlarged and filled with a granular substance, are described as exudation or inflammation globules. The same holds good with respect to tubercles; and as fat and pigment are the contents of the primary nucleiferous cells in the normal state, so, also, pathological substances appear to be deposited, in the first instance, within the primary cells, as Müller has already proved to be the case with most forms of tumour. The so-called exudation-globules of kidneys affected with Bright's disease, comport themselves exactly as the replete primary cells of which the tubercles are composed. Mere microscopic examination might lead us to believe this peculiar granulation of the kidneys to be infiltrated tuberculous matter, but here microscopic observation alone will not suffice.

Explanation of the Figures.

Fig. 1. The cells of the *plaster-epithelium* isolated, in order to exhibit the gradual spreading and flattening of the cells; *a*, those from the lowest stratum of the *mucosa*, or that lying next the cutis; *b*, *c*, from the middle layers; *d*, from the superior desquamated, or layer ripe for desquamation. The cells *c* and *d* are represented just as they appear upon the edge.

Fig. 2. *Plaster-epithelium*, seen from the surface; *a*, from the serous membrane, the deepest layer of a mucous membrane; or the external skin, *b*, from the uppermost layer of the cutis and rete mucosum, with the stratiform epithelium.

Fig. 3. *Plaster-epithelium*, vertical section.

Fig. 4. Transition form.

Fig. 5. Cylinder epithelium.

Fig. 6. Ciliated epithelium: *figs. 4—6*, vertical section.

Fig. 7. Cylinder and ciliated epithelium parallel to the mucous membrane, seen from above.

Fig. 8. Mucous and purulent globules.

Figs. 9—12. Successive changes wrought on these by acetic acid.

Fig. 13. Folded mucous membrane of the trachea along with the *tunica nervea*, deprived of epithelium.

Fig. 14. Filled primary cells, out of tubercles.

Fig. 15. Transition of primary cells into cellular tissue, out of granulation.

NOVEL EXPERIMENTS

ON

ARTERIES AND THEIR CONTENTS.

By JAMES TURNER, *Veterinary Surgeon*,
London.

[Abstract of "*A Register of Experiments, Anatomical, Physiological, and Pathological, performed on Living Animals*, by James Turner, *Veterinary Surgeon*, 311, Regent-street, London, Author of '*A Treatise upon the Foot of the Horse, and a peculiar Method of Shoeing*.'"] London: Longman and Co. 1839. pp. 51.]

MR. TURNER thus prefaces the interesting pamphlet from which the subjoined breviate is made:—

The following description of an unique experiment on the blood-vessels, together with the results, develops some new facts,

so important and startling in the contemplation of animal life, that, in the opinion of the author, they constitute an entirely new field for the inquiry of the physiologist.

I must premise, that I commenced active practice as veterinary surgeon in the British cavalry when a youth of nineteen, and continued attached to the same regiment until after the close of the Peninsular war. My military appointment afforded me many years of valuable experience, and being upon the home service, I also enjoyed very extensive private practice; from thence to the present hour my time has been wholly devoted to the practical part of the veterinary profession. Blessed with undisturbed rude health throughout that lengthened period, I have never been an absentee from the pursuit for one whole week; and all my intervals of leisure have been devoted to theory and experiment. My opportunities for experiments have been so numerous and varied, that I blush with shame at not having produced earlier and better fruits. I have, however, availed myself of some; and if fortunate enough to bring a tithing of them to a successful issue, my ambition will be gratified.

Although precision and dexterity are essential to the success of our chief operations in veterinary surgery, yet their rapid execution is not indispensable, as in the human patient, where its prolongation adds an hundred-fold to the excitement of the nervous system. In the intervals between the struggles of our patients, curious phenomena are forced upon our notice, such as we may have never heard or read of in books.

