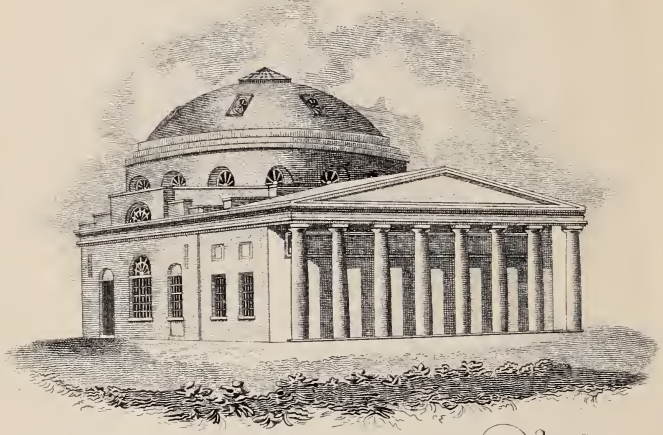

A

REGISTER OF EXPERIMENTS

ANATOMICAL, PHYSIOLOGICAL, AND PATHOLOGICAL,

PERFORMED ON

LIVING ANIMALS.

BY

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PREFACE.

The Author, in now publishing the three following Parts, embodied in one memoir, thinks he cannot do better than refer his readers to the able review in the 'Veterinarian,' for July, 1857, from which he has made the following extracts:

"A brief comment on the remarkable example of the value of experimental investigations, furnished by the three Memoirs of Mr. James Turner, President of the Royal College of Veterinary Surgeons, whose spirit of penetration appears to have anticipated by ten years the remarkable discovery of Dr. Richardson, as to the cause of the blood's coagulation, to which the last Astley Cooper Prize of three hundred guineas has been awarded. . . . . And in other parts of his memoirs our author insists upon a gaseous current as constant and retained within the blood-vessels; he maintains that rarefied air is the solvent of the blood, and that it is only when such gas finds escape that the liquid blood becomes coagulated. Now, if the scientific world confirm Dr. Richardson's discovery, it cannot be denied that Mr. Turner's opinion, pronounced as it was on the basis of experiment, is one of the most remarkable examples on record of what can be regarded as little else than scientific prophecy. . . . . Perusal of these memoirs will amply repay every real student of nature, for they are rich in evidences of a master mind, in material for reflection, which can but lead to the great end of scientific progress. . . . . Mr. Turner may say with justice that had his voice been sooner echoed, the prize of discovery would have been sooner won."

"Mr. Turner, the respected President of the Royal College of Veterinary Surgeons, by a series of physical experiments, very much resembling some of mine, but preceding those, came to the definite conclusion that coagulation occurs from the escape of volatile matter from blood.

"Mr. Turner's labours were independently conducted; and I have sincere pleasure in claiming for him a successful and original place in this interesting inquiry."—Dr. Richardson '*On the Coagulation of the Blood.*'

ADVERTISEMENT.

THE few following pages contain the description of an unique experiment as repeated upon the blood-vessels of living animals; together with results which consist of the development of some new facts, so important and startling in the contemplation of the phenomena of animal life, that, in the humble opinion of the Author, they constitute an entirely new field for inquiry, worthy the research and scrutiny of the human physiologist, having the same reference to the structure and economy of man as to inferior animals.

Horse Infirmary, 311, *Regent Street*,
London, *April*, 1839.

TO THE MEDICAL PROFESSION.

An individual so obscure as the writer of these pages soliciting the time and attention (though merely a passing notice) of a body of men constituting a scientific class of the community, justly acknowledged the most learned, the most wise, and at the same time the most useful to mankind at large, is impressed with a deep sense of the magnitude of his task, though not deterred from the undertaking.

Notwithstanding the confidence expressed in my advertisement, I feel that I cannot reasonably expect to excite your attention and interest without respectfully placing before you some of my pretensions for having embarked in so bold a procedure; but aware of the immense value of your time, it behoves me to be brief.

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, fostered by an ardent love for it, and 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, through your candour, to bring a tithe part of them to a successful issue, my ambition will be gratified, and I shall not regret the labour I have bestowed; and

more, that, whether successful or not in this Essay, I shall persist in experimental inquiries, and ere long again appeal to you for a second hearing.

The few brief remarks which I have to make upon the veterinary profession generally I hope you will tolerate, otherwise I fear of convincing you that, as a body of men engaged in a pursuit although inferior yet not dissimilar to your own, we possess many facilities to aid us in prying into some of the hidden secrets of Nature which are denied to your own class.

It is well known that veterinary science has flourished in this country, under the new and improved system as emanated from the Royal Veterinary College, for nearly the last half century. Talented members of the profession have favoured the public with elaborate works upon the anatomy, physiology, and pathology of the horse, which will ever reflect credit upon their authors and the age in which they were written.

The veterinary art has recently been condescendingly styled by the giants of human surgery the "sister science;" and our venerable and ta-

lented Professor Coleman inculcates the necessity of his students cultivating a respectful acquaintance with the surgeons of the district where they may be located; but I trust I may be allowed to add, for the honour of the profession of which I am a humble member, that the day is now arrived when the medical man no longer walks into the infirmary of horses to *dictate*, but merely for the pleasure both of giving and receiving professional information with that animus which ought ever to subsist between brothers engaged in kindred sciences.

I think I perceive that veterinary writers of the new school, with one or two highly creditable exceptions, have principally devoted themselves to the physiology of quadrupeds exclusively: my humble efforts will be directed in the same channel, except that it will be my design to concentrate my feeble powers and experience by selecting subjects that may gain for me your encouragement and approbation, as being equally applicable to the human frame.

Two generations of veterinary men may now

be said to have appeared before the public upon the basis of a medical education and scientific principles combined; and Professor Coleman, the veterinary surgeon in chief of Her Majesty's cavalry, through the influence of his successful professional carèer, and backed by his gentlemanly deportment, having many years ago procured for cavalry veterinary surgeons the rank of commissioned officers from his late Majesty George the Fourth, all respectable veterinary surgeons, whether in the army or not, *claim* a station in society to which before that consummation they had, perhaps, *aspired*, but which can now no longer in fairness be withheld from them.

I take this occasion, but with the utmost deference, to hint to the medical profession that an intercourse with the veterinarian somewhat more social would be duly appreciated by him; and, I will venture to add, would contribute greatly towards the ends of science.

The operating and scientific veterinarian, in some points of view, may be regarded as enjoying facilities for the zealous prosecution of physiolo-

gical research, perhaps even greater and more frequent than yourselves.

Although precision and dexterity are essentials to the success of our chief or major operations, yet their rapid execution is not indispensable, as in the human patient, where its prolongation adds terrors a hundred fold to the already excited nervous system. In the intervals between the struggles of our patients, just in proportion as the operator possesses a philosophical mind, will curious phenomena present themselves to or rather be forced upon his notice within the lesions, and such as he may have never heard or read of in books.

As we emerge from our leading-strings, and aided by all these advantages, the public, and the medical profession in particular, have a just right to expect from our researches the contribution of an occasional mite towards extending the limits of anatomical, physiological, and pathological knowledge as applicable to the human frame.

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, by possibility, have met the eye of human surgeons when practising upon their fellow-creatures; and I feel very much 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, the human surgeon penetrates to the seat of disease invariably by an incision through the skin or common integuments by a scalpel, or 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. This is also effected by a steel instrument with a knife-like edge, but, observe, *red hot!* The in-

stant the skin is 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, and notwithstanding the horse's hide at this part is very thick; the subcutaneous tissues continue for the space of several minutes, presenting a most interesting spectacle to the inquiring physiologist as regards the smaller blood-vessel system. Secondly, 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 arborization, 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.

Gentlemen, anxiously soliciting for my humble endeavours the utmost stretch of your candour, and the exercise of your kindliest feelings, my

first essay will be upon the Blood, *as found contained in the living vessels—more especially the arterial system.*

I shall now address a few words to the humane, which, however, are not dictated by any feelings of resistance to their laudable sensitiveness for the protection of the brute creation.

As before stated, I have been occupied the greater part of my life in surgically operating upon the horse, and, perhaps, severely, but with the honest view of rendering the animal serviceable to the owner; and I fearlessly and conscientiously avow, without any remorse; yet in every instance, and I confess they have been numerous, that I have been tempted or warranted in operating *experimentally*, a thrilling of my nerves has invariably been an attendant, and oftentimes I have abandoned my purpose in consequence.

I merely mention this to show that I am not devoid of feeling; and that, unless the object

sought is otherwise unattainable, or of such paramount importance as to seem to give me a moral right, I never use nor encourage the employment of the scalpel.

ON THE BLOOD.

THE precious life-blood, that fluid so often referred to in holy writ, must have arrested man's attention, when in his earliest and rudest condition, upon beholding the fatal consequences to animal life when spilled from its vessels. Doubtless he marvelled much; and we have it upon record that, from the first dawn of science, the most learned men devoted themselves to the contemplation of the phenomena of this important fluid and its vessels; and the investigation appears to have been followed up by every succession of sages down to the periods of our immortal countrymen, Harvey and Hunter.

The latter, 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 has been produced, and which has continued unabated throughout Europe

for the last fifty years, the result of the joint labours of these two never tiring physiologists.

John Hunter's professional deeds, which justly obtained for him the admiration of all the scientific world, instead of being the offspring of an imaginative genius, that by flying leaps had pounced down upon numberless important discoveries, were, in truth, the valuable *creation* of an intellectual slave, if I may be allowed such a phrase.

Conviction reached home to the minds of his contemporaries and lookers-on as to the truth of his doctrines, because they beheld with admiration his Herculean labours, and perceived the print of his foot upon every round of the ladder of Fame before he reached the top: the whole world echoed in affixing the stamp of truth upon *all* his writings; and if ever man had a right to be deemed an oracle by his fellow men, it was John Hunter.

Now, let us reflect for a moment upon the consequences of this unbounded confidence reposed in the doings of a single individual. They have been almost hallowed—they have been deemed by succeeding writers sufficiently sound, both as to

quantity and quality, to have formed for them the basis of a stupendous superstructure, a more huge pile of physiological and pathological gleanings, perhaps, the world has never before seen accumulated.

