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ON

EPILEPSY; THE SPLEEN;

AND

THE THYROID BODY;

&c. &c.

" He that proceeds upon others' principles in his inquiry into any sciences, though he be resolved to examine them and judge of them freely, does yet at least put himself on that side, and post himself in a party which he will not quit until he be beaten out; by which the mind is insensibly engaged to make what defence it can, and so is unawares biassed. I do not say but a man should embrace some opinion when he has examined, else he examines to no purpose; but the surest and safest way is to have no opinion at all until he has examined, and that without any the least regard to the opinions or systems of other men about it. This, I own, is no easy thing to do, but I am not inquiring the easy way to opinion, but the right way to truth."—Locke.

AN INQUIRY

INTO

THE NATURE AND CAUSES

OF

EPILEPSY;

WITH

THE FUNCTION OF THE SPLEEN;

AND THE

USE OF THE THYROID BODY,

&c. &c.

By JOHN JACKSON,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS, LONDON.

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PREFACE.

A KNOWLEDGE of the mechanism and purposes of the several parts of the human body has so long been regarded as an essential pre-requisite to the just comprehension of its diseases, and the sciences of Anatomy and Physiology have therefore been so long cultivated, that it appears extraordinary, that the uses of two organs of such magnitude as the Spleen and the Thyroid Body should still remain hid in obscurity. The circumstance, however, of the uses of these organs not having been ascertained, ought not to lead us to suppose that they are inscrutable; nor, indeed, does it justify the supposition that they are necessarily less obvious than those of other organs, for it sometimes happens in Physiology, as in other sciences, that the simplest truths are those which longest elude discovery.

In the following pages I have endeavoured to shew, not only that the Spleen and the Thyroid Body are, each in its own way, subservient to the most important of all functions, namely, the CIRCULATION (our knowledge of which we have long erroneously believed perfect), but also that the disordered action of the former is capable of greatly deranging that function, and thereby of influencing the cerebro-spinal system, and thus of giving rise to certain morbid phenomena, for the production of which, those who have looked exclusively to the Nervous System have failed satisfactorily to account.

JOHN JACKSON.

10, RED LION SQUARE, LONDON.
April 22*nd*, 1842.

CONTENTS.

ON

EPILEPSY; THE SPLEEN;

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&c.

THERE is, perhaps, no disease to which humanity is liable that has attracted a greater share of attention than Epilepsy. It is of so singular and striking a character, so obscure in its cause, and productive of such serious effects, that it has from time immemorial been the subject of speculation and inquiry. Seldom, however, have researches been less successful in their results; for of all maladies it probably is still the least understood; and, notwithstanding the great number of authors, both ancient and modern, who have written upon the subject of epilepsy, it may yet be doubted whether its nature was more a mystery in the days of Hippocrates, than it is in the nineteenth century.

It does not fall within the province of this inquiry to detail or discuss the opinions which have been already advanced regarding the proximate cause or essential nature of epilepsy; it is, however,

necessary to observe, that none which have been hitherto offered are founded on the basis of experiment, nor account either for the production of the phenomena which are observed during the seizure, or for its subsequent effects.

The great error into which nearly all inquirers seem to have fallen, is, in imagining that the appearances observed after death were the actual causes of the disease: thus we read even in the most recent works on medicine, that epilepsy may be caused by the presence of a tumour or exostosis within the cranium or spine; by cartilaginous or osseous deposits, or thickening of the membranes; by induration or softening of the white substance; or by certain changes in the pituitary or pineal glands. These opinions, however, are entirely subverted by the following facts: firstly, that such lesions are neither invariable, nor general; secondly, that they have been found in persons who have never been affected with epilepsy; and thirdly, that in those cases in which the attacks have not been followed by permanent derangement of the intellect and voluntary movements, even when the patient has died during the seizure, a state of simple engorgement of the cerebral substance, membranes, and sinuses, is all that the most careful dissection has revealed; or, if death has taken place from a casual attack of thoracic or abdominal disease, or from accident, no pathological change whatever has been detected to which the onus of causing the epilepsy could be attributed. "In this disease

(says Dr. Cheyne) we are unable to lay hold of the first link in the morbid catenation, and dissection, instead of affording assistance, rather perplexes us by the multiplicity and diversity of the changes of structure which it discloses."

If, indeed, the most carefully conducted autopsies could have revealed to us the primary and proximate causes of epilepsy, they would have been ascertained ere this. The opportunities afforded for such investigations by the Bicêtre and Salpêtrière hospitals * are immense, and accordingly, Esquirol, Bouchet, Cazauvieilh, &c., have given the details of numerous accurate dissections, which has also been done by the two distinguished German anatomists, the Wenzels; but our continental brethren, although possessing advantages, in many respects, so decidedly superior to our own, are, so far as I have been able to ascertain, just as ignorant upon the matter as ourselves. The former (the French pathologists) were of opinion that there was a great resemblance between insanity and epilepsy; that insanity depended essentially on chronic inflammation of the cineritious, and epilepsy, of the medullary substance of the brain; whereas, the latter (the Wenzels), judging from upwards of twenty elaborate dissections, attributed the production of epilepsy to disease of the sphenoid bone, pineal and pituitary glands, and affirm, that in fifteen cases out of twenty, the brain and cerebellum were unaffected.

* Parisian hospitals for the insane and epileptic.

M. Foville, the author of the article on epilepsy, in the Dictionnaire de Medicine et de Chirurgie (Paris, 1831), states, that anatomy reveals neither the essential cause nor the constant effects of the disease; and that to attempt to discover the cause which has produced the temporary insensibility and convulsions, appears to him as futile as to endeavour to trace in the brain the changes which it undergoes in directing the voluntary movements. M. Andral, in his Lectures (Lancet, No. 502,), says, that "the seat of epilepsy is clearly in the brain, although its origin may exist elsewhere;" and in reply to the question, "Does this disease leave behind it in that organ any invariable traces of its existence? that it certainly does not; and that so far we are completely ignorant of what it is that constitutes the essential pathological character of epilepsy."

Epilepsy is derived from the Greek verb, ἐπιλαμβανω, *I seize*, and has received a great variety of names, mostly indicative of its supposed supernatural origin;* such are, Morbus Sacer, M. Herculeus, M. Demoniacus, &c. It is rather a common affection, and occurs with nearly equal frequency in both sexes. It is most common in early life, least so in

* "L'epilepsie (says M. Foville) a été observée dès la plus haute antiquité. Dans les temps d'ignorance et de superstition, sa forme effrayante, son invasion subite, l'ont fait considerée comme infligée par les courroux des dieux. À Rome les assembleés du forum étaient dissoutes quand un epileptique tombait. La science est aujourd'hui debarrassée de toutes ces superstitions; mais elle n'est pas encore bien avancée dans la connaissance de cette maladie."

advanced age. From the circumstance of children being so frequently attacked by this disease, it has been termed by the French, 'Mal des enfans.'

The following table, shewing the comparative frequency of epilepsy, at different ages, among the females at the Salpêtrière, is extracted from Andral's Lectures, published in the Lancet (No. 502).