By the exercise of one remedy alone, viz., the actual cautery, I have enjoyed almost daily for years, an insight into the mechanism of the circulation in minute blood-vessels, such as cannot possibly have met the eye of surgeons when practising upon their fellow-creatures; and I feel inclined to assume, that few, even of the most practical veterinarians, have been indulged with the like inspection of the movement of the living blood-vessels. My reasons for such supposed exclusiveness are, first, because the human surgeon penetrates to the seat of disease invariably by an incision through the common integuments by a scalpel, or by cold steel, in some shape or other; *blood* necessarily follows; and hence a physiological *view of the circulation* within the vessels, is veiled from his sight. On the contrary, in my operations upon horses by cautery lesions, for the removal of chronic lamenesses (consisting of thickened ligaments, tendons, and especially spavin, this last disease being a chronic tumour upon the hock-joint), I invariably make an incision through the skin in its centre, from top to bottom, by a steel instrument with a knife-like edge, but *red hot*! The instant the skin is thus severed, a considerable dilatation of the lips of the wound

ensues, the tumour is exposed to view, and, in three instances out of four, without the escape of a single drop of blood, or stain sufficient to soil a white handkerchief, notwithstanding that the horse's hide at this part is very thick. The subcutaneous tissues then continue, for several minutes, presenting a most interesting spectacle as regards the smaller blood-vessel system. My second reason is, that veterinarians, generally speaking, do not practise these deep cautery lesions.

The cellular membrane and fasciæ have an aspect delicately white, upon the surface of which is to be seen a beautiful network of blood-vessels, highly injected, forming a complete arborisation, the skin having receded without affecting their integrity, and the efflux of blood from the highly vascular skin itself being most effectually prevented by the sealing effect of the cautery.

My first remarks will be upon the blood, *as found contained in the living vessels, more especially in the arterial system*, first remarking to the humane, that in surgically operating upon the horse, it has always been with the honest view of rendering the animal serviceable to the owner; yet in every instance that I have been tempted to operate *experimentally*, a thrilling of my nerves has induced me to abandon my purpose. I am not devoid of feeling; and unless the object sought is otherwise unattainable, or of such paramount importance as to seem to give me a moral right, I never use the scalpel.

Hunter, in addition to his own discoveries, having proclaimed those upon the blood of his predecessor, Harvey, to be just and well founded, an overwhelming effect was produced, and has continued unabated throughout Europe for the last fifty years. The whole world assented in affixing the stamp of truth upon *all* his writings; and if ever man had a right to be deemed an oracle, it was John Hunter.

If there was a fatal error in too general an adoption of his doctrines, it is no reflection upon the great man from whom they emanated. They should have exercised more discrimination, although nine out of ten of his multifarious propositions are manifest advances in physiological science. But the great Hunter accumulated such a huge mass of before unknown facts, that even his theories have been held in greater veneration than some discoveries of more humble individuals.

John Hunter, however, was but a man; it is just possible that he may have been in error as to one or more of his fundamental principles regarding the blood, when he broached his great theory of the vitality of the blood, the causes of its coagulation, &c. Those who have perused the physiological works of our own countrymen during the last twenty years, must have been struck by the manner in which they have all har-

monised in regard to the attributes of the blood, viz., its circulation, uses, life, coagulation, separation, constituents, &c. The philosophical chemist occasionally wrangles about some elementary atom which his skill may have separated; but, notwithstanding the additional lights thrown by chemistry upon the blood, the theories as to its physiology, circulation, and coagulation, remain unchanged to the present hour.

I propose not now to question the validity of this universally received doctrine, excepting as I may show the possibility of investigating the character, properties, motion, &c. of the blood *while in the natural state, within its living vessels*. I shall confine myself to an exposition of its characteristics while traversing its natural channels, with the perfect integrity of the vessels, and during the health of the animal, believing that I have hit upon an expedient which will test its qualities and motion after a manner heretofore unknown.

Scepticism as to some of Hunter's doctrines of the blood having possessed my mind, I resolved upon tracing, with jealous scrutiny, the several operations and experiments which had induced him to form those opinions. I soon conceived an utter dissatisfaction as to the manner in which he had conducted his chief *experiments* upon the living animals, with the view of testing the "coagulation" of the blood; because I fancied I could perceive that the anxious object of his search had eluded his mighty grasp.