If there has been a fatal error committed by his followers through their sweeping credulity in too general an adoption of his doctrines, it is no reflection upon the great man from whom they have abstracted so much. They should have exercised more discrimination : nine out of ten of his multifarious propositions are manifest advances in physiological science, and, as before said, the route by which they were arrived at was simply and plainly laid open. The truth is, that the great Hunter in his glorious pursuit accumulated such a huge mass of facts before unknown to the scientific world, that even his theories have been held in greater veneration than plain important discoveries, the offspring of more humble individuals.

Now, as John Hunter was but a man, although one of no common order, it is just possible that

he may have been in error as to one or more of his great fundamental principles regarding the blood, which he most prized when he broached his great theory of the vitality of the blood, the causes of its coagulation, &c. I doubt not for a moment but he sincerely believed in its truth. But mark the caution of this rigid observer of facts, wherein he makes this exclamation—"To conceive that blood is endowed with life while circulating is, perhaps, carrying the imagination as far as it can well go."

Those who have been in the habit of perusing the standard physiological works of our own countrymen as they have appeared during the last fifteen or twenty years, and which have not been few nor poor, must have been forcibly struck by the extraordinary manner in which their authors have all harmonized with each other in regard to the attributes of the blood—viz. its circulation, uses, life, coagulation, separation, constituents, &c.; this harmony continuing to the present hour, as if inviolable, except by the occasional advances of the philosophical chemist, who disdains to

notice it at the *fountain*, but wrangles about some elementary atom which his skill may have separated through the agency of some chemical attraction perhaps unknown on the day before. But, notwithstanding the additional lights of chemistry upon the blood have been important, still the theories as to its physiology, circulation, and coagulation remain unchanged.

Now, when I confess to my readers that I propose not in this section of my work to question the validity of this universally received doctrine of the blood, except so far as I may show the possibility of investigating the character, properties, motion, &c. of this interesting fluid *while contained in the natural state within its living vessels*, it will be obvious to the reader that I am released from the onus of an elaborate dissertation upon the blood generally, and that I may confine myself to an exposition of the characteristics of that fluid while traversing its natural channels with the perfect integrity of the vessels and health of the animal. In attempting to carry out this object,

I am buoyed up with the vanity of believing that I have hit upon an expedient which will test the qualities and motion of this mysterious fluid after a manner heretofore unknown.

Heretical scepticism as to some of the Hunterian doctrines of the blood having possessed my mind, I resolved upon tracing with jealous scrutiny the several operations and experiments combined which had conspired to form in John Hunter's mind those opinions upon the blood which have proved so popular to this hour, having passed current for half a century and upwards.

I soon conceived an utter dissatisfaction as to the manner in which that great authority had conducted his chief *experiments* upon the living animal, with the view of testing that important property of the blood called coagulation; because I fancied I could perceive that the anxious object of his search eluded his mighty grasp, giant as he unquestionably was.

I then quitted the great Hunter for a season, repaired to Harvey, and followed his experi-

ments *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 medical works of the living stars of this unrivalled metropolis, without beholding Nature duly reflected from their mirror, as regards one section of their labours, viz. the physiology of the blood, my peculiar views being at variance with the prevailing theory, misgivings gathering daily in my mind, I resolved (considering myself something beyond a tyro) on marking out my own path into the living domains of Nature.

But as victim upon victim would be necessarily involved in this undertaking, I paused, deliberated, studied, and, I hope, with Christian feeling, upon the least possible amount of animal suffering. I then applied myself to the invention of a mechanical apparatus, the instantaneous spring of which I intended should seize within a barrel about an inch and a half in length, or more, of either of the larger arteries which might be preferred (the carotid, for instance), of any living healthy animal,

the machine being so constructed that each extremity of the barrel or spring clasp should act simultaneously in the constriction of the denuded artery. The reader will now, I trust, be prepared to allow me to utter my protest against the old mode of exploring the contents of living arteries.

I mean to contend, that the process hitherto employed has been *too slow to have been certain*, and that the experimenters have been deluded. Even the indefatigable 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 his arteries than has been dreamed of by physiologists of the last two centuries; and I flatter myself that I am in a condition to maintain this bold position by actual demonstration.

I shall commence my exposition by quoting John Hunter's own words, in his memorable 'Treatise on the Blood,' *vide* page 14:—"The frequent recourse which is had to the lancet in diseases has afforded the most ample opportunities of ob-

servation, almost sufficient to explain *every principle in the blood*, without the aid of further experiment."

At page 17, "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."

From these passages it must, I think, be inferred, that Hunter's theory of the blood was founded chiefly upon his observation and experience of that fluid *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!"

This is strictly true; many of us have found

the same result; and I believe the same will always be found, provided the experiment be conducted as described above.

The phenomena exhibited, such as the coagulated state of the blood, and its dark colour, being strictly in accordance with Hunter's expectations, both in theory and practice, this great observer was lulled into the delusive hope, that he had exhibited a fair sample of the same identical blood of which the volume was composed.

Now, 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, and that, by the result of this momentary isolation of the arterial trunk and its contents, no men will be more astounded than the admirers and faithful followers of the late John Hunter.

EXPERIMENT I.

A horse, eleven years old, in fair condition, about fifteen hands two inches high, three parts bred, was cast. A longitudinal incision of about three inches in length was made in his neck, on the off side, in the direction of the carotid artery, and deepened with the greatest caution, to avoid an unnecessary flow of blood from the capillaries, till about an inch and a half of the trunk of this artery was denuded. On being exposed to view, its pulsation was distinctly felt.

Very little blood had escaped up to this stage of the operation; and during the time occupied in pulsing the artery the bleeding quite ceased from the minute vessels. The connexion of the artery by its cellular tissue to the surrounding parts having been removed to a length corresponding to the contemplated embrace of the instrument, my newly invented apparatus was now placed under the carotid, the artery pulsating strongly, and the instrument seized the vessel instantaneously, to my entire satisfaction.

At this juncture the operator and patient may both safely have a few moment's respite: the object sought after is isolated, and securely locked up within a case, the calibre of which being sufficiently ample to avoid the slightest compression of the imprisoned artery, except at both extremities, which are hermetically sealed by the sudden constriction of the instrument. Ligatures were now passed round both ends of the carotid above and below the machine employed.

Without further delay the apparatus with its contents was detached from the living animal by severing the carotid artery with a pair of scissors, as closely as possible to each extremity of instrument. The external wound having been closed by two or three sutures, nothing remained to be done but to release the animal from the ropes.

Although my curiosity was excited to the utmost stretch to unlock the casket and view the contents immediately, I refrained, but placed it in a medium temperature, and stationary, until four hours had elapsed from the moment of the incarceration of the artery.

Examination of the Contents of the detached portion of the Artery.

Without pretending to anticipate whether the vessel contained anything or not, I fortunately had the precaution to place it upon a dish. One extremity of the artery was now opened by slackening the instrument, and a small quantity of fluid instantly escaped with a slight jet. The stream was minute and momentary, of a bright scarlet colour, and of remarkable tenuity, and was dispersed in a splash over the surface of a small dish, appearing at the moment 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.

Of course, I most anxiously watched this interesting fluid, thinking it might be fibrin in solution, or held in suspension; but, strange to say, no part formed into a clot—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.

Now, to return to the red particles as they appeared to the unassisted eye, and I do not pretend at present to offer a microscopic description; in fact, I am much at a loss how to describe these bodies. 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 drainings of the last drop from the bottle; but of a brighter red colour.

Here arises a vital question. Was this blood? I answer, that it was *not*, according to the general acceptation of that word. But before it can be pronounced what it was, a phalanx of talent must be energetically employed—a new system of investigation must be instituted—the researches of

the chymist, in conjunction with the most dexterous, patient, and industrious anatomists, aided by the microscopic field; and when all these lights have been brought to bear, we may, perhaps, be reluctantly driven back to the reconsideration of the theory of the ancients.

Startled by the result of my first experiment, I began to ask myself whether, like hundreds of others now silent in their graves, who had indulged in prying into Nature's secrets, I had added another deluded mortal to that number, yet eagerly clinging to the vain hope that I had struck into a new track towards the development of some great physiological truth.

I reasoned with myself thus:—If I have stolen a march, and approached somewhat nearer a great secret, that which I have obtained from a living carotid was procured under circumstances of great outrage to the organization of the parts concerned, and to the vascular system generally, how can I or any other human being tell but the mere circumstance of exposing the external surface of so large and important a vessel to the impression

of the atmospheric air, independent of and prior to the rude application of an instrument, may have instantly revolutionized its contents, and subverted the action of the organ.

Now, in telling the *truth*, and not withholding the *whole truth*, I found that the arterial trunk pulsated energetically in proportion to the exposure and degree of irritation to which it was subjected *prior* to the seizure by the apparatus.

With these reflections, therefore, I considered my experiment anything but conclusive, and immediately resolved upon another, by which I should carry the same thing out under very different circumstances.

It occurred to me that I would make a seizure with my instrument of the spermatic artery of a living animal, because every facility might be afforded for the effectual embrace of the vessel without the artery being denuded, exposed to the air, or even the actual contact of the instrument, plenty of cellular tissue being interposed.

EXPERIMENT II.

A fine healthy stallion ass was procured, five years old, vigorous, full of flesh, and from hard work. 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 epididymus 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.

After much reflection upon this case, I feel inclined to believe that the spermatic artery and contents were instantaneously enclosed while in their normal condition.

1st. The coats of the artery had not been one moment exposed to the atmospheric air, as was the case in the carotid experiment.

2d. During its compression the instrument never touched the vessel, all the other tissues of the chord being interposed.

3d. Not a particle of blood or substance had been removed from the chord; it was entire, except the very trivial perforation above described, through a part which was transparent from its thinness.

The imprisoned portion of the spermatic artery was about two inches in length, and as in the former experiment of the carotid, it was not opened and examined until after the lapse of four hours: it yielded precisely the same result, but the quantity of the fluid was very small.

EXPERIMENT III.