				Cases.	
Ages from	1	to	5	18	nine congenital.
	5	.....	10	12	
	10	.....	15	11	
	15	.....	20	10	
	20	.....	25	4	
	25	.....	30	4	
	30	.....	35	1	
	35	.....	40	2	
	40	.....	45	1	
	45	.....	50	2	
	50	.....	55	0	
	55	.....	60	1	
				66	

Thirty-eight were previous to the commencement of the catamenia, and twenty-eight afterwards.

Epilepsy has been divided, since the days of Hippocrates, into idiopathic, in which the cause of the disease is supposed to exist in the brain (pure, or cerebral epilepsy), and sympathetic, in which the cause is supposed to be an *irritation* in some other organ, or part, affecting the brain by *sympathy*. The following have been mentioned by authors as sympathetic epilepsies :—spinal, pulmonary, cardiac, hepatic, stomachic, nervous, or atonic, nervous from

irritation in the course of a nerve, uterine, genital; —also traumatic, inflammatory, rheumatic, metastatic, arthritic, intermittent, cancerous, scrofulous, ricketty, syphilitic, and complicated ! The existence of sympathetic epilepsy was first denied by C. Lepois, who remarks, that it is illogical to attribute an affection of the head to other parts or organs in which there is no appreciable alteration of texture. M. Georget (Dict. des Sciences Med.) expresses a similar opinion, and states that he has never witnessed epilepsy produced by sympathetic influence, although he does not deny the possibility of such occurrence.

The causes of epilepsy have been usually treated of under the three heads of predisposing, exciting, and proximate or essential. The proximate or essential cause is the pathological state which gives rise to the symptoms, or upon which they are immediately dependent ; but this pathological state cannot produce itself; the proximate cause is therefore an effect, and it is the cause of this effect which is to be regarded as the primary cause, or *cause par excellence*, in the production of epilepsy.

There is perhaps, strictly speaking, only one predisposing cause, namely, hereditary predisposition. According to Calmeil, out of 130 epileptics, 99 were descended from healthy parents, and 31 from parents affected either with insanity, epilepsy, mental imbecility, or hysteria. This agrees with the observations of MM. Bouchet and Cazauvieilh, who state, that out of 110 epileptics, 31 were hereditary.

The former observes, that 14 epileptic females had together 58 children, 32 of whom died young and in convulsions; of 26 who lived longer, 14 had neither epilepsy nor any other nervous malady, 7 had various nervous diseases without convulsions, 2 only were epileptic, 2 had simple convulsions, and 1 was hysterical. M. Georget mentions an extraordinary example of the hereditary influence; he states that an epileptic father had eight children, all epileptic, of which number seven died in early life (en bas âge), and the eighth in his eighteenth year.*

Cranial conformation is considered by some writers as a predisposing cause. Epilepsy is frequently, but by no means generally, observed in persons with a low, contracted, and receding forehead, more or less approaching the idiotic; but this peculiarity of the shape of the cranium is owing to arrested growth or imperfect development of the cerebrum, and ought, perhaps, to be regarded rather as an effect than as a predisposing cause of the malady.

That epilepsy is not essentially dependent on, nor necessarily connected with, defective organization, or disease of the cerebrum, producing idiocy, mental imbecility, or insanity, is proved by the fact, that some of the greatest men of ancient and modern times, men alike eminent both for talent and acquirements, have been subject to occasional attacks of this disease.

* It has been stated, but I do not know with what degree of truth, that when epilepsy is hereditary, it is most frequently derived from the father, and hereditary insanity from the mother.

A great number of exciting causes have been mentioned by different authors. The sympathetic epilepsies are merely technical expositions of some of the supposed exciting causes. Dr. Elliotson states, in his Lectures, that "the disease may arise from every sort of irritation in every part of the body." It would indeed be difficult to say to what it has *not* been attributed; for example, M. Andral (Lancet, No. 502) is represented to have said, that "a great majority of cases are known to occur by night, and it would be difficult to decide, whether sleep, or the absence of the sun from the hemisphere, was the actual cause; both, perhaps, contribute to the effect produced!"

The following are considered as the principal exciting causes:—

1. Sudden fear or fright.
2. Inordinate mental emotion; as, anger, grief, anxiety, disappointment, &c.
3. Excessive venery, and masturbation.
4. Suppression of accustomed evacuations, especially the hæmorrhoidal; repelled cutaneous eruptions.
5. Eruptive period of certain exanthematous affections; as, small-pox, measles, scarlet fever.
6. Plethora, or anæmia; excessive blood-letting; hypercatharsis; worms.

Tissot, Esquirol, Georget, and J. Frank, indeed all the best authorities upon the disease, both British and foreign, agree in regarding *Fear* as the most

frequent and important of the exciting causes of epilepsy. M. Georget states (Dict. des Sciences Med.), that fear *produces* the disease in the majority of cases; M. Tissot, that it *renews* the paroxysm most frequently; and J. Frank affirms that out of eighty cases which came under his observation, the disease in sixty had been brought on by fear.

It would be premature in this early stage of the inquiry to treat of the proximate cause or pathological state which gives rise to the symptoms; or of the primary cause. I shall therefore proceed to mention the phenomena which sometimes precede the paroxysm.

The paroxysm is occasionally preceded by certain precursory or admonitory symptoms, sometimes observable by the friends or persons immediately about the patient, and sometimes by the patient himself. These premonitory symptoms are by no means frequent, but M. Georget must, I think, be in error, when he says that they do not occur in more than five or six instances out of a hundred.

The patient may evince certain changes in his disposition, or an oddity in his manner; he may hesitate in his speech, or appear confused; he may be capricious, or morose, or unusually irascible; he may complain of giddiness, of indescribable sensations, or 'curious feels,' of a feeling of fulness, or emptiness of the head; there may be alternate paleness and flushing of countenance, and very commonly a slight swelling of the hands and lividity of the ends of the fingers may be observed; he may

have also various illusions of the senses, that is, he may hear an extraordinary noise, see luminous objects, smell disagreeable odours, or have a singular taste in the mouth, &c.; or lastly, he may feel an acute pain, or have a sensation of numbness, or of warmth, or heat, or cold, or chilliness, or creeping in some part or other; this has been termed the *aura epileptica*, but it, like the others, is merely a false or illusory sensation, and does not occur in the great majority of instances.

These sensations, which the French call "prodrômes" (warnings), may cease and recur at intervals, or precede the fully developed paroxysm. The peculiar giddiness or momentary state of half consciousness, to which epileptics are so liable, is indeed an imperfect seizure, and differs only in degree and duration from the state called catalepsy; it is termed by the French 'vertige epileptique' or 'petit mal,' in contradistinction to the perfect seizure, or 'grand mal.'