I then quitted Hunter for a season, and followed the experiments of Harvey, seriatim, upon the living animal, and in vain did I seek for proof positive, even in this high quarter.

Not stopping here, but consulting the works of the living stars of this metropolis, without satisfaction as regards the physiology of the blood, I resolved on marking out my own path of inquiry; but first deliberated on the least amount of animal suffering that could be occasioned. I then invented a mechanical apparatus, the instantaneous spring of which should seize (within a barrel) an inch and a half in length, or more, of either of the larger arteries (the carotid for instance) of any living healthy animal, each extremity of the barrel or spring clasp acting simultaneously in the constriction of the denuded artery. I protest against the old mode of exploring the contents of living arteries. The process hitherto employed has been *too slow to be certain*, and the experimenters have been deluded. Even Hunter lost the race when he undertook to imprison the vital current in its normal condition within the living vessels.

A more subtle fluid, in the natural state of the animal, traverses its arteries than has been dreamed of in the two last cen-

turies. I am in a condition to *demonstrate* this position.

John Hunter, in his "Treatise on the Blood," page 14, says,—“The frequent recourse which is had to the lancet in diseases has afforded the most ample opportunities of observation, almost sufficient to explain *every principle in the blood*, without the aid of further experiment.”—Page 14. “There is, I think, more to be learned of the use of the blood in the animal economy from its coagulation than from its fluidity.”—Page 17. From these passages I infer that Hunter's theory was founded chiefly upon his observation of the blood *when removed from its vessels*.

Now, let us inquire how he conducted some of the most important of his experiments. He says, at page 65, “I laid bare the carotid artery of a living dog, for about two inches in length; I then tied a thread round it at each end, leaving a space of two inches in length, between each ligature, filled with blood; the external wound was stitched loosely up. Several hours after I opened the stitches, and observed in this vessel that the blood was coagulated, and of a dark colour, the same as in the vein!” Many of us have found the same result. The coagulated state of the blood, and its dark colour, being strictly in accordance with Hunter's expectations, this great observer was lulled into the hope that he had exhibited a fair sample of the identical blood of which the whole mass was composed.

But I make bold to deny the truth of these positions; and I undertake, by the sudden seizure of an inch and a half of the carotid artery of a living animal, to cause an *instantaneous imprisonment* of its contents in their transit. By the result of this momentary isolation, no men will be more astounded than the followers of Hunter, who, with the utmost conviction, contemplated the *circulation, life, and death* of this mysterious fluid.

EXPERIMENT 1.—A horse, eleven years old, three parts bred, was cast. A longitudinal incision, three inches long, was made in the direction of the carotid artery, and deepened with the greatest caution, to avoid blood from the capillaries, till an inch and a half of the trunk was denuded, and its pulsation on view distinctly felt. Very little blood had escaped, and during the pulsing of the artery the bleeding quite ceased from the minute vessels. The connection of the artery to the surrounding parts having been removed for the embrace of the instrument, my newly-invented apparatus was placed under the carotid, pulsating strongly, and the vessel instantaneously seized. A few moments' respite followed, the object sought being securely locked within a case, the calibre of which was sufficiently ample to avoid the slightest compression of the

imprisoned artery, excepting at both extremities, which were hermetically sealed by the sudden constriction of the instrument. Ligatures were now passed round both ends of the carotid, above and below the machine. Without further delay the apparatus, with its contents, was detached by severing the artery, with scissors, close to each extremity of the instrument. The external wound was closed by sutures, and the animal released from the ropes. My curiosity was excited to the utmost to unlock the casket and view the contents immediately, but I placed it in a medium temperature, and stationary, for four hours; I then removed it to a dish, and opened one extremity of the artery by slackening the instrument, when a small quantity of fluid instantly escaped with a slight jet, of a bright scarlet, and of remarkable tenuity, and was dispersed in a splash over the dish, appearing at the moment to be homogeneous, but it instantly separated into two distinct parts,—red particles (I do not say, globules) and a transparent liquid, thin and almost colourless, exactly resembling condensed vapour. The red particles did not float, but gravitated.