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

A healthy ass was cast, an incision in the skin of about three inches in length was made in the jaw of the off side, in the direction of the artery, commencing exactly where this vessel crosses the jaw-bone, and continued upward towards the face; nearly an inch and a half of that portion of the artery was exposed to view, which was believed to send off little 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 expo-

sure of the blood-vessel. The apparatus was then applied, and it effectually embraced both trunks.

Ligatures were then applied to the artery and the duct, and the animal was released.

This artery and its contents were examined within *three* hours after the operation, with the same results, and not a particle of clotted blood or coagulum could be found.

Having announced in detail the foregoing facts, which have resulted from repeated dissections of the living animal, I do not hesitate to avow, that I think John Hunter was wrong, wherein 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.*"

As a sceptic of the Hunterian and Harveian doctrines, I here take my stand. But there are luminaries of the present day guided mainly in their decision upon all the phenomena of the blood, its physiology, pathology, &c. by its coagulating power, by the presence of fibrin as to quantity and quality.

If we turn to our neighbours on the continent,

we find that indefatigable French philosopher, Magendie, absolutely absorbed by the subject, vide his invaluable lectures in the "*Lancet.*"

This model of a teacher of animal organization, who wisely rejects every theory which is found to quail under the test of experimental inquiry,—even this cautious inquirer, this just critic upon a hugh pile of groundless theories, with the utmost complacency experiments upon the clot of blood recently abstracted by ordinary bloodletting from his patients (to use his own words), from the temporal artery, for instance, and then expatiates upon the quality and quantity of the fibrin it contains, as though he imagined that cup of arterial blood to have been a fair specimen of the fluid which was traversing that vessel the instant before he plunged in his lancet, and opened a communication between its cavity 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 Greek physicians of olden time; but that dazzling theory of the mo-

derns, the "vitality of the blood," has so amused the sages of the last century or two, as to have dispelled all reflection upon that notable fact duly noted by our forefathers.

But modern authors and lecturers have built so largely, have raised such an immense superstructure upon Harvey and Hunter's groundwork, and all its machinery having hitherto worked well, seemingly down to our own time, in all probability the present generation will combine heart and hand in underpinning and vamping up this breach in the foundation, as disclosed by the foregoing experiments upon the blood-vessel system of living animals.

EXPERIMENT IV.

A muscular blood stallion, eight years old, fifteen hands and three inches high, vigorous, and in working condition, was cast and secured in the ordinary way for castration: the testicles were large and sound. The scrotum was opened by the scalpel with especial care, to permit the

escape of the testicles without wounding or in the slightest degree impairing the integrity of those organs. My new apparatus before mentioned was applied to the spermatic chord above the epididymus, encircling the entire rope. At the will of the operator the instrument causes an *instantaneous compression* or ligature of all the blood-vessels of the chord connected with the organ. This large vascular gland is isolated in a twinkling, and the contents of its blood-vessel tissue may be fairly considered imprisoned suddenly while in their normal condition; and, in order that no communication 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?

From the following experiment upon the contents of living blood-vessels, an opposite result was produced.

EXPERIMENT V.

A healthy middle-sized horse, seven years old, in good flesh, was chosen, having a good tail, that is, his dock entire, and abundantly supplied with hair, was prepared for the operation of docking in the common way. The tail was amputated rather high up with the ordinary docking machine, and it was severed instantaneously.

It was my design to trace the contents of the blood-vessels of the detached portion, as I had before done of the testicle.

Accordingly, while an assistant was amputating the tail, I had a firm grasp with my hand upon that portion which was to come off, having it held in that direction 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 a very attentive and immediate examination of this raw surface remaining uppermost in my hand, instead of its becoming coated or sealed over with a clot of congealed or coagulated blood, I found that, in a few seconds, a transparent lymph accumulated, and covered the entire surface, and which 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 for my dissection and tracing of the blood-vessels.

The greater part of the transparent lymph had

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.

CONCLUDING OBSERVATIONS.

Having instituted a series of novel experiments —at least I conceive them to be new—and having now laid a portion of them before the public, especially the medical community, accompanied with an earnest solicitation that they may condescendingly test their accuracy, with the exercise of all the candour and kindness which they are wont to bestow upon persevering efforts at improvement, however feeble may be the power exercised, I proceed at once to a cursory review of them, and conclude this section of my work by venturing to draw some inferences; but as I contemplate appearing again on this subject before the public, I deem it prudent to premise, that, while I aspire to the honour of favorable notice by accumulating and placing upon record physiological *facts* as developed by patient and intricate research, I earnestly hope that I may not be seduced into a train of speculative deductions.

I am not unaware that if, by the dint of accidental good fortune, application, and a little tact, I should succeed in raising a few buried truths to the light of day, my inferences from those facts may be erroneous and worthless, and therefore it will be my policy to leave hypotheses for the speculation and risk of others.

Remarks on Experiment I.—All physiologists of the present and of the last century with one accord 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 the vessels of a healthy animal, whether from artery or vein, it has quickly assumed a solid form. When, actuated by the spirit of experimental inquiry, they have imprisoned the blood of the living animal within the large trunks, either of arteries or veins, between two ligatures, and after the lapse of three or four hours, upon slitting them open, they have invariably found the blood coagulated, and of a dark colour (vide Hunter, Sir Astley Cooper, Majendie, and others). But when

I lay bare the carotid artery of a living animal, availing myself of the aid of peculiar machinery, and *isolate* about two inches of the vessel, with its contents, *instantaneously*, and thereby catch the containing fluid flying or in its transit, and, after allowing it to remain quiescent in a temperature of sixty degrees for three or four hours, then slit the vessel open, 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; 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 physiologically in all their bearings would, I conceive, be no easy task. For my own part, I shall not pretend to it until I have been enlightened by adopting the same course of exploration through the venous system as that which I have just described with the arterial.

The veins I have experimented upon with the apparatus only in part.

With regard to the *trunks of veins*, in the present stage of the inquiry, I have not sufficient confidence to report progress, although I am exceedingly sanguine as to the result of future investigation upon the foregoing principles.

The Experiments II and III are merely confirmatory of the first: but Experiments IV and V I imagine are pregnant with matter soliciting deep and serious reflection.

It will be seen, that I contrived with my apparatus to strangle the testicle of a vigorous horse by the instantaneous gripe of the instrument upon the spermatic chord, preserving, at the same time, the perfect integrity of the gland and its adjacent parts. It was isolated, dead; but allowed to remain attached to the animal for twelve hours after the operation, when it was removed by a pair of scissors.

It was my design, in conducting this experimental operation, besides effecting the *sudden* stoppage of the arterial and venous systems through-

out 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.

I am quite aware of the exclamation this must call forth ! What can this writer mean by his "blood's *gas* or *steam ?*" I answer, fearlessly and without reserve, that I believe the present generation of philosophers are doomed to the humiliating task of retracing the steps of the ancients upon more important points that one vitally connected with the animal economy.

Those of the very old school have reiterated that no perforation, however small, can be effected in a living blood-vessel without the *instantaneous extrication of vital air ;* and they go on to say, that the escape of the blood, which is so evident to our optics, is a necessary sequence of the communication thus opened between the vessel and the atmospheric air.

I have been brought up legitimately in the new school, but by a long persistance in experimental

inquiry, I am constrained thereby to go over to the old school, as regards the physiology of the blood.

Not unmindful of the impotency of these remarks of mine, unless supported by *proof*, I hasten to avow, that in my next Essay I expect to substantiate them chiefly upon the practical basis of absolute demonstration, relying upon theory only as an auxiliary, and in nowise admitting it except as collateral evidence.

By hermetically sealing the trunks of blood-vessels at the instant a gland or any distinct organ is isolated from the rest of the living animal, as, for instance, the testicle, tail, head, or penis, 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 at present account for the blood retaining its perfect fluidity after the lapse of twenty-four hours from its death, as illustrated in Experiment IV of the horse's strangled testicle.

This result suggested to me the necessity of Experiment V, the amputation of the tail of a

horse high up towards its root, which is instantaneously effected by the common method of operating. It will be remembered that, although every drop of blood was preserved within the vessels of the detached member, no provision in this case was made for the detention of the *halitus*, or *blood's gas.*

Did an anxious inspection of the contents of the vascular trunks 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.*

On the contrary, 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, on the other hand, with the amputated tail, I was spared all trouble of dissection, for 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, amounting to two inches in length, of coagulated blood 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. I mean to assert broadly, that the application of the Hunterian theory of the *vitality* of the blood will not reconcile these differences.

I have as yet limited the description of the application of my new apparatus for testing the contents of the trunks of living blood-vessels *to the arteries only,* though its use has also been ex tended to the jugular veins; but I feel very considerable hesitation at present in reporting progress thereon: enough, however, has transpired to warrant me in prosecuting these experiments much further, particularly as regards the venous system.

Before I dare to 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 and opportunity to extend my *experimental inquiry,* as the reader will

remember I profess to despise conjecture or hypothesis upon a subject paramount in importance to every other connected with the organization and laws of animal life.

In order to carry these views out, whether successful or not in the issue, 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.

I intend that some early number of the *Register* shall be provided with an Engraving representing the construction of my new apparatus.

In quitting the chronicling part of this subject for a short season, in order to return more vigorously to its practical part, I shall avail myself of the opportunity it presents of addressing a very few words to the brethren of my own subordinate though important profession, having commenced my Essay by an appeal to all the charitable and best feelings of the members of the elder science in behalf of these humble efforts.

I am forcibly struck with the idea, that my veterinary compeers are the men most likely, in the

end, to bring to bear a refutation or confirmation of the views herein advanced with reference to the blood, notwithstanding a perfect willingness on my own part to succumb to the predominant attainments of the members of the elder science, supposing zeal and application upon equality between the two classes.

The superior eligibility of the veterinarian will consist in the facilities which every succeeding day will afford him of testing, in a variety of ways, the new points which I have ventured to broach; still pursuing his ordinary avocations, in his natural element, and within his accustomed sphere of action. Not so easy, however, with the medical man, who takes up the subject honestly and zealously.

He must make his mind up to encounter at the onset an assemblage of vexatious circumstances, viz. the sacrifice of his valuable time and money, and must even procure veterinary assistance, to furnish the tact necessary for surgically operating upon very *large* animals; and I shall conclude by offering my opinion, that the carrying out of

these researches upon cold-blooded animals, or on any animals of *very small* dimensions, will be futile.