The epileptic paroxysm, or perfect seizure, equally sudden in its invasion whether preceded or not by any of the foregoing symptoms, is ushered in by a loud and peculiar cry or scream, and the patient falls senseless to the ground. This state of insensibility continues throughout the paroxysm, and is so complete that the most powerful impressions or stimulants, as pungent odours, pinching, burning, &c., fail to produce the least sign of consciousness. After a brief period of muscular quiescence, or relaxation, there is next observed a state of tetanic

rigidity of the neck, trunk, and limbs, which is also usually of short duration, being quickly succeeded by powerful convulsions of the whole muscular system; occasionally, however, one side of the body is more convulsed than the opposite. The eyes roll, or are fixed, and there is an unnatural, and sometimes hideous, strabismus; the pupils may be either dilated or contracted, but are motionless. The mouth is drawn to one side, and there is gnashing and grating of the teeth, by which the tongue is often bitten, and the teeth broken.* The distortion of the features is ever varying, according to the alternate contraction and relaxation of the different facial muscles. The upper extremities are usually more convulsed than the lower; and the hands are clenched and the thumbs flexed and thrust into the palms. There is also foaming at the mouth, the face, the neck, and hands become swollen, the jugular veins are excessively distended, and the countenance, more especially the lips, and also the fingers, are violaceous or livid. The respiratory function is very imperfectly performed, or is altogether arrested, the patient as it were holding his breath, and as Dr. Reid observes, "if the abdomen be forcibly compressed, a very peculiar flapping of the diaphragm is felt," which indicates that this muscle is equally convulsed with the rest of the muscular system. There is also intermission, or greatly en-

* Van Swieten relates an instance in which the lower jaw was dislocated in a violent epileptic attack.

feebled action, and irregularity of the pulse.* In addition to these symptoms there is often expulsion of the urine and fæces, and sometimes emissio seminis. Such are the ordinary symptoms of an epileptic paroxysm, which may endure less than a minute, or may be prolonged to five or six minutes. The mean duration, according to Georget, is from two to three minutes. The muscles then relax, and the convulsive movements are at an end; the lividity and turgescence vanish, and are succeeded by paleness; the patient draws a deep sigh, breaks out into a sweat, is still unconscious, motionless, and appears in a kind of lethargic sleep, or sopor, which may last from five minutes to half an hour. He then regains the power of voluntary motion, and consciousness, but has no recollection of what has passed during the paroxysm.

For an indefinite period subsequently, the patient appears drowsy, is averse to moving about, answers questions in a confused manner, feels fatigued, and complains of more or less pain in the head and limbs; and is perhaps affected with nausea or vomiting. In some instances, when the paroxysm has been very violent, or there has been a succession of paroxysms with short intervals, a partial and tem-

* "It will be found on careful attention, that the first symptom of an attack is the suspension of the action of the heart, and consequently an intermission of the pulse, which may continue from a few seconds to about three minutes, which was the longest period of intermission I have as yet known."—On the Pathology of Epilepsy, by Dr. Reid, p. 361, Vol. iv., of the Transactions of the King and Queen's College of Physicians, in Ireland.

porary paralysis, some degree of mental aberration, or even mania, supervenes.

Death, during the paroxysm, is not of infrequent occurrence, especially amongst children; when this takes place, the intervals between the respiratory acts are extremely prolonged.

The symptoms of an epileptic paroxysm bear a close resemblance to those observed in asphyxia from suspension. When a criminal is executed, or an animal is hung, the following phenomena are produced :—unconsciousness—convulsions, chiefly of the face and upper extremities—turgescence and lividity of countenance—relaxation of sphincters—seminal emission—and death. Precisely the same group of symptoms, therefore, as occur in a fatal epileptic paroxysm. But suppose that a person attempts suicide by suspension, and is only *half* hung, —that he is cut down before life is extinct, and recovers,—the analogy still holds; he has no recollection of having suffered during the suspension. The following quotation is from Dr. Elliotson's Lectures: "Although the individual may struggle, and although he may be all but dead, and may hang so long as to be insensible, it does not appear that there is any suffering. There is an account in Lord Bacon's Works, of a person who was hung and all but killed, and yet he did not suffer. There is a short account written by * * *, the poet, from which it appears that he three times attempted to commit suicide, and one of these attempts was by suspension. He there mentions that he suspended

himself over his chamber door in the Temple, and became insensible. He only recollected a flash of light appearing before his eyes. His weight at last caused him to drop on the floor, where he was found, and after a short time he recovered. He says that although he was thus in the jaws of death, and had become perfectly insensible, yet he had no previous suffering."

Observing the analogy between asphyxia from suspension (which I suppose does not differ from the other asphyxiæ except in the mode of its production) and the epileptic paroxysm, that they are attended by a similar train of phenomena or symptoms, I was led to suspect that the pathological state which gives rise to them might be the same in both instances; and which state I conceived (although erroneously) to be that of simple cerebral congestion, outward evidence of the existence of which, during, but more particularly towards the termination of the epileptic paroxysm, is afforded by the lividity and turgescence of the face and hands. I determined, therefore, to ascertain by experiments the real value of simple, yet perfect, cerebral congestion; and to learn whether it is merely a symptom and an effect, or whether it is at all concerned in the production of insensibility and convulsions. Having found that tying the jugular veins on both sides of the neck of a living animal is insufficient, because of the vertebral veins, to produce perfect cerebral congestion, I resolved to place a ligature upon the superior cava, and, with this intention, I

availed myself of the able assistance of Mr. Spooner of the Veterinary College.

Exp. 1. An incision was made through the cartilages of two ribs on the right side of a dog, immediately behind the scapula, the anterior extremities being drawn forward by an assistant; the integuments, intercostal muscles, and pleura costalis, connecting them with the adjacent ribs, anteriorly and posteriorly, were then divided to a considerable extent in the direction of the spine, and thus a large opening was made into the cavity of the chest: the hæmorrhage was not very considerable, the intercostal vessels only having been divided, and a ligature was quickly, and with but little difficulty, applied upon the superior cava above the vena azygos, which in dogs terminates in that vessel just as it is about to enter the auricle. The two ribs were then replaced, and the wound closed by sutures. Upon the application of the ligature there rapidly ensued great lividity and turgescence of the tongue and mucous lining of the mouth, which was attended by perfect insensibility, as was proved by pricking the nose and feet, but no convulsions occurred. After the lapse of a few minutes, the turgidity and lividity of the tongue and mucous membrane had diminished, although it was still considerable. The cords by which he was fastened were then removed, and to the astonishment of all present he got upon his legs, shook himself, and, without much apparent difficulty, walked to the other end of the room, where he lay down. After the cava had been tied a full

quarter of an hour, he was evidently much less insensible, and appeared, indeed, to be gradually recovering from the immediate effects of the operation. I even began to suspect that the ligature had become loosened; and, as the object in view was not to ascertain how long a dog could live after having a ligature placed on the superior cava, but what immediate consequences would result from simple yet perfect cerebral congestion, about a drachm of hydrocyanic acid was administered, which was speedily fatal; and, on re-opening the chest, I satisfied myself that the ligature still remained perfect.

The result of this experiment, although only in part what I had anticipated, was important, inasmuch as it proved that cerebral congestion is productive of insensibility, but not of convulsions. As the turgidity and lividity of the tongue and mucous membrane, and also the insensibility, had become less shortly after the operation than they were immediately after it, I inferred that the cerebral congestion had also diminished, which I accounted for by the communications of the lateral sinuses and jugular veins with the vertebral veins, of the vertebral veins with the vertebral sinuses, and of the latter with the intercostal veins, branches of the *vena azygos*; and that by these venous anastomoses, the blood from the distended cerebral sinuses found its way through the medium of the vena azygos into the auricle.