I most anxiously watched this interesting fluid, thinking it might be fibrine in solution, or held in suspension; but, strange to say, no part formed into a clot; there was no jellying—no solidification; not a particle would adhere to a pin's point, or even to its head. I then slit open the artery, and found it perfectly empty, not omitting to examine, most minutely, the parietes of the artery at each end, which had encountered the instantaneous grasp of the instrument; but not a particle of *congealed* blood was imprisoned even there. The red particles, as they appeared to the unassisted eye, I am at a loss to describe; they were of a florid, crimson hue, and very much resembled, in shape and size, the sediment of old port wine, as it appears at the bottom of a wine-glass after receiving the last drops from the bottle, but of a brighter red.

Here arises a vital question. Was this blood? I answer, that it was *not*, according to the general acceptance of that word. But before it can be pronounced what it was, a new system of investigation must be instituted; the chemist, the patient anatomist, aided by the microscope, must bring their lights to bear upon it, and then we may, perhaps, be reluctantly driven back to reconsider the theory of the ancients.

Startled by the result of my first experiment, I began to ask myself whether I was another deluded mortal clinging erroneously to the hope that I had just developed some great physiological truth. I reasoned thus: That which I have obtained was procured under great outrage to the parts concerned, and to the vascular system generally, and

the mere circumstance of exposing so large a vessel to the air, independently of the rude application of an instrument, may have instantly revolutionised its contents and subverted the action of the organ. In fact, I had found that the arterial trunk pulsated energetically in proportion to the exposure, and to the degree of irritation to which it was subjected *prior* to the seizure by the apparatus. With these reflections I considered my experiment anything but conclusive, and immediately resolved to carry the same thing out under very different circumstances. It occurred to me that I would make a seizure of the spermatic artery, because every facility might be afforded for the effectual embrace of the vessel without the artery being denuded, or in actual contact with the instrument, plenty of cellular tissue being interposed.

EXPERIMENT 2.—A healthy stallion ass was procured, five years old; he was cast; his testicles were well developed. An incision was carefully made in the scrotum, to allow the left testicle to escape from its capsule without wounding that organ or its spermatic chord. Several inches above the epididymis a small puncture was made, through the chord, lengthways, but only in the slight connecting medium between the blood-vessels and the vas deferens, a transparent cellular tissue, thin as gauze, and bloodless, merely for the passage of the instrument, that it might encompass artery and vein without including the vas deferens in the gripe. The spring apparatus having performed its office effectually, it was immediately detached, with the testicle appended to it, and the animal was allowed to get up, retaining the other testicle for a future experiment.

I feel inclined to believe that the spermatic artery and contents were enclosed while in their normal condition. Not a particle of blood or substance had been removed from the chord; it was entire, excepting the very trivial perforation, above described, through a part which was transparent from its thinness. The imprisoned portion of artery was two inches in length, and was not opened for four hours; it yielded *precisely the same result*, but the quantity of the fluid was very small.

EXPERIMENT 3.—The external submaxillary artery in the horse is of considerable calibre, considering its superficial situation where it passes over the lower jawbone; and being so familiar with it, as the most convenient part for feeling the pulse, I was tempted to explore its contents, more particularly from the facility of exposing it to view with so little previous dissection.

A healthy ass was cast, an incision three inches in length was made in the direction of the artery, commencing exactly where it crosses the jawbone, and continued upwards towards the face; nearly an inch and a half

was exposed to view of that portion of the artery which was believed to send off few or no branches. The duct of the parotid gland being so contiguous to the artery at this part, it was decided not to separate them, to avoid unnecessary exposure of the blood-vessel. The apparatus then effectually embraced both trunks; ligatures were applied, the animal was released, and the contents examined within *three hours*, with the *same results*; not a particle of clotted blood or coagulum could be found.

From the foregoing facts, and repeated dissections of the living animal, I do not hesitate to avow that I think John Hunter was wrong, when he states, at page 17, as before quoted, "*that more is to be learned of the use of the blood in the animal economy from its coagulation than from its fluidity.*"

I here take my stand. But there are luminaries of the present day who are guided, mainly, in their decision upon all the phenomena of the blood, by its coagulating power,—by the presence of fibrine, as to quantity and quality.