Part II will be devoted to the consideration of the Venous System, with the narration of numerous experiments.

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PART II.

NEW VIEWS

OF THE

CIRCULATION OF THE BLOOD,

IN MAN AND QUADRUPEDS;

WITH AN EXPOSITION OF SOME

FALLACIES IN THE HARVEIAN DOCTRINE.

PREFACE.

The First Part of these Records of Experiments upon living animals was prefaced by an Address from the author to the medical profession. The present Part is more especially dedicated to the reading public generally, and technicalities are therefore as much as possible dispensed with,—a course which will be adopted in the succeeding portions of the work.

A general knowledge of the structure of the human body, together with the functions of the organs essential to *life*, constituting a part of the education of every nobleman or gentleman of the present day, he is competent—although non-professional and without knowledge of *minute* anatomy

—to comprehend these experiments, *unique* as they unquestionably are, and, if he choose, may satisfy his curiosity as to whether Harvey, Hunter, and their followers have told him the *truth*, the whole *truth*, and nothing but the *truth*, touching the *blood's movement*.

Horse Infirmary, 311, *Regent Street*,
London, *March* 1843.

ON THE BLOOD.

PART II.

The Harveian doctrine, as regards the circulation of the blood, has stood the test of the scrutinizing researches of hosts of physiologists for upwards of two centuries. It has been confirmed by our great oracle, John Hunter, and adopted by all the continental philosophers. Harvey's theory prevails in India, and it has been promulgated throughout America.

By the aid of the microscope of the present century the charm of ocular demonstration has been superadded.

The oft-repeated experiments of my own upon the vascular system of living animals have at length assured me that the Harveian theory contains much truth, and that it is founded upon an ever-

lasting basis; yet I have sufficient grounds to declare, most unequivocally, that it is lamentably deficient of the *whole truth;* other matters of great moment are concerned in the circulation of the vital fluid.

To bring fairly out a precise account of this deficit is the task I have set myself; and in prosecuting my present undertaking, I hope at least industriously to apply all my feeble forces. Why, the task is herculean! exclaims the reader, with indignation; and which reminds me of a stricture of an elegant writer on the blood, lately deceased,— "It would seem as if a rude hand were about to be laid upon our great countryman."

Now, when we reflect that the swell of national pride, being the accumulation of several successive generations, may have had its tendency to lull suspicion and put down scepticism in this country, as to the integrity of the Harveian doctrine, we may be well assured that it has received no such shield from the philosophical inquirers upon the continent. Could they have wrested such a laurel from us, they would have deemed it worthy the

effort. The vast amount of intellect which has been concentrated upon this subject, in all countries, and during an age, perhaps, of the highest civilization of the known world, sufficiently stamps it as a genuine truth, and we have on record this pleasing accompaniment,—that the great founder did not stumble upon his discovery accidentally, or between sleep and awake, but that it was the result of toil and talent most assiduously applied.

I now disclaim any heretical feeling; but I assert, roundly, that Harvey did not live sufficiently long to go far enough; neither have any of his followers in their investigations as to the *circulation* of the blood; therefore there is yet a wide field unexplored, richly deserving the best energies of philosophers or inquiring physiologists.

The great error of Harvey and modern physiologists consists in their having recognized a current of liquid *only* through the arterial channels; whereas, there exists also a *gaseous* current, of equal volume, traversing the same vessels in conjunction at one and the same time.

The whole volume of blood within the arteries

and veins of every warm-blooded animal is extremely diluted with *air:* its globules and ultimate particles of fibrin are preserved in a state of separation by a free *gas,* very great in volume, which pervades the arterial apparatus, but which is less in proportion in the veins.

Arterial blood, in its *transit,* is a fluid of extreme tenuity, of a bright scarlet colour, composed of the liquor sanguinis and red corpuscles, circulating in conjunction with a gaseous medium.

When by accident or design an arterial trunk of a living animal is severed, the whizzing noise which is heard with the escape of the stream of blood is owing to the extrication of this *gas,* a communication having been opened with the common atmosphere. An experimenter of the present day, collecting a basin full from this arterial stream, would expect, and fearlessly assert, that it was identical with the fluid which formed the current the instant *before* the breach was made in the vessel. *It is no such thing;* for just in proportion to the amount of gas which has escaped from the bloodvessel, and lost itself in the external

air, has fibrin in excess found its way into the basin; not by the one continuous stream, but by derivation from every anastomosing branch in the vicinity of the wounded trunk. Nature's spontaneous cure of hemorrhage by coagulation of the blood and plugging up of the vessel is an illustration of this. The great Architect of Nature appears to have ordained that, in the exact ratio as the vital gas has escaped from the breach, so shall fibrin follow by derivation.

The occasions upon which I have caught the arterial fluid in its transit have now become so numerous, and, having invariably found it of the same undeviating subtle, thin, scarlet, transparent character, I am fully impressed with a belief that the web of fibrin which it contains is so extremely diluted in the aëriform fluid with which it is mingled, that it does not of itself, *per se*, possess the qualities of coagulation sufficient to plug a breach in its vessel.

It is well known that the records of the ancient physiologists are very voluminous, as to the arteries being air-carriers; and hence their name:

but as their writings contain no proofs or demonstrations by actual experiment, the utmost that can be awarded, in fairness, to those of olden time is the credit of having guessed the fact.

Their hypotheses, however, prevailed down to the time of Harvey, by whose discoveries they have been overwhelmed for two hundred years, and thus for a season exploded.

The *coagulation* of the blood was a stumbling block to the great Hunter, if I may dare such an expression. All physiologists, even of the present century—foreign as well as British—have, more or less, confessed their inability satisfactorily to determine upon the cause or causes of the coagulation of the blood: while some have supposed the coagulation of the fibrin a proof of the death of the blood, others have regarded it as an act of vitality. But if it can be shewn that there exists in the *circulating* blood a very large constituent, forming one of its constant and natural elements, which has hitherto eluded the observation of philosophic pursuers, this difficult problem may possibly be rendered more easy of solution.

To substantiate this daring declaration, and bring conviction home to the mind of the reader, I am well aware that negative proofs alone will not suffice, but that I must advance many of a positive character.

This Second Section of my work will contain several experiments never before published; but I must commence by recurring to some of the experiments to be found in Part I, of the "Register" for 1839*. The peculiar instrument employed by me for the investigation of the characteristics of the blood while traversing its natural channels, during the perfect integrity of the vessels and health of the animal, or, briefly speaking, catching the blood in *transit* within its artery, is thus described at page 21: "A mechanical apparatus, by the instantaneous spring of which an inch and a half, or more, of a denuded artery—the carotid for instance—of any living healthy animal is suddenly seized within a barrel; the instrument being so constructed, that each extremity of the

* A few copies of Part I may yet be had of Messrs. Longman & Co.

barrel acts *simultaneously* in the constriction of both the exposed extremities of the vessel;—the caliber of the barrel being sufficiently ample to avoid the slightest compression of the imprisoned artery, except at both its extremities, which are hermetically sealed by instantaneous compression."

Hitherto, when physiologists have imprisoned the blood of a living animal in any large trunk—the carotid artery, for instance—of the space of two inches, between two ligatures, and have allowed three or four hours to elapse, they have invariably found the blood *coagulated*, and of a dark colour, upon slitting open the vessel. (*Vide* Hunter, Sir Astley Cooper, Magendie, and others.)

But when I undertake a sudden seizure of such a portion of the artery of a living animal with the new instrument, and cause an *instantaneous imprisonment* of its contents in transit, a result totally different is obtained.

The reader is now most earnestly referred for details to Experiment I, page 25, of my Register of Experiments, for 1839. I have there shewn

that all the blood within the isolated artery retains its perfect *fluidity*, together with its bright scarlet hue. To account for these phenomena, viz. the *coagulation* in Hunter's experiment between the two ligatures, and the *non-coagulation* in my experiment with the new apparatus, will now be my immediate object.

I have before stated, that, by my method, two inches of the denuded artery are seized with the utmost rapidity, and both its extremities are hermetically sealed at the same instant of time. It is, therefore, fair to assume, that the contents of the isolated artery would be a true specimen of the fluid which constituted the current the instant before the vessel was interrupted: this is my sincere belief.

At the expiration of three hours after the operation, I found the imprisoned artery distended with *blood* and *air;* forming together an extremely thin fluid of a bright red colour. Upon its escape from the vessel into a plate, the red corpuscles gravitated immediately—all the residue was a thin limpid fluid uppermost. After the

lapse of eight or ten minutes, shreds of coagulated fibrin might be drawn in strings by the point of a pin or needle from the colourless portion; but in the first instance not the minutest particle could be detected in a congealed or *coagulated* state, or withdrawn by adhesion or any other means.

I therefore infer, that *air* is the *solvent* of the blood, or, rather, that the atoms of the blood, while circulating in the arterial tubes, are separated by the presence of rarefied air.

John Hunter describes his experiment, in his memorable Treatise on the Blood, in the following words, 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!" a result diametrically the reverse of that which I have described as attending my experiment.

Now comes the question, Why was the blood found *coagulated* in this instance? I have said that, in my case, it retained its fluidity owing to the co-existence of a large proportion of air. In Hunter's case it coagulated, I apprehend, from a comparative *absence* of air. All experimenters who have practised this operation tell us, they tie that portion of the artery *first* which is most *remote* from the heart, taking care to select a space of the arterial trunk in which no branches are given off; therefore, long before the second ligature can by possibility be applied, a considerable influx of obstructed blood must have taken place; the artery must be distended near the ligature to the full extent of its elasticity, forming a sort of blind pouch. Now, I am of opinion that, in blood stagnated in the vessel for ever so short a time, there is a tendency for the free air to separate itself, and which, in this instance, would retrograde, and instantly join the current, leaving within the obstructed vessel between the ligatures an incalculable proportion of the fibrinous part of the blood, disposed for coagulation in

the ratio in which the gaseous element had separated from it. Mr. Ancell, in his admirable Lectures on the Blood, published in the *Lancet*, has observed as follows: "Every attempt to explain the phenomenon of the coagulation of the blood on chemical or mechanical principles has signally failed;" and he goes on to say, that the numerous experiments and the strenuous efforts which have been made for the purpose prove it to be impossible. Much as I agree with this gentleman's views upon the phenomena of the blood generally, I am at issue with him on this point; because I believe the ultimate particles of the circulating blood are mechanically kept apart by the diffusion of air, and to which the fluidity of the blood is mainly owing.