As *insensibility* was the consequence of *cerebral* congestion, it occurred to me that *convulsions* might

probably be produced by *spinal* congestion; and therefore I determined, in the next experiment, to tie the vena azygos as well as the superior cava. It is here necessary to remind the reader of a fact the importance of which has not been duly appreciated, namely, that all the blood from the vertebral sinuses enters the right auricle by the superior cava, with the following trifling exception:—the blood which is supplied to the cauda equina and lower part of the spinal membranes by the two inferior lumbar arteries, and the arteriæ sacræ laterales, is returned by corresponding veins to the inferior cava; but even the inferior lumbar veins communicate with the superior lumbar, and the latter with the radicles of the vena azygos. The vena azygos usually communicates on the right side with the inferior cava, and on the left side with the renal vein, and returns at least three-fourths of the blood from the vertebral sinuses; and, with the exception just pointed out, the remainder enters the subclavians by the two vertebral veins.

Exp. 2. On the following day, the chest of a dog was opened in the same manner as in the preceding experiment, and one ligature placed around the vena azygos, and another under the superior cava, the latter being tied directly after the former. Insensibility the most complete, accompanied by strong tetanic convulsions of the whole muscular system, immediately ensued; and there was also, as in the first experiment, great lividity and turgescence of the mucous membrane of the tongue, lips, and

mouth; and these symptoms (the insensibility and convulsions, as well as the lividity and turgescence) continued until the animal's death, which quickly followed; but not until after we had closed, by two or three sutures through the integuments, the opening which had been made into the cavity of the chest.

Exp. 3. The last experiment was repeated, but with no observable difference in the effects which were produced.

The three preceding experiments, it is thought, will justify the following inferences :—

1. That cerebral congestion gives rise to insensibility, and spinal congestion to convulsions.*

2. As the presence of cerebro-spinal congestion in the epileptic paroxysm is denoted by the lividity and turgescence of the face and hands; and as insensibility and convulsions are the two essential symptoms of the paroxysm,—that cerebro-spinal congestion is the pathological state or proximate cause which gives rise to those symptoms.

3. That the primary cause, the cause *par excellence*, or primum mobile of the epileptic seizure, is necessarily a *something* which is capable of rapidly inducing cerebro-spinal congestion.

In the second proposition it is stated, that livi-

* It must be borne in mind that the anterior columns of the spinal cord are the motor columns, and that the vertebral sinuses are in front of the theca vertebralis; and, also, that each spinal nerve in passing through the corresponding intervertebral foramen is closely embraced by a plexus of veins.

dity and turgescence of the face and hands are evidences of the existence of cerebro-spinal congestion during the paroxysm; they are, however, usually regarded as signs merely of cerebral congestion, and as they are not observed at the commencement of the paroxysm, and are most marked just before it terminates, it has been inferred that congestion (by which cerebral congestion only is meant) cannot be the cause of the symptoms, namely, insensibility and convulsions, inasmuch as these symptoms commence before it is supposed the congestion is produced. But, in the first place, it is incorrect to regard lividity and turgescence as indications of cerebral congestion *only;* it being manifest, that whatever the cause may be which prevents in the epileptic paroxysm the return of blood from the head and arms, must also necessarily prevent its return from the spinal cord; in other words, that if the venous current in the subclavian, jugular, and vertebral veins, and cerebral sinuses, be arrested, it must also be arrested in the vena azygos and vertebral sinuses: and, secondly, it is erroneous to suppose that the congestion does not commence before its existence is denoted by the outward signs of lividity and turgescence, because the former can be almost instantaneously produced, whereas the latter require a certain time for their development.

To cerebro-spinal congestion, therefore, is assigned the production of the symptoms; it is consequently to be regarded as the *proximate* cause. The next question is: What is it which in epilepsy can give

rise to cerebro-spinal congestion? or what is the nature of the *primary* cause?—It has already been observed that in epilepsy the seizure is sudden, and that it is commonly of only two or three minutes' duration; the congestion therefore, to arrive at its height and to terminate in so short a space of time, *must* be dependent upon some cause preventing during that brief period the return of the venous blood from the brain and spinal cord simultaneously. Now what is there that is capable of producing this effect? It cannot be any thing *above* the opening of the vena azygos into the superior cava, or the congestion would be merely cerebral, and not cerebro-spinal; it must therefore be *below*.

It is evident that the superior cava cannot oppose the return of blood from the brain and spinal cord; we must therefore descend to the right auricle; and here we find no malformation, no change of structure, nor indeed any physical cause capable of arresting the current which enters it by the superior cava. But in epilepsy this arrest *does* take place, and consequently some cause, near or remote, must prevent ingress by that venous trunk into the auricle; for, if the blood have free and constant admission from the former into the latter, there can obviously be no cerebro-spinal congestion.

There are, I conceive, at least two ways in which the ingress of blood into the auricle from the superior cava may be suddenly prevented, and cerebro-spinal congestion consequently induced. Firstly, blood being returned to the heart of a *quality* more

or less incapable of stimulating its right cavities, and which the ventricle therefore refuses to propel or very imperfectly propels, through the lungs; the immediate effect of which necessarily is, that distension more or less excessive of the right cavities is produced, and the further ingress of blood from both venæ cavæ either greatly impeded, or altogether denied: and secondly, the *quantity* of blood supplied to, and the force with which it enters the auricle by the *inferior* auricular opening, being suddenly and temporarily augmented by a force greater than that with which the blood descends into that cavity from the superior cava; and which sudden and temporary augmentation can only be effected by an inordinate rush of blood from the hepatic veins: then, in this case as in the former, the right cavities, but more especially the auricle, would suffer undue distension, ingress by the superior cava would be prevented, and cerebro-spinal congestion would ensue, and endure so long as the rush into the auricle from the hepatic veins continued. But what is there to cause an inordinate rush of blood into the auricle from the hepatic veins? In order to answer this question it will be necessary to consider, first the vessels themselves; and secondly, to ascertain the nature of that *power* by which the blood is propelled through them to the inferior cava and auricle.

The hepatic veins consist of two or three large veins, called from their size venæ *cavæ* hepaticæ,*

* There are two injected preparations in the Museum of the Royal College of Surgeons, Nos. 18 and 19 of Part vi., which

which open into the inferior cava, just before it penetrates the diaphragm, and six or seven smaller ones, which open into that vessel before the terminations of the larger veins. These veins return the blood from the liver, and not being surrounded by a loose cellular envelope like the trunk and branches of the portal vein, but firmly connected with the substance of the organ, they are simple canals, always of the same calibre, and therefore must always contain the same quantity of blood.

The radicles of the hepatic veins commence in the centre of each lobule, and communicate with the portal plexuses, but not with the minute branches of the hepatic artery, nor the biliary ducts; and, as the hepatic veins are mere canals and destitute of valves, it is impossible for them to act upon their venous contents in any way; they have neither the power to oppose nor to assist, and as they communicate with only one set of vessels in the liver, the minute divisions or plexuses of the portal vein, it is to this vessel necessarily that we must look for the power which propels the blood through the hepatics.