On the continent we find the indefatigable Magendie absorbed by the subject. Vide his invaluable lectures in THE LANCET. This model of a teacher, who wisely rejects every theory which is found to quail under experimental inquiry,—even this cautious inquirer, this just critic of groundless theories, with complacency experiments on the clot of blood recently abstracted from his patients, from the temporal artery, for instance, and then expatiates upon the quality and quantity of the fibrine it contains, as though he imagined that cup of arterial blood to be a fair specimen of the fluid which was traversing the vessel on the instant before his lancet opened a communication between it and the surrounding atmosphere.

This extrication of invisible gas, or rather, *blood steam*, from the aperture in the artery, appears to have been known to the old Greek physicians; but that dazzling theory of the moderns, the "*vitality of the blood*," has so amused the sages of the last century or two as to dispel all reflection upon the notable fact duly recorded by our forefathers.

EXPERIMENT 4.—A muscular blood stallion, eight years old, was secured in the ordinary way for castration; the scrotum was opened by the scalpel with especial care, to permit the escape of the testicles without in the slightest degree impairing the integrity of those organs; my new apparatus was applied to the spermatic chord above the epididymis, encircling the entire rope. At will an *instantaneous compression* or ligature of all the blood-vessels of the chord connected with the organs ensued. This large vascular gland is isolated in a twinkling, and the contents of its blood-vessel tissue imprisoned suddenly, in their normal condition; and, in order that no communi-

cation might be opened between them and the atmosphere, while they retained any animal heat, the testicles were allowed to remain appended to the animal for about twelve hours before they were cut off; and during their excision every drop of fluid which escaped was carefully collected. Then immediately followed a most tedious and patient dissection of the testicle, commencing by unravelling the convolutions of the vessels of the chord, and tracing their branches until lost in the body of the testicle.

After laying open the blood-vessel tissues from end to end, and finding them to contain a dark-red fluid, shall I be believed when I declare that they were devoid of a particle of clot—I mean of congealed or coagulated blood?

EXPERIMENT 5.—From the following experiment an opposite result was produced.

A healthy horse, seven years old, having a good tail, that is, his dock entire, was prepared for docking. The tail was amputated, rather high up with the ordinary docking machine, and severed instantaneously.

I designed to trace the contents of the blood-vessels of the detached portion, as I had before done of the testicle. The Hunterian theory of the *vitality* of the blood will not reconcile these differences.

Accordingly, while an assistant was amputating the tail, I had a firm grasp with my hand upon that portion which was to come off, so holding it that its wounded surface would be the most elevated at the moment of excision, thereby preventing more than a single drop or two of blood falling from it to the ground. Upon immediate examination of this raw uppermost surface, instead of its becoming coated over with a clot of congealed or coagulated blood, I found that, in a few seconds, a transparent lymph covered the entire surface and remained a perfectly thin fluid after the lapse of several minutes, and that a few particles of red blood, in patches, might be seen through this transparent fluid, oozing from the mouths of two or three principal vessels.

In this elevated position I secured the stump, and left it in a temperature of about sixty degrees for nearly three hours, when I returned to trace the blood-vessels. The greater part of the transparent lymph had then evaporated or disappeared, but had not coagulated. In this case I was spared the trouble of a minute dissection; for the moment I inspected the mouths of the principal vessels, I found each completely plugged with red coagulated blood, so fibrinous and tenacious, that I was enabled to pull out strings of blood some inches in length from one or two of the principal trunks. Whereas, in the dissection of the testicle there was nothing like so much

clotted blood to be found in the entire organ as commonly escapes in the space of two minutes from a man's chin in accidentally shaving off a pimple.

REMARKS.—I earnestly solicit the medical community to test the accuracy of these experiments; I leave hypotheses to others.