In Part I of the "Register," I have demonstrated by experiments, that if the trunk of the blood-vessels of any extremity of a living animal be instantaneously compressed—the spermatic cord, for instance, thereby isolating the testis, and detaching it from the animal without opening a communication between its vessels and the external

atmosphere—the entire blood of the organ will be found in a *fluid* state at the expiration of several hours from the period of the operation; but I beg the reader's especial notice of the next point of consideration, which is, that upon puncturing the distended trunks, veins as well as arteries, the blood will be seen to commence coagulation in the course of a few minutes after it has escaped in a liquid state.

What was the agent which prevented its coagulation within these dead vessels? I answer, it was the retention of the *blood's gas,* which is co-existent with healthy blood: allow it to escape, and coagulation quickly follows.

The indefatigable Magendie, in the course of his diversified experiments upon the bloodvessels of living animals, has unwittingly contributed incontrovertible evidence of the truth of my new doctrine; viz. the circulation of the blood involving the necessity of the presence of a gaseous volume. I shall quote his own words, which will shew, at the same time, that the great experimenter was bewildered at what he beheld. Vide Magen-

die's memorable lectures on the blood, published in the *Lancet* in 1838-9. Lecture the ninth, *Lancet,* No. 794, November 1838, page 282, the Professor was experimenting upon the comparative *force* of the femoral and carotid arteries, and observes to his audience as follows:—

"I have applied two ligatures to the carotid; one is intended to prevent hæmorrhage by the upper end; the other, to fix the lower end of the artery to the tube introduced into its cavity for the purpose of transmitting the blood to the body of the syringe. Every thing is now arranged. You see that the blood pushes the piston up of itself, and enters the instrument. The syringe is half full: I now drive its contents backwards into the artery. I have now refilled the syringe, by simply allowing the force of progression of the blood to drive the piston back."

As my peculiar bloodvessel experiments already published had all been performed at that time, the following comments of Magendie, on turning over to the next page of the *Lancet,* arrested my attention, and have ever since held possession of my

mind in no ordinary degree. Vide page 284, he says—"One of the most curious phenomena we have just observed is, that the blood extracted from the arterial system remained unchanged in the body of the syringe during several minutes. How shall we account for its not having coagulated from the contact of the metallic syringe? There was a circumstance which, by its physical influence, probably aided the blood in retaining its fluidity. In order to give the experiment a greater degree of precision, I took the precaution of allowing the liquid contained in the instrument to communicate freely with that in the artery, so that the impulsion of the heart, the movements of respiration, &c. acted with their full force on the contents of the syringe. The latter were, therefore, kept in constant agitation by all the causes of movement that act on the circulation, and were placed in a very different condition from what they would have been had they been exposed to the open air, and kept motionless in a vase. The proof that the influence of the contraction of the left ventricle was as distinctly felt in the instrument as in

the artery itself is, that, as you plainly saw, the piston gradually rose of its own accord, as it were, until the body of the syringe was completely filled. It is very possible that constant agitation prevented the liquid from becoming solid."

My version, on the contrary, is, that the blood retained its fluidity when extravasated into the syringe because it had not parted with that essential constituent, its *free air*.

That such an element traverses the entire bloodvessel tissues of every warm-blooded animal in nature I shall be enabled to prove by a variety of incontestable facts; not confined to the trunk, but pervading the entire capillary system.

I am not prepared to speak chemically of what this gas is composed; but I believe it is derived from the atmosphere, and distributed to the remotest parts of the body, mingled with the liquor sanguinis; and in all trunks of arteries, large and small, which I have suddenly imprisoned, red corpuscles have been present.

EXPERIMENT VI.

I felt great desire to dissect a plethoric hearty horse, whose death had been sudden, without the loss of blood or any of the blood's gas. A well-bred carriage horse, ten years old, in blooming condition, but incurable from partial paralysis of the loins, was condemned. A single blow of the poleaxe was so ably directed that life was extinguished instantaneously, as he fell with all his legs in a flexed position, and did not survive the blow long enough to extend them. It happened, that not an ounce of blood escaped from the skull. He was immediately placed on his back, and the abdomen skinned and opened as quickly as possible, and the bowels exposed to view from sternum to pubis, taking care to avoid bloodvessels. The groin of the near thigh was next skinned, and by which time the horse had been dead many minutes; a knife was immediately plunged into the crural artery and vein at their origin. The flow of blood was so copious, and the current so strong, that it

formed a high fountain, and from this single orifice twenty-one quarts were quickly abstracted, and collected in pails, after which the blood continued trickling down the pelvis, from the same orifice, into the abdomen, where about twenty more measured quarts were collected; thus, from a single orifice, and that remote from the heart, nearly all the blood in the system was abstracted.

It was extremely interesting to observe, that while it was flowing in a clear thin stream from the artery, the blood had already coagulated into a solid mass in the first pail which received it.

Here is an instance in which the whole volume of pure healthy blood preserved its fluidity for a considerable period after death, simply owing to the vascular apparatus having remained *entire* at every part, and retaining thereby the free air in conjunction with the blood. From the moment a breach is effected and a communication is opened with the external air, coagulation is seen to commence.

I now appeal to those of my readers who may have had the most experience in post-mortem ex-

aminations of horses. Had I allowed the carcass of this dead horse to have remained untouched for twelve hours before I proceeded to collect and measure his blood, could I, by the greatest labour and art, have procured half the quantity, reckoning solid as well as fluid? In our public hospitals, has not great surprise always been expressed at the small quantity of blood found in human bodies on dissection the next day after the sudden death of those in full health?

Hunter himself has confessed in print his inability to account for the paucity.

In post-mortem examinations generally, both of man and brute, if conducted the next day after dissolution, the arterial trunks are found empty, whilst the right side of the heart and venous trunks invariably contain all the blood of the system, even though the animal may have died in a plethoric state.

What has become of one moiety of the blood which the vessels of the animal may be supposed to have contained at the moment of his decease? Will the absence of one-half be accounted for by

the reduction of its temperature from 98 degrees to the temperature of the day, say 50 degrees? No:—but as the circulation flags, the air and the liquor sanguinis disunite, the gas distends the arteries, whilst the liquor sanguinis stagnates and congeals in the veins.

The greatest physiological error which has been committed since the days of Harvey is the theory that the caliber of the arteries and veins of a healthy man are maintained by the circulation of sheer blood: the actual fact is, that it is a joint gaseous and sanguineous circulation.

EXPERIMENT VII.

A young vigorous horse, incurably lame, was subjected to my peculiar carotid operation, as detailed in Experiment I. The carotid artery was taken up by ligature on one side, and upon the following day the carotid of the other side was taken up in a similar manner, and, strange to say, the vital functions appeared to be but little disturbed by this outrage. The patient was well

nursed and gruelled and attended to for two or three days, a healthy suppuration appeared from the wound, and I sincerely believe he would have recovered; but, upon the third day, I also took up by ligature one of his jugular veins; by this, in conjunction with the deprivation of his carotids, his respiration became disturbed and stertorous. Upon the following morning, I was astonished to find that he had rallied: no hemorrhage whatever had occurred from either of the wounds—his breathing, though somewhat quick, was silent, and not very laborious—his secretions and excretions appeared to be natural. As it was decided that the horse should be destroyed on this, the fifth day, it occurred to me that, for the ends of science, it was expedient that he should lose the other jugular; and, accordingly, I tied it also in the early part of the morning. The breathing became laborious immediately, with an occasional cough; perspiration ensued from irritation, and the horse plunged considerably, but no hæmorrhage occurred—not a drop. Pulse at the heart above 100.

I should here observe, that casting for the operations was avoided in each instance, the patient having been suspended the whole time in slings, and otherwise supported at all sides by a large wooden framework purposely contrived. I expected death would quickly ensue; but, on the contrary, in the course of three or four hours, he became more calm, plunged less frequently, breathing hurried, though not quite so laborious; but the pulse at the heart 120. At this stage I invited some friends, who saw him alive minus all the four great vascular trunks.

Twelve o'clock at night came. I was sorry to find him yet alive, all his symptoms remaining about the same, except more frequent paroxysms of coughing: pulse could not be counted. At about half past twelve, in a more violent fit of coughing than heretofore, one of the carotids gave way with profuse hæmorrhage, and he was dead in a few minutes.

I offer no comments upon this experiment with reference to my theory, but have introduced it merely as the record of a fact never before demon-

strated, so far as I have heard or read; viz. the possibility of so large an animal as a horse surviving for nearly twenty-four hours after the deprivation of both carotid arteries and both jugular veins.

EXPERIMENT VIII

Will be found interesting, as shewing the extraordinary effect of cold or rigor upon the arterial circulation in the extremities. A saddle-horse, condemned for unsound wind, but not old, was thrown for the purpose of taking up the metacarpal artery of each fore leg. This vessel is inviting for experiment, the trunk being single and of a very large caliber just before it bifurcates to form the pastern arteries.

It happened that this horse stood without any cloth or covering for nearly an hour before he was thrown, on a cold day, and in rather a strong current of wind (not, however, by design). It was observed while the casting-tackle was being adjusted, that he shivered; but I had forgotten this circumstance, or rather had not regarded it, till I had

far advanced in the operation, and almost bared the artery; when my attention was arrested by finding that the wound through the integuments was bloodless, and the foot and leg below the knee of icy coldness. The trunk of the artery was immediately exposed fully to view; but it was without pulsation or motion, either to the sight or touch. I imagined at the moment that a fatal accident had happened. It was soon apparent, however, that he was not injured by the casting, the pulse at the heart and jaw being vigorous, and his respiration tolerably steady. As quickly as possible he was turned upon the other side, and the metacarpal artery of the opposite leg immediately exposed to view. No such phenomenon presented itself here: a bounding pulse could both be seen and felt: the leg was warm, and the cutaneous wound bled about as usual.