The roots, trunk, and branches of the portal vein are also destitute of valves, but this vessel differs from the hepatic veins by being surrounded, from the commencement of the trunk to the terminations of the branches in the portal plexuses, by a loose cellular tissue, which accompanies it from, and is a prolongation of, Glisson's capsule; and by this

give a correct idea of the *relative* magnitude of the hepatic veins, and the superior and inferior venæ cavæ.

peculiarity the portal trunk and branches are especially adapted to contain more or less blood; as it allows either of their distension or collapse in proportion to the varying quantity of their contents. It is, however, evident, that each of the three divisions of the portal vein is as incapable as the hepatic veins of rendering any active assistance in the propulsion of the venous blood.

The portal vein conveys to the liver the venous blood from the spleen, pancreas, gall-bladder, stomach, and intestines; and which organs are supplied with arterial blood by the cæliac axis, and the superior and inferior mesenteric arteries. We have next, therefore, to turn our attention to these arteries; to consider the size of their trunks and principal branches; the large size and flexuosity of the splenic—the small size of the hepatic—and the arched or tortuous course of those distributed to the stomach and intestines; the frequent divisions, subdivisions, and anastomoses of the latter before they terminate in the extensive capillary network between the mucous and muscular coats; and then we have to inquire: Is the vis à tergo of the heart's action through the cæliac and mesenteric arteries and their several branches, an *adequate* power, not only to propel the blood through their capillary terminations* and the corresponding veins to the

* The capillaries of the splenic artery terminate in the venous plexus of the spleen; those of the hepatic, as Mr. Kiernann has demonstrated, not in the radicles of the hepatic veins, but in the plexuses of the portal vein.

point where they unite to form the portal trunk ; but also, through the trunk of the portal vein, through its divisions and subdivisions in the liver, through another extensive capillary system, the portal plexuses ; and then through the radicles, branches, and trunks of the hepatic veins, to the inferior cava and auricle? and this (in the erect posture at least), in direct opposition to the influence of gravitation, and without the assistance of valves? Müller (see Baly's Trans. p. 234) says, that "in all the vertebrate animals, the vis à tergo of the heart's action *is* sufficient to propel the blood through the liver after it has already circulated through the capillaries of the other abdominal viscera:" and this, indeed, is the opinion which has been held unquestioned since the discovery of the circulation ; but, notwithstanding its antiquity, it is (as further examination will demonstrate) both unsupported by probability, and unfounded in truth.*

As we do not observe in any other part of the economy the vis à tergo of one set of arteries propelling the blood through two venous and two capillary systems, we might (if so strange an anomaly did really occur) expect to find the cæliac and

* "The capillary circulation, that is to say, the passage of the blood through the capillary vessels, is of all the parts of the circulation that which, without being independent of the action of the heart, is yet less subjected to it. It is the point of the circulation at which the motion of the blood is the slowest ; and at which the blood, divided into minute threads, has the most points of contact with the walls of the vessels."—Béclard, Trans. by Dr. Knox, p. 177.

mesenteric arteries and their branches so disposed, that the blood in passing through them should meet with the least possible resistance, and thus any great diminution or expenditure of the vis à tergo be prevented. But does any such favourable disposition of these vessels exist? On the contrary, their numerous flexuosities and anastomoses render them of all vessels (with the exception, perhaps, of those supplying the brain) the most calculated to retard and impede the arterial current. Again, after the blood has been propelled through the first capillary system into the radicles of the portal vein, instead of its ascent through the three divisions of that vein being *more* facilitated and assisted than any other ascending venous current, which (as the portal blood has to overcome the resistance offered by a second capillary system, the portal plexuses) we might reasonably suppose would be the case, we find that it is *less* so; for its ascent is not favoured, as in other parts, by muscular contraction, nor is its descent prevented by valves.

If we consider the arteries of the lower extremities, and contrast them with those supplying the stomach and intestines, we remark that the former are nearly straight, whereas the latter, as we have before remarked, are disposed in arches which anastomose freely one with another. The vis à tergo in the iliac, femoral, tibial, and peroneal arteries, undergoes the least possible diminution of power, being lessened neither by sudden changes in the course of the vessels, nor by large and frequent

inosculations, and the blood returned by the corresponding veins is greatly assisted in its ascent by muscular contractions, and its descent prevented by valves: but notwithstanding this disposition of the vessels of the lower extremities, *varicose veins* are of common occurrence, and among those persons chiefly whose occupations compel them to stand daily for many hours; and this condition of the veins is produced by the operation of two causes: first, the constantly opposing influence of gravitation upon the ascent of the venous current; and secondly, the non-agency of muscular contraction. If, then, without the assistance afforded by muscular contraction, the vis à tergo in the arteries of the lower extremities has a difficulty in propelling the blood through the corresponding veins after it has passed through a single capillary system, and that vis à tergo neither lessened by flexuosities nor anastomoses,—is it reasonable to suppose that the vis à tergo in the cæliac and mesenteric arteries, after suffering a great necessary diminution from the tortuosity and frequent inosculations of the numerous branches of those arteries, is a *sufficient* power to propel the blood, without the assistance of valves, without the agency of muscular contraction, and in direct opposition to the influence of gravitation, through *two* venous and *two* capillary systems?

We have observed that from the construction of the hepatic veins, they must always contain the same quantity of blood; but we cannot thence infer that the velocity of the blood's progress through those

veins is also unvarying; on the contrary, it is certain that it does vary, and for the following reason:—The blood in the hepatic veins is acted upon through the medium of the blood in the portal vein, and the latter is expressly adapted to contain much or little; now when there is but little blood in the trunk and branches of the portal vein, it cannot be so propelled as to have an equal effect in the propulsion of the never-varying quantity contained in the hepatic veins as when the former are distended; indeed, it is more than probable that a certain distension of the portal trunk and branches must be produced before the blood in the hepatic veins can be moved at all. We are then, I think, justified in drawing the following inference, that the velocity only with which the blood is propelled through the hepatic veins can vary, but in the portal vein, i. e. the portal trunk and branches, both the velocity and quantity:—this leads to the further inference, that a regulating as well as propelling power is required: for the due performance of so important a function there should be an organ; and there is; an organ to which the real function has not hitherto been ascribed, and that organ is the SPLEEN. It is the spleen which propels the portal blood through the portal trunk, branches, plexuses, and hepatic veins, to the inferior cava and auricle, and regulates the quantity and force with which it is propelled.

That such is the *function* of the spleen,—that it assists in the return of the venous blood,—and that it is therefore to be regarded as an ASSISTANT CIR-

CULATORY ORGAN, will be attempted to be proved in the course of the succeeding pages: it may be well, however, to premise, that the opinion is grounded upon a consideration of the following circumstances :—

1. That for the reasons already specified, the vis à tergo of the heart's action appears to be inadequate duly to propel the blood through two venous and two capillary systems, and that an additional power is therefore required for its propulsion through the second venous and capillary system — the portal trunk, branches, plexuses, and hepatic veins.
2. That the spleen, by its structure, properties, and position,—and by its connection with the trunk of the portal system by the splenic vein, is eminently adapted for the performance of such function.
3. Because there is another organ, the function of which is analogous, and the texture of which bears the closest possible resemblance to that of the spleen.
4. Because much more venous blood is returned to the heart by the hepatic veins than there is arterial blood supplied to the digestive organs by the cæliac and mesenteric arteries.
5. Because the spleen is relatively much larger in man than in the quadruped; a greater power being needed for the propulsion of

blood through a venous system, the direction of which is vertical, than through one the direction of which is horizontal.