All modern physiologists have referred to the *coagulating* property of the blood as one of its most interesting attributes. They have always found, that upon blood being spilled from a healthy animal, whether from artery or vein, it has quickly assumed a solid form; when they have imprisoned the blood within the large trunks, between two ligatures, after the lapse of three or four hours, they have invariably found the blood coagulated and dark. But when I lay bare the carotid artery of a living animal, and, by the aid of peculiar machinery, *isolate* two inches of the vessel *instantaneously*, and thereby catch the fluid in its transit, in three or four hours what do I find? A fluid? Yes. Is it blood? I do not know. It appears to the eye like condensed steam or vapour of a bright-red hue, extremely thin and transparent; the colouring particles gravitate, and a limpid fluid floats on them; not a particle of coagulum is to be seen or detected for hours afterwards; the red particles adhere tenaciously to the dish, but the delicate fluid evaporates rather quickly. To account for this difference in the results of the two operations I shall not pretend, until I have adopted the same course of exploration through the venous system as well as the arterial. The veins I have experimented upon, with the apparatus, only in part. With regard to the *trunks of veins* I have not yet sufficient confidence to report progress.

Experiments 2 and 3 merely confirm the first; but experiments 4 and 5 solicit serious reflections.

In strangling the testicle of the horse, it was my design, besides *suddenly* stopping the arterial and venous systems throughout the organ, also to effectually retain within the vascular tissues the full quantum of the blood's *gas* or *steam*, as well as the blood itself, which naturally and properly belonged to the detached testicle; and I think I perfectly succeeded. To the exclamation "What can this writer mean by his *blood's gas* or *steam*?" I answer, fearlessly that I believe the present generation of philosophers are doomed to retrace the steps of the ancients upon more important points than one in the animal economy.

Those of the very old school have reiterated that no perforation, however small, can be affected in a living blood-vessel without the *instantaneous extrication of vital air*; and they say that the escape of the blood is a necessary sequence of the communication between the vessel and the atmospheric air. By a long persistence in experimental inquiry, I am constrained to go over to the old

school, as regards the physiology of blood. In my next essay I expect to substantiate my remarks by absolute demonstration.

By hermetically sealing the trunks of blood-vessels at the instant of separation, I imagine that, besides securing the whole of the blood in its proper vessels, the *halitus* is also preserved. In no other way can I account for the blood retaining its perfect fluidity for twenty-four hours from its death, as in experiment 4. This result suggested to me experiment 5. In the amputation of the tail, although every drop of blood was preserved within the vessels of the detached member, no provision was made for the detention of the *halitus* or *blood's gas*. Did an anxious inspection of this dead tail furnish products corresponding with the vessels of the dead testicle? By no means: they agreed only as containing blood; but mark well how they disagreed; in a much less space of time after the amputation than in the preceding experiment, the blood was found *firmly coagulated within its vessels*. With the testicle I had to trace the vascular canals throughout their ramifications to obtain even small clots of congealed blood, such as would lodge upon a pin's head; while, with the amputated tail, I was spared all trouble of dissection. By merely applying the forceps to the mouth of each trunk, I not only seized a clot, but its tenacity was so great that shreds of coagulated blood, two inches in length, were withdrawn; and, further, each portion of this blood was in a state of solidity, and appeared to correspond exactly, as to shape and volume, with the calibre of its vessel.

Before I give utterance to all that I have already collected affecting the stability of the Harveian doctrine of the circulation of the blood, I must be allowed time to extend my *inquiry*. But in order to carry these views out, I regret to add, that the vena cava, anterior or posterior, or both, of a large-sized living animal, must be embraced by the new instrument—perhaps the heart itself. Some early number of the "Register" shall contain an engraving of my apparatus.

My veterinary compeers are the men most likely to refute or confirm the views here advanced. Every day will afford them facilities for testing the points which I have broached. The medical man must encounter an assemblage of vexatious circumstances, the sacrifice of much time and money, and must even procure veterinary assistance, for surgically operating upon very large animals; for my opinion is, that these researches employed upon cold-blooded animals, or on any animals of very small dimensions, will be futile.

Mr. Turner concludes by saying, that Part 2 will be devoted to the consideration of the venous system, with the narration of numerous experiments.