But to return to the cold, bloodless leg:—In the interval the wound had been left without a bandage. The patient by this time had struggled two or three times; his body slightly perspired, and I need scarcely add, that the skin-wound was

found bleeding, and the pulsation of the denuded artery could be felt as distinctly as in the other, the leg having become warm as its fellow.

I could not refrain from recording this chance case, because I conceive that it makes well for the advocates of cold affusions in very many cases of local inflammation, both of man and brute. The ice-boot for the leg and foot of the horse deserves to be more in requisition; and I trust it will not be deemed a digression, because, at the least, it furnishes negative evidence of a temporary suspension of the arterial circulation, solely the result of the sensation of cold. London veterinarians are familiar with something analogous to this, in which an interruption occurs to the circulation within the *venous* system.

A plethoric young horse, fresh from the country, say four years old, is observed at exercise in the morning with a glossy skin, all gaiety, and scarcely to be held in his freaks: towards the same afternoon or evening, he is found in his stall, not feeding like his companions, but standing back from

the rack to the extremity of his halter, hanging down his head and shivering, with a staring coat, although in a stable at a high temperature. His pulse very indistinct, but frequent; and his breath hot and feverish; legs and ears icy cold: in short, he is suddenly seized with acute bronchitis. Now just at this juncture, and *before* there has been time for the second stage of fever to have set in, I have satisfied myself times and oft that the circulation of the blood in all the subcutaneous or superficial veins—the jugular excepted—of this large animal is completely suspended: the large thigh vein feels under the finger exactly as flat as a piece of tape; the same with the plate vein at the axilla, and every other venous trunk at the surface. In many horses which have been so circumstanced and afterwards perfectly recovered, I have had the opportunities of reducing this physiological and pathological point to a certainty, by having made apertures, by lancet, into the thigh and shoulder-veins large enough to admit the tip of one's little finger, without abstracting more than a few drops

of black blood; whereas each of these venous trunks, in health, will readily yield from a gallon to six quarts at a single bleeding.

A most striking contrast to this collapse of the superficial veins may be witnessed upon a sunny day in summer with every successful English race-horse.

Let us suppose a Derby winner being led from his stable leisurely up to the starting-post in his clothes; he is then stripped for saddling. His high breeding and high training in conjunction have rendered his skin as fine and thin as a satin vesture; the development of his prominent muscles is distinctly visible through it. By the time his jockey has quietly mounted and walked him forty or fifty yards, his skin universally presents the most beautiful network imaginable of superficial veins, from his ears to his heels, starting, as it were, from evident distention: the thigh veins are especially conspicuous. There is all this demonstration of health and extreme vigour, even before he has had a canter.

These well known facts are introduced for the

purpose of demonstrating the actual condition of the venous system under varying circumstances, when, from opposite causes, the equilibrium of the circulation may have been disturbed, as, either from the rigor of fever, or the gentle excitement of the nervous system in walking through the public throng to the starting-post, as the case may happen to be; shewing that there exists an ever varying degree of distention of the vascular trunks, more particularly of the superficial circulatory apparatus.

In perusing standard physiological works of a comprehensive scale, I have often wondered, and felt disappointment, that their authors have not commented more largely upon this fluctuation as regards the physical distention or collapse of the superficial venous trunks. Veterinary pathological writers have the more especially surprised me in this respect by their silence. I have long ago satisfied myself that the venous system is full to plethora, or comparatively empty, just in proportion as it sympathizes or is influenced by the nerves and exhalents of the skin.

The florid *arterialized* blood drawn from the

jugular vein of a horse while labouring under the acute stage of general inflammatory fever,—this is an abnormal state of the blood, although repeatedly noticed in passing, which has never yet been duly philosophized upon.

In prosecuting these inquiries into the laws of the circulatory system, phenomena of a startling character sometimes result from our experimental operations.

When Sir Astley Cooper, also the eminent anatomist Mr. Erasmus Wilson, and others, passed a ligature round the posterior aorta of a living dog, very near to the heart, each of their patients not only survived the operation, but lived for a year and upwards; and, strange to say, the system did not appear to have sustained any desperate shock.

Now we have the fact before us, that, notwithstanding this outrageous and sudden obstruction of the grand viaduct, nature's resources were such, that the circulation was carried on, even to the hind feet and tip of the tail. According to the rationale of the day, it was accomplished by anastomoses of vessels; although, by the strictest ana-

tomical references, no other passage could be found than those insignificant channels, the intercostal arteries.

According to the principles of the established theory of the circulation of the blood, the perfect cures of these two mutilated dogs are utterly inexplicable; but the moment we recognize a current of steam within the aorta, the accommodating theory of communication by anastomoses becomes more reconcileable, and readily may we imagine its speedy diffusion throughout the system by retrograde motion.

That a retrograde movement of the arterial fluid as one of the consequences of a breach in the vessel does occasionally occur, we have the authority of Mr. Wardrop. In his great work on Aneurism, page 56, he says—"Independent of a knowledge of the fact, that hemorrhage takes place from the orifice beyond the ligature, whether applied on the cardiac or distal side of an aneurism, the circumstance illustrates the change produced in the circulation of the blood, when an arterial trunk is obstructed, and points out that it assumes

a retrograde motion in the vessel beyond the ligature. This retrograde course of the blood, in the portion of the artery between a ligature and the capillary arterial branches which anastomose with its ramifications, is a curious pathological fact; the branches of the obstructed vessel thus acquiring a power to transmit the blood in a direction opposite to its natural course."

I have endeavoured to prove, that arterial blood secured in its transit within the living vessel is not identical with that which is abstracted in a stream by puncture from a lancet; that the former is light, airy, and volatile; while the latter, when collected in a basin, is a thick ponderous fluid. The former appears to contain only a fractional proportion of the solid materials of the latter, and is transmitted with electrical velocity throughout the arterial apparatus.

Even in the calm unexcited state of the animal the current seems to be rapid, while no resistance is offered beyond the slight degree of physical impediment from the attraction of the walls of the vascular tubes through which it passes.

We know that, when an artery has been obstructed by ligature for the cure of aneurism, a plug of solid coagulable lymph is formed in the cavity of the artery above and below the ligature, and the canal, after a time, becomes impervious from that part to the anastomosing branches. I believe that in this example of the obstructed current, and in every like case, the sanguineous air and the liquor sanguinis are instantly disunited owing to the barrier: the gas retrogrades and joins the current by the nearest anastomosing branches, and a deposit of fibrin or coagulable lymph within the obstructed vessel is the result; and layer upon layer, like laminæ, are contributed by every subsequent contraction of the heart, until a plug of sufficient amount has accumulated.

It is after this manner that I account for John Hunter and Sir Astley Cooper finding the arterial blood coagulated and dark-coloured, like that in a vein, after two or three hours' confinement in the carotid between two ligatures. The first ligature tied was the farthest from the heart; and when they had allowed the blood to distend the vessel

the utmost extent of its capacity, they tied the other, leaving a space between the ligatures of two inches.

For the sake of argument, let it for a moment be admitted that I am right in my views; that the arterial stream is *aërial,* but impregnated with sanguineous fluid: as such, the current is abruptly stopped by their first ligature, because there is no anastomosing branch at that part of the carotid; then, of necessity, the stream retrogrades; but mark, with this important difference in its quality,—the molecules of the blood, which were before widely diffused in air, have, by the mechanical obstruction, been brought within the sphere of attractive influence; the volatile part, being liberated, retrogades, and joins the general current before the application of the second ligature, while the more substantial constituents remain imprisoned in the vessel.

That pure atmospheric air, or a modification of it, in large volume finds a ready entrance into the left side of the heart there can exist no doubt; and I am of opinion that the left heart is essen-

tially a *gasometer*, that every pulsation of the aorta brings the air we breathe into immediate contact with the ultimate internal tissues of our body, and which undergo a fresh irrigation almost every moment of our existence by a gaseous fluid impregnated with liquor sanguinis. Morbid anatomy also affords conclusive evidence that the channel by which the air inspired by the trachea and transmitted throughout the system by the arterial ramifications is much less complicated than the theories of respiration and circulation at present in vogue would represent.

I will relate a case of hydrothorax in a horse, an extreme one, certainly, but common-place to every man in large practice. There is a stage in the progress of this complaint in which an able practitioner might safely predict, almost to an hour, the time at which life would be extinct, although his patient would be standing on his legs, and perhaps feeding, I may say, with avidity. In this individual case I performed the operation of paracentesis; not, however, simply by puncture and evacuation through a canula, but by an exten-

sive incision with a scalpel the width of the hand, between the 7th and 8th ribs, first upon one side. The enormous quantity of transparent serous fluid collected was nearly two large horse-pails. A few hours after, the other side underwent a similar operation, and another four-gallon horse-pail of fluid was collected. This was a condemned horse in the infirmary; but, in two or three days after, his respiration was perfectly tranquil, his appetite keen, and countenance cheerful. The owner claimed him, and he was removed to his own stable, a few hundred yards off, and in a fortnight after he taunted me by saying the patient was in every way convalescent, that he breathed and fed as well as his others. I only replied, he will surely die, because the chest will be refilled with water. In a few days afterwards he fell in the act of feeding, and died instantly.

In the post-mortem examination, both thoracic cavities were found enormously distended with fluid; and I might almost assert that the lungs could not be found; the owner remarking, it was needless to search, as "they were dissolved in the

water." Now, the contracted state of each lung almost defies description: their pleural envelope was entire; but, upon cutting through it, the parenchymatous substance was entirely absorbed, and there appeared literally nought left but the bronchi and their ramifications.

The atrophy of these lungs appeared to be simply the result of the mechanical pressure of the water, absorption having taken place of the soft and delicate organization, while the harder and less-organized air-channels must have remained tolerably pervious, or how could life have been so long sustained. The heat of this horse's blood from the jugular vein was tested immediately before the tapping operation, and found by the thermometer to be 98°.

We are informed by the greatest authorities, that the heat of the human blood in the last stage of phthisis not only maintains the healthy standard, but often somewhat exceeds it.

It therefore appears that, although three-fourths of the lungs of man or beast may be annihilated, a very considerable quantity of the atmospheric

air, or its essence, finds admission into the left side of the heart several times in a minute.