That the vis à tergo of the heart's action is not adequate *per se* to propel the blood through two venous and two capillary systems, and that some additional power is necessarily required for its propulsion through the second venous and capillary system, has perhaps been sufficiently shewn in the preceding observations; we have next, therefore, to consider the situation, structure, and properties of the spleen; a brief and general description of which is, however, all that will be required for the purposes of this inquiry.

The spleen is situated in the posterior part of the left hypochondrium, between the great end of the stomach and the ninth, tenth, and eleventh ribs. It is completely invested by peritoneum, a duplicature of which proceeds from the stomach to the spleen, enclosing between its laminæ the splenic vessels. Under its peritoneal investment is a membranous and highly elastic capsule, from the inner surface of which numerous thread-like and also equally elastic prolongations proceed through the organ to its opposite side, and which by their frequent communications present a reticulated appearance. The spleen is composed entirely of vessels, and of these elastic prolongations from its capsule. It receives the splenic artery, the largest of the three divisions of the cæliac, and which divides into five or six branches before it penetrates the concave

surface of the organ: the ultimate divisions of these branches of the splenic artery are arranged in tufts, and terminate in the great venous plexus, of which the chief bulk of the organ is composed, and from which the splenic vein originates. The veins forming this plexus are remarkable for their large size, tenuity, and extensibility, and for their free communications with each other in every possible direction, by numerous large lateral orifices: hence the cellular, spongy appearance of the cut surface of an inflated spleen, and its resemblance in texture to the corpora cavernosa penis. This similarity, together with the following circumstances, namely, that in the living animal the spleen varies considerably in size at different times, and that it becomes greatly distended when the splenic vein is compressed or tied, and quickly returns to its former dimensions when the compression is remitted or the ligature removed, has given rise to the observation, that in "texture and phenomena the spleen bears a close resemblance to the erectile organs."—(Béclard.)

The splenic vein is nearly five times the size of the splenic artery, and is joined behind the pancreas by the great mesenteric vein, this junction forming the trunk of the vena portæ, the area of which is much less than the combined area of the two veins by which it is formed. The spleen is therefore connected by means of the splenic vein with the origin of the portal trunk; is placed at the very commencement of the second or additional venous system; is possessed of highly elastic and contractile

properties; has no excretory duct; and is in man an organ of about one-sixth of the weight of the liver, and in quadrupeds, only one-twelfth, one-fourteenth, or even one-sixteenth.

Magendie, Précis Elémentaire de Physiologie, tome 2, p. 408, makes the following observations :— "Sur les animaux vivants, les dimensions de plusieurs organes peuvent être augmentées à volonté. Prenez, par example, les trois dimensions de la rate d'un chien, puis, l'abdomen étant ouvert, injectez une pinte de sang d'un autre chien dans ses veines, vous verrez la rate grandir graduellement, et avoir acquis, à la fin de l'injection, un tiers ou une moitié en sus de ses dimensions premieres.—Faites l'expérience opposée : après avoir mesuré la grandeur de la rate d'un animal, saignez-le jusqu'à défaillance, et vous verrez la rate diminuer sensiblement de volume à mesure que le sang s'ecoulera. Des observations analogues peuvent être faites sur le foie, mais comme le tissu de cet organe est moins extensible que celui de la rate, les changements de volume sont moins marqués." * * * "Ce que vient d'être dit sur les dimensions de la rate, par rapport au volume du sang, est de nature à jeter quelque lumière sur *les fonctions* de ce singulier organe. D'après ce que nous avons dit, la rate est un véritable réservoir à parois élastiques, qui presse incessament sur le sang qu'il contient, et qui tend à le faire passer dans le système de la veine porte. Le peu d'épaisseur et d'elasticité des parois de cette veine, l'absence des valvules à son intérieur, doivent permettre facile-

ment au sang pressé par la rate d'y pénetrér. La rate doit d'autant plus facilement expulser le sang qu'elle contient, que non-seulement elle est très élastique, et tend ainsi physiquement à revenir sur elle-même, mais qu'en outre elle est douée d'une force contractile d'une genre particulier, et qui se met en évidence sous l'influence de certaines substances, la noix vomique, par exemple."

From the preceding quotation it appears that Magendie was of opinion, that the spleen, by its elasticity and peculiar contractile power, assists in propelling the blood along the trunk and branches of the portal vein; but he would not have confined himself to this single observation had he been aware of the importance of his opinion, and had he not supposed that this was merely a subordinate, and not its chief, use; indeed the expression "les fonctions" is sufficient to prove that he did not regard the spleen as an assistant circulatory organ, simply. The little importance which has been attached by others to this remark of Magendie's is shewn by the fact that it is passed over unnoticed in all the subsequent systematic treatises on physiology.

The resemblance of the spleen in "texture and phenomena to the erectile organs" is certainly remarkable; but it has a stronger and more important resemblance to another organ, namely, the Placenta, in structure, in properties, and also, as will be attempted to be proved, in function, and in disease, which it is singular should have hitherto escaped observation. Take a spleen in one hand, and

a small and contracted placenta* in the other, and the outward similarity between the two will not fail forcibly to strike the observer. The circumference of both is more or less lobulated, or fissured; the spleen is enveloped by an elastic capsule—the placenta is enclosed between the two layers of an elastic membrane, the decidua; both organs present a spongy and reticulated texture, consisting almost wholly of vessels, and chiefly of veins; "nervi lieni paucissimi sunt et minimi," observes Haller, and the same remark is applicable to the placenta, in which, however, the existence of nerves is usually denied;† both organs are possessed of a peculiar contractile power.

The similarity of the spleen and the placenta is most striking after they have undergone maceration, and their texture been unravelled; they then present a cellular and flocculent appearance, and so close is their resemblance to each other, that if it were not

* When only one ligature is placed upon the umbilical cord before dividing the latter (as recommended by Smellie and Dewees), the placenta becomes emptied of its contents almost completely, partly by its own contractility, and partly by the subsequent contractions of the uterus, and the consequent compression to which it is subjected in passing through the cervix and os uteri; it is then upon inspection only half, or even one-third, the size which it is when two ligatures are employed, and when consequently it is allowed to become gorged with blood, almost to rupture, previously to expulsion.

† "Sir E. Home and M. Bauer believed they had detected nerves in the placenta by the aid of a strong magnifying power; and this is also the opinion of Chaussier."— Ramsbotham's Obstetric Medicine, p. 91.

for some difference in size and shape it would be difficult to distinguish between them.*

Whether or not it be conceded that the spleen is the organ which subsequently to birth propels the blood through the portal plexuses and the hepatic veins to the inferior cava and right auricle, regulating its quantity, and also the force with which it is propelled, I presume there are none who will be disposed to deny that the placenta performs that function in the fœtus: and as before birth the umbilical vein conveys the blood in which is contained the *materiel* for the nutrition and growth of the fœtus, which blood is propelled by the placenta through the capillaries of the fœtal liver to the right auricle, so subsequently to birth the portal vein conveys the blood returning from the digestive tube diluted with the fluids taken up by venous absorption, and which is propelled through the portal plexuses and hepatic veins to the auricle by the spleen. To add another argument, therefore, to those which have already been adduced in support of the opinion that the vis à tergo is inadequate to propel the blood through two venous and two capillary systems, and that some additional power is necessarily required for its propulsion through the second system of venous and capillary vessels, it may be observed, *that much more venous blood is returned to the heart by the hepatic veins, than there is arterial blood sup-*

* There are two preparations of this kind in the Museum of St. Bartholomew's Hospital, which display the remarkable similarity of texture of these two organs.

plied to the digestive organs by the cæliac and mesenteric arteries. If, therefore, the spleen be *not* an assistant circulatory organ, the vis à tergo, per the cæliac and mesenteric arteries, propels, not merely the blood which those arteries receive, through a single capillary and venous system, but also (notwithstanding the many disadvantages which have been already pointed out) propels with, and in addition to, that blood, *all the fluid which enters the digestive tube by food or drink through the second system of venous and capillary vessels;* i. e. through the portal trunk, branches, plexuses, and hepatic veins, to the inferior cava and auricle.