Upon referring to those highly interesting experiments of Sir Benjamin Brodie many years back, of artificial respiration on decapitated animals, we shall find pretty conclusive evidence that the great one thing needful to animal life, viz. respiration, paramount as the function is, the apparatus and the working of it must be as simple as it is general throughout animated nature.

In Sir Benjamin's second experiment, the artifical breathing was continued upon a dog for two hours and a half, and *after one hour and thirty minutes* from the moment the animal lost its head, *the pulse had risen to* 84 *in a minute.*

Here we have ocular demonstration, that the fluidity of the whole of the blood in the system was maintained after the dog had been literally dead for upwards of an hour and a half, by the continued physical operation of syringing into the left side of his heart the breath of life.

To suppose that in every round of the circulation through the lungs of this *dead* dog, an in-

terchange of gases or any energetic movements occurred within the air-cells, would be absurd.

I have before alluded to the varied states of distention or collapse of the superficial venous trunks under peculiar circumstances, both of health and disease.

This fluctuation as to the degree of physical distention by the amount of contents of the vessel is certainly more apparent to our senses in the venous system, yet I think it also obtains in the arterial system.

Cold locally applied in a current upon the extremity of a limb will operate so decidedly as a sedative or nervous shock upon the muscular tunic of the principal arterial trunk as to render it temporarily impervious, and, as a necessary sequence, passive as to pulsatory action. I flatter myself that Experiment VIII has proved thus much to demonstration : although I admit that the solitary case referred to belongs to the chapter of accidents, yet to my mind it is conclusive.

In contemplating the influence of varied temperature upon the tissues of our bodies, it awakens

to my recollection a passage I have lately read in the luminous work of Liebig, wherein this philosopher asserts, that the finger cannot be applied to the head without effecting a *combustion* of muscular tissue. Taking this as a truism, how intense must be the fire created within the muscular fabric of our successful English race-horse while winning the great Derby race over Epsom! In each of these severe contests there is always a portion of the race which is known to sportsmen as the *struggle* or test to the winning horse. He may achieve the mastery in the early part of the race, in the middle, or within a short distance of the winning post; but be that as it may, the exciting and interesting portion of the ground is literally covered at the *flying rate of a mile per minute.*

This locomotive power, almost incredible, is the sole result of successive contractions of muscular fibre. What a problem for Liebig himself! Who else can estimate the amount of caloric generated? By what physical means is it suppressed or neutralized? What is the degree of rarefaction of the

gases of the contained blood? What are the safety valves which preserve the left side of the heart from rupture? Altogether it is an enigma past finding out. Whence the source of that plethora or distention of both the arterial and venous systems which we are sure must exist almost to rupture at the crisis just prior to the entire surface of the body being suffused in sensible perspiration? Will a heightened temperature of the blood account for the distended state of its vessels?

I am now about to refer to experiments by which the *abnormal* contents of *veins* are explored; but as my researches by dissections of living animals, as to the contents of venous trunks in transit and in their *normal* condition, have been numerous and complicated, they must necessarily wait their turn in these records.

The plethoric state of a *venous trunk* in the vicinity of a diseased part, or rather contiguous to a sensitive organ which may be suffering severely from a mechanical injury, as an *abnormal* condition, is highly interesting for exploration by my new proceedure of experimenting.

An illustration of distended vein resulting from disease may be here introduced. I was called to a horse of my own at straw yard a few miles off, the farming man stating that the animal's eye was put out either from a bite or kick; and ghastly indeed was the appearance; but the eye was not lost. Tears flowed copiously, the lids were much tumefied and inverted, the eyeball retracted within the socket, the membrana nictitans projected nearly over it, and the inflammation of the conjunctiva was intense. The whole cause was simply a piece of oat-chaff, which had adhered to the transparent cornea, but so tenaciously, that it had actually impacted itself into the substance, without, however, ulcerating through it. The angular vein under the eye was enormously distended, as we always find it in such cases of unrelieved injury: as he was a thin-skinned blood horse, it was especially prominent in this instance.

To commence my treatment by extracting the foreign body from this irritable and sensitive organ, naturally enough, first suggested itself: but no; I

felt that there was a duty which I owed to science that was paramount to that of sympathy in this instance.

The horse was therefore immediately cast, his head secured, and the following

FIRST VENOUS EXPERIMENT.

Was performed upon the distended angular vein. I need not remind my brother practitioners that the throbbing and excitement of the adjacent vessels was so great, that had this vein been then punctured with a lancet the blood would have started out copiously in jets, and most assuredly would have appeared of a bright vermilion hue, resembling arterial blood, as every surgeon knows.

A longitudinal incision was carefully made through the integuments, in the direction of the vein, about an inch and a half in length, and fortunately the distended vessel was denuded with the perfect integrity of its coats. It now only remained for my *clasped* instrument to be passed under it, as before described and practised upon

arteries (carotid and others), by which it will be remembered, an inch or more of the denuded vessel is instantaneously grasped and imprisoned, by two ligatures at the required distance from each other at the *same instant of time:* this being perfectly a simultaneous action, the contents of the vessel are fairly caught in their transit.

In this instance, the imprisoned vein was immediately removed—encased in the apparatus—placed at rest in a temperature of about 60°, and when examined exactly at the expiration of three hours, by puncturing its coats, a quantity of red blood escaped *perfectly fluid,* and left the internal coat of the vein free from stain or coagulable deposit. In the course of a few minutes *after* its escape it coagulated, with an excess of serum.

I should have stated, that no more time was lost in removing the piece of chaff from the sufferer's eye; and I have the satisfaction to add, that, after the lapse of two or three months, vision was perfectly restored, and almost without blemish of the cornea: therefore, an *engorged vein* was

explored by an experimental operation, without opposition to the cure.

The above operation was performed upon the vein by the same apparatus which I had been in the habit of using for taking up the submaxillary and other small arteries; but I have since found that, for taking up venous trunks in their normal condition, such as the jugular, when the system is calm, in health, and unexcited, considerable modification of the instrument is required (the venous current being certainly very slow), but the details of this will be furnished at a future and not very remote period, with accurate descriptions of the requisite instrument.

Compton and Ritchie, Printers, Middle Street, Cloth Fair.

PART III.

A NEW AND STRIKING FACT,

DEMONSTRATIVE OF A (PROBABLE)

UNIVERSAL PRINCIPLE

PERVADING THE

HUMAN ORGANISATION AND ALL ANIMAL LIFE,

NOT HITHERTO EXPOUNDED BY

COMPARATIVE ANATOMISTS AND TEACHERS OF HUMAN PHYSIOLOGY.

ADDRESS TO THE GENERAL READER.

The important fact alluded to in the title-page of this the third part of my labours is the discovery of a free channel of communication for the transmission of ordinary atmospheric air directly into the left cavities of the heart, as received by the nostrils and windpipe, and transmitted through the lungs, wholly independent of the vascular pulmonary circulation.

Horse Infirmary, 311, *Regent Street*,
London, April 1847.

ON THE BLOOD.

PART III.

EXPERIMENT IX.

A VIGOROUS young horse having opened his knee-joint very extensively by a fall, was condemned by his owner to be destroyed, quickly after the accident; but in the interval, while his case was under consideration, the animal was well suspended in *slings;* his position therefore was very favourable and inviting for experiment. A longitudinal incision of about two inches in length was made in front of the trachea a hand's-breadth below its upper extremity; a long-necked phial containing sixteen ounces of quicksilver being in readiness, the divided rings of the windpipe easily admitted the neck of the bottle, and eight ounces

of the quicksilver were instantly allowed to descend into the trachea and bronchi. The bottle being withdrawn, the tracheal opening closed from the elasticity of its rings, and two minutes were allowed to elapse to watch results. No cough whatever ensued, and very little disturbance in the system was perceptible. The phial was then re-introduced, and the remaining eight ounces, making a pound of crude mercury, entered the windpipe, without a particle returning or falling by the way. All restraints were immediately removed from the animal, such as the slings, hobbles, &c., except the confinement of his head, which, it must be remembered, was firmly secured with double halters, and much elevated from the commencement of the experiment. No cough was yet heard; but the respiration became greatly accelerated, with excitement and restlessness, and much pawing, attended with partial sweating, the animal remaining firmly on his legs for five minutes, when he made a violent plunge all fours, and alighting on his croup (his head remaining secured and elevated), continued in a sitting posture, apparently comatose,

for four minutes; he then suddenly arose, stood firmly on his legs, but with his breathing extremely laborious and stertorous. Eleven minutes had now elapsed from the first introduction of the foreign body into the channels of the respiratory organs. All symptoms were attentively watched for four minutes longer, the horse continuing on his legs, and gradually becoming comparatively calm: in short, it was the opinion of the bystanders that he would have survived the shock of the experiment; but he was immediately shot.

Dissection very shortly after Death.

To prevent the escape of a particle of the quicksilver from the aperture of the windpipe during the skinning of the carcass, the head was left in the same elevated position as during life. The contents of the thorax were well exposed to view *in situ,* by freely sawing of the ribs, and the heart and lungs in conjunction were most carefully removed for the exploration of their contents in the minutest manner. These were immediately

examined. The windpipe was found empty to within three inches of its bifurcation in the lungs, the canal at this part being about half full of a thick white froth, which, upon the point of the scalpel, was evidently a mixture of mucus and large globules of quicksilver. As the large divisions of the bronchi were opened, they were found full of the same froth; but as they were minutely followed into the substance of the lungs the globules of mercury became less and less, though in every portion of the tissue they were perceptible to the naked eye.

Considering that this animal died without the escape of more than an ounce of blood from the aperture in the skull where the shot entered, the engorgement of the lungs was not so great as I expected; but both sides of the heart contained blood, and all the vital organs proved perfectly sound.

My design in instituting this and other subsequent experiments was that of tracing the atmo-

sphere in its *route*, throughout the animal organism, commencing with its inhalation at the nostril.

The breath of life rushes through the trachea of a new-born infant with the force of a torrent from the mountain top: it does not wait in the cells of the lungs to be decomposed, as taught by the schools, but rapidly pursues its course, unaltered, into the left cavities of the heart direct, and from thence to the remotest parts of the organized system; so that each living atom of the interior of a sound man's frame undergoes irrigation with common atmospheric air at least seventy times in every minute of his healthy existence through the medium of the arterial vascular apparatus, consisting of open elastic tubes universally diffused, and never continuing collapsed, either in life or death; a tube so unique in its construction and material, that it retains the property of preserving itself open when boiled.

But to continue with my dissection: I do not hesitate to avow, that this experiment was insti-

tuted expressly with the expectation—ay, even with the hope—that I should find *running mercury within the left ventricle of the heart.* I am well aware how this confession may prejudice my report in the minds of many readers; but then, on the other hand, I am also aware that those inquiring experimentalists who will tax themselves with the trouble of following me (and those of my own profession assuredly will), must also find the fact I am about to describe so obvious, "that those who run may read;" and therefore, being a thing readily demonstrable upon all fitting occasions, there is no objection to a candid statement in every particular.

Perhaps the liberality of the present age may tolerate these heretical opinions as they emanate from an old pioneer in pathological pursuits, and one who has habitually seized upon all opportunities through his life as they have arisen for experimenting in physiological research. Although presenting himself in such direct opposition to received opinions, the author confidently expects

some lenity even from his opponents, because he is not trifling with his readers either by hypothesis or theory, but plainly unfolding to public view numerous important facts, which he has seen with his own eyes, and such as have not lain near enough the surface to be casually stumbled against.

Exploration of the Contents of the LEFT *Side of the Heart.*

Upon laying open the left ventricle from top to bottom, about four ounces of blood, of a florid scarlet colour, were found slightly adhering to the walls, rather inspissated or grumous, but not coagulated or presenting a distinct uniform clot. After exposure to the air a very few minutes, a slight film on its surface was quite evident to the naked eye, of a dirty white colour, and apparently metallic.

On opening the left auricle, about an ounce of blood was found rather more fluid; but it pre-

sented the same metallic film on its surface. The blood from the auricle and ventricle has since been analysed by an eminent chemist, and pronounced to be strongly impregnated with crude mercury.

It must, I imagine, be conceded, that structures which could be permeated by particles of a metallic body would be most readily penetrated by unmixed or pure atmospheric air. That the ordinary air of the atmosphere did accompany these particles of the quicksilver throughout the bronchial tubes to the utmost limits of their ramifications in the horse experimented upon, I take it must also be admitted: then it is obvious, that one of the most important functions of the left heart must be that of a gasometer pump to the entire organized system: it may also have other functions to perform equally important.

Comparative anatomy and comparative physiology in conjunction, and perhaps I may add vegetable physiology, most abundantly prove that the

universal vivifying principle of aëration, instead of depending for its efficiency upon extreme complication of structure, conjointly with a concatenation of circumstances for its operation, as taught by the schools, such as the *endosmose* and *exmosmose* of gases, is a magnificent example of the Creator administering to his creatures the first great essential or supporter of animal life in the most unsparing, simplest, and direct form. That the function of expiration, and the processes connected therewith, as constituting the grand *emunctory* of the circulatory system, is a highly complicated affair, I feel thoroughly assured; and to this department of the animal economy it will hereafter be found that most of the laborious and valuable experiments of physiologists really apply. But with regard to *inspiration*, I boldly make my stand, by asserting that all connected with it is the simplest of Nature's operations; that the same identical particles of common air which in the one moment we inhale by the nostrils are distributed by the next pulsation of the heart to the interior of our toes;

that the common element ever surrounding us from our entrance in the world to our final exit is thus universally diffused throughout the minutest textures of our system, in conjunction with *some* of the essential ingredients of the blood.

Comments upon the Analysis *of the Blood.*

Anatomists, physiologists, and, above all, our philosophic modern chemists, especially the continental inquirers, have of late ardently exerted themselves in investigating the component parts, with their relative proportions, in the vital fluid. Nothing, I believe, can be conceived more minute than the details which they hand to us for our enlightenment upon the important subject of the composition of the blood. Partly from the peculiar doctrines upon which I am undertaking to write, but more especially from the circumstance of being actuated in my description solely by the observance of certain facts which cannot by possibility have ever met the eye of any others than

the very few who may have instituted similar experiments (if any there are), I feel that I am about to be betrayed into expressions which, I hope and trust, will not be construed by any of my readers as unbecoming or disrespectful towards the parties who may be named. I disclaim any such intention; for no man breathing entertains a higher veneration than I do for those luminaries who have gained for themselves distinguished honours by their laborious and elaborate researches into the mysteries of human physiology.

Obscure a labourer as I am in the subordinate field of science, viz. *animal physiology*, I am in the possession of a gathering of facts which warrants me in predicting that the illustrious Baron Liebig himself, robed in his well-earned laurels, is doomed to do *this section* of his work over again. By the perusal of several recent publications on animal chemistry, British and foreign, I find that they commence their analyses, particularly as to the distinction between arterial and venous blood, with the utmost composure and confi-

dence, contenting themselves by merely abstracting the blood from the jugular vein of an ox, horse, man, or any large animal, and collecting it in several vessels, as in common phlebotomy. A superficial artery is then opened with a lancet—the temporal, or perhaps some larger vessel—a carotid may be laid bare, and a corresponding quantity of blood is then collected in the open air, and in open receivers, as in common blood-letting. A most searching and protracted examination of the abstracted blood then takes place; all the lights of modern science are brought to bear in effecting its analyzation, and I have the most profound faith in their efficiency in this art; but that supposes they have commenced upon a right basis, viz., by having secured *all* the ingredients of the blood. Here, however, is the rock upon which they have foundered; they have neglected to do so. Owing to their unguarded manner of collecting the blood, one of its chief ingredients, the *blood's gas*, has eluded their grasp. Immediately on puncturing the neck vein, they carefully collect all they see flow from the orifice; but it so happens there

is an *escape* at the same time, which is *invisible*, and which becomes lost in the surrounding atmosphere, instead of making its way into their retorts. I therefore take upon myself to deny the accuracy of the published analyses of the blood as promulgated by the philosophic chemists of the day. A correct analysis of the circulating blood is only practicable or possible by collecting it during its transit, and at the same time effecting a requisite accumulation in a receiver by means of an apparatus so contrived that the external atmosphere shall be thoroughly excluded; and this *isolation* must be maintained until the blood is actually under the manipulations of the analysing chemist.

EXPERIMENT X

Stands here merely as a record, shewing that a *moderate* quantity of quicksilver may be introduced into the circulation by the trachea without a fatal result, and apparently with no very considerable disturbance of the system.

A blood mare, five years old, being condemned for acute glanders, an incision, lengthways, of about two inches, was made in front of the windpipe towards the upper part through the cartilaginous rings. At first only two ounces in weight of quicksilver were allowed to run down the trachea through the aperture mentioned, and it was administered as slowly as possible. The mouth of the phial was then withdrawn, and the wound sealed with adhesive plaster. The respiration became flurried almost immediately; and in this instance, after the lapse of five minutes, an irritable cough ensued, and which recurred frequently.

The mare remained firmly on her legs, tossed her head up and down, and pawed occasionally with her fore foot, evidently slightly irritated, but not distressed. After ten minutes had passed, two ounces more of the quicksilver, making a quarter of a pound, were allowed to fall *suddenly* into the trachea. This caused considerable agitation for a minute or two: the animal plunged rather violently, but remained firmly on her legs; the diffi-

culty of breathing increased, and slight perspiration ensued. (This, as also the foregoing experiment, were conducted safely without casting the animals.) The wound was closed, and no more quicksilver introduced. When half an hour had elapsed from the first exhibition of the metal, the mare appeared to be very little affected from the outrage she had endured, except the occasional irritation of a cough.

Six hours after the experiment no symptoms of uneasiness were discoverable. The mare fed with avidity. At that period she was shot; but no dissection was permitted in this case.

Had the subject been allowed to live, I make no doubt that, in the course of a few weeks, chronic disease would have been set up in the lungs, the result of the invasion of a foreign body.

EXPERIMENT XI

Was in every particular merely a parallel one to that of Experiment IX, both in the manner of conducting it as well as the results, except that it was performed on a *glandered horse,* whose lungs proved on dissection to be full of miliary tubercles. Two or three of these happening to be much more developed than the rest, I cannot resist the digression by describing what I conceive to be a pathological fact of the highest import and interest to the human practitioner. While tracking the passage of the mercury throughout the substance of the lungs, my attention was suddenly arrested by one of the larger tubercles, where the parenchyma around it was especially charged or studded with minute specks of the metal, and which continued visible into the very substance of the tubercle; but it abruptly presented a line of demarcation between the cell or capsule of the tubercle, thereby proving the interior or contents to be an *unorganised substance,*

not a particle of the quicksilver having penetrated into it.

But to return to my subject. That the essential duty of the aorta is to transmit an aërial current, and by its ramifications to distribute common atmospheric air to every atom of the organised tissue, I have in reserve a host of overwhelming evidence, and which will be detailed in the course of narration of many more cases.

The chief phenomena attendant upon those magnificent experiments of Sir Benj. Brodie's, by keeping up artificial respiration in animals for an hour after decapitation, admit of a different version from that given by the illustrious experimenter. Sir Benjamin tells us the blood continued to circulate even to the extremities for an hour after the animal was dead, and that the heart continued to beat. Then the blood must have remained *fluid*. Why did not the blood coagulate in all this time ? I answer, because of the diffusion of atmospheric air which he pumped into the lungs

by measured proportions, in imitation of natural respiration.

The most difficult problem in physiology which remains to be solved in these enlightened days is the rationale of the *coagulation* of the blood. Here John Hunter himself met a barrier that his genius never surmounted, as his published works testify. To all inquirers into the phenomena of animal life who have halted to think for themselves, there has always been a void, a link of the chain wanting, in this division of science. Writers of the greatest research have especially pointed to the *vitality* imparted to the blood by its *contact* with *living* vessels, and thus reasoned on its *fluidity*. The more I reflect on this theory, the more I am convinced that it is in accordance and association with the retention of a *volatile constituent* of the blood, with which, ere long, we shall find it our business to become better acquainted.

Part IV is in preparation.