The ultimate divisions of the umbilical arteries terminate in the fœtal portion of the placenta in the venous plexus forming the umbilical vein, in like manner as the ultimate divisions of the splenic artery terminate in the venous plexus which forms the splenic vein; but in neither instance does the vis à tergo by these arteries afford any assistance in the propulsion of the blood through their corresponding veins. That the placenta, at least, is alone adequate to effect this propulsion is proved by the circumstance of acephalous and other fœtal monsters being commonly acardiac.

Before birth the liver is large—very large in comparison with other organs, and the spleen is small, and its artery smaller than the hepatic; after birth the splenic artery becomes larger than the hepatic: if we bear in mind the inverted position of the fœtus in utero, and also the two terminations of the umbi-

lical vein, we shall have no difficulty in understanding why the fœtal spleen is so small; its function of propelling the portal blood through the capillaries of the liver only commences after birth, that function before birth being performed by the placenta.

Having remarked the similarity in the external appearance and internal organization of the spleen and the placenta; that the latter and the umbilical vein perform previously to birth the function of the former and the portal vein; and that the spleen, and therefore the placenta, in texture and phenomena bear a remarkable resemblance to the erectile organs, the most important of which is the penis; and having moreover observed that the spleen and the placenta, in addition to their elasticity, possess a peculiar contractile power, by which power both are enabled to propel the blood through the capillaries of the liver and the hepatic veins to the right auricle; we are now prepared to expect that this *contractility* alike possessed by each of these organs, the penis, spleen, and placenta, will be excited by the same agencies, whether of a moral or physical nature.

Fear, or fright, it has already been observed, is regarded as by far the most frequent exciting cause of epilepsy; and it is also a very powerful agent in exciting the contractility of these organs. No physiological remarks, it is presumed, will be needed to prove its influence upon the contractility of the penis; some observations are, however, required to

shew that it is capable of exerting a similar influence upon the contractility both of the spleen and the placenta.

Fear is the most common exciting cause of abortion as well as of epilepsy; and it may here be remarked, that the exciting causes of these two diseases, or, as they ought rather to be considered, *medical accidents*, are, in general, the same. When abortion is induced by fright, or from the administration of ergot (the former the most frequent, and the latter one of the most powerful of its exciting causes), it is supposed in either case to be the effect of some direct or specific influence upon the uterus. It is probable, however, that neither exerts any direct or specific influence upon this organ, but upon the placenta; that their effect is to excite the contractility of the latter, and that it is contraction of the placenta, either natural or induced by artificial means, which, whether in abortion, premature labour, or parturition at the full period, invariably gives rise to, and is the appropriate stimulus of, uterine contraction.

The heart, to which organ the uterus bears a considerable resemblance in the kind of its muscular texture, is excited to contract by an internal and appropriate stimulus, a moving and vital fluid; and therefore the uterus, which like the heart is a hollow muscle, is probably also excited by an appropriate, internal, moving, and vital stimulus, a contracting placenta—the duration, frequency, and power of the uterine contractions being respondent to, and go-

verned by those of the placenta, and are therefore intermittent, or remittent, weak, or powerful.

That fear exerts a depressing influence upon the heart, it is impossible to doubt; can we then admit that the same moral agency which in a measure paralyzes the heart, acts as a direct stimulus to the uterus? Deglutition, the peristaltic motion of the digestive tube, expulsion of the urine, fæces, &c., are all excited by *internal* stimuli. The argument, however, hardly needs the support of analogy, inasmuch as we have positive proof that the most certain and speedy means of exciting contractions of the uterus, is the introduction of an internal and moving stimulus into its cavity. "When the uterus (says Dr. Ramsbotham, see Principles of Obstetric Medicine) is in an uncontracted state after withdrawal of the placenta, the patient is subject to a continuance of the uterine hæmorrhage; but it generally happens that the stimulus of the hand excites uterine contraction, and that the hand and the placenta are expelled together. Should this however not occur (he adds p. 520), we may keep the hand a short space of time within the uterine cavity, and endeavour to ensure contraction by quietly *moving* our fingers, so as to irritate the parietes in some trifling degree." The same author also states that this seldom fails to induce efficient contraction of the uterus.

As it is therefore evident that the most certain and effective method of inducing uterine contraction artificially, is by internal stimulation; as the con-

tractions of the heart, pharynx, œsophagus, &c., are excited by appropriate internal, and indeed moving stimuli,—it would be an extraordinary deduction to conclude that the uterus is an exception to what appears to be a general rule, and that it is not the placenta which excites its contraction. In the ninth volume of the Medico-chirurgical Transactions, a case is recorded in which expulsion of a blighted fœtus, and placenta, occurred at the seventh month of pregnancy, a living child still remaining up to the full period. The fœtus was about the size of a fœtus at the third month; the placenta was perfectly healthy, and natural in appearance, and of the size it usually presents at the seventh month. Now what are we to believe was the stimulus which excited uterine contraction in this case, if it was not a contracting placenta? If it (the uterine contraction) were induced by the mere presence of a dead fœtus, and of a non-contracting, though still living, placenta, why did not their expulsion take place sooner? If the uterus, unsolicited by the placenta in question, took upon itself to contract, why did it cease its action after the separation and expulsion of a part only of its contents, and retain the remainder up to the full period of gestation? and, again, if separation of the placenta be the effect entirely of uterine contraction, and the placenta itself affords no assistance in that separation, how happened it that in this instance the uterine contractions which were adequate to effect the separation of one placenta, did not produce that of both? It is not improbable

that the placenta was here the chief agent in effecting its own separation; but be that as it may, that the placenta is capable of contraction, and of powerful contraction too, is still further indicated by the fact, that the first symptom of abortion is not pain from uterine action, but more or less hæmorrhage from a partial separation of the placenta; which partial separation and consequent hæmorrhage must therefore be attributed to contraction of the placenta itself, and more especially of its maternal portion (which probably possesses more nerves and a greater contractile power than the fœtal portion of the organ); whereas the uterine contractions, by which the separation is completed, and expulsion effected, are only secondary, and excited by its (the placenta's) own previous contractions.

If we admit placental contraction to be the natural and appropriate stimulus of uterine contraction, then we must also admit, that when abortion is induced by fright, ergot, or any other known exciting cause, it is owing to such cause exciting the contractility of the placenta. The influence of fear upon the contractility of the spleen, and the instinctive actions to which that influence gives rise, will occupy our attention at a future stage of the inquiry. That ergot acts upon the contractility of this organ has been observed by Mr. S. Wright, who, in an essay on the physiological action of that substance, published in the Edin. Med. and Surg. Journal, Nos. 141-2, remarks, that when dogs have had small doses of ergot administered to them daily for several

weeks, the spleen is so much reduced in size, that upon examination after death, it is with difficulty found and recognized. There is therefore but little reason to doubt that both fear and ergot exert a precisely similar influence upon the spleen and the placenta, which, considering the close analogy between these two organs in structure, properties, and function, we might *à priori* have been led to expect.

There are, however, several other agents besides fear and ergot which have the power of exciting the contractility of the spleen. The remark was first made by Defermon in the Nouvelle Bibliothèque Medicale for 1828, and has been repeated by Magendie and others, that strychnia, camphor, and muriate of morphia, cause the spleen to contract; and I have observed that hydrocyanic acid has the same effect upon this organ, and in an equally remarkable manner as strychnia.* Whether these poisons exert any similar influence upon the contractility of the placenta, we are at present ignorant; it is, however, probable that their action upon both organs is essentially the same.

It is not a little singular that every one of the above-named and seemingly heterogeneous agents, namely, (1) strychnia, (2) camphor, (3) muriate of

* The spleens of dogs which have been destroyed by any of these poisons, present a striking contrast when compared with the spleens of other dogs which have not perished by the same means. In the former they are contracted to the utmost, and are consequently much smaller and harder than in the ordinary or natural state.

morphia, (4) ergot of rye, and (5) hydrocyanic acid, produces paroxysms of insensibility and convulsions, closely resembling those of epilepsy. Camphor and ergot, it is said, are capable of inducing epilepsy; the paroxysms resulting from nux vomica (strychnia) have been mistaken for those of epilepsy; and the pathological state produced by hydrocyanic acid is believed to be identical with that which gives rise to epilepsy.

The following cases of poisoning by some of these agents, and observations upon the physiological action of others, are introduced to shew the similarity between the effects which each of them produces, and the symptoms of an epileptic paroxysm. What the pathological condition is which gives rise to those effects; whether it be cerebro-spinal congestion consequent upon prevented ingress into the auricle; and whether it be the same as, or different from, the proximate cause of epilepsy, will be subsequently considered.

1. Strychnia. In the London Medical Repository for 1823, p. 448, a case of fatal poisoning by nux vomica is detailed by Mr. Ollier, Surgeon to the Western Dispensary, of which the following is an abridgement:—A young married woman having quarrelled with her husband, took as nearly as could be ascertained about two drachms and a half of nux vomica in water. Forty minutes elapsed before any particular symptoms were produced; she was perfectly sensible and without pain, but seemed in alarm, and entreated her husband not to leave her

(the previous day he had threatened to abandon her); she then threw herself back in the chair, her legs being extended and considerably separated; her pulse was faint and quick, and she called frequently for drink. Two drachms of pulv: Ipecac. were mixed in a tea-cupful of warm water, and a fourth part administered every five minutes; of which three doses were taken, the last with great difficulty: she had also warm water at intervals. Before taking the first dose she had a slight and transient convulsion; great trepidation succeeded, and in a few minutes she had another and more violent attack, and shortly afterwards a third. The duration of these fits was from a minute and a half to two minutes: the pulse and respiration were imperceptible during the paroxysms. Her whole body was straightened and stiffened, and her legs pushed out and forced wide apart; the face and hands were livid; the muscles of the former, especially of the lips, were violently agitated, and she made constantly a moaning, chattering noise. She was not unlike one in an epileptic fit, but that she did not struggle, though, as she was forced straight out, it became difficult to keep her from falling on the floor. During the short intervals of the attacks she was quite sensible; her pulse was quick and faint; she was thirsty, perspired, and made many attempts to vomit. A fourth and most violent attack soon followed, in which the whole body was extended to the utmost, and she was rigidly stiff from head to foot; she then fell into a state of asphyxia, from

which she never recovered, for she never breathed again. She relaxed her grasp ; her discoloured hands dropped upon her knees, and her face too was livid ; the brows were contracted ; the lips wide apart, shewing the whole of the closed teeth, and a salivary foam issued plentifully from the corners of her mouth. The expression of her countenance was at this moment very frightful. In lifting her up to lay her on the bed it was discovered that the urine had been discharged. All this took place in little more than half an hour after Mr. Ollier first saw her. About five hours afterwards she was still straight and stiff, and on the following day the head and trunk were opened ; the joints had then become as pliable as before they were unyielding. The vessels of the pia mater were turgid with blood, and there was an ounce of fluid in the ventricles : there was also a small quantity of bloody fluid in the cavity of each pleura. The heart was pale, flaccid, and empty ; and in the stomach about a pint of brownish fluid was found. There was also a slight but extensive redness of the internal coat,—the surface probably to which the poison had been applied.

A remarkable occurrence, shewing the power of nux vomica in producing paroxysms of insensibility and convulsions not distinguishable from epilepsy, took place at the Lock Hospital, in the year 1835. The then house-surgeon, Mr. Chappell, was sent for to no less than six in-patients, all males, who were seized, within the space of a few hours, with what at the time were considered as genuine epileptic fits.

One of them had two seizures; the rest only one each, and fortunately none of them were fatal: one man, however, bit his tongue very severely. So many cases occurring in such rapid succession could not fail to excite surprise, and inquiry as to the cause of their production. It shortly transpired that all these persons had gonorrhœa, and for which they were taking cubebs. Suspicion naturally fell upon the medicine; and upon inquiry being made at the shop of the herbalist, from whence a supply of the cubebs had been recently procured, it was ascertained to have been ground in a mill in which nux vomica had been ground previously, and that from the carelessness of an assistant the mill had not been properly cleaned. No doubt therefore remained, that a portion of the nux vomica had become mixed with the cubebs, and had given rise to this singular, and fortunately not tragical occurrence.

2. Camphor. The following remarks are extracted from Dr. Pereira's Elements of Materia Medica and Therapeutics :—" Camphor specifically affects the nervous system. Regarding the symptoms of this effect but little difference of opinion prevails. In large doses it causes disorder of the mental faculties, the external senses, and volition; the symptoms being lassitude, giddiness, confusion of ideas, disordered vision, noise in the ears, drowsiness, delirium or stupor, and convulsions. These phenomena, which have been observed in several cases, agree with those noticed in experiments on

brutes.* In its power of causing stupor, camphor agrees with opium, but it differs from the latter in its more frequently causing delirium and convulsions. *Epilepsy has been ascribed to the use of camphor.* In excessive doses it acts as a powerful poison. The best related case is that of M. Alexandre (Exper. Essays, p. 128, 1768), who swallowed two scruples in syrup of roses. In about twenty minutes he experienced lassitude and depression of spirits, with frequent yawnings; at the end of three-quarters of an hour his pulse had fallen from 77 to 67. Soon after he felt giddy, confused, and almost incapable of walking across the room. He became gradually insensible, and in this condition was attacked with violent convulsions and maniacal delirium. From this state he awoke as from a profound sleep; his pulse was 100, and he was able to reply to interrogatories, though he had not completely recovered his recollection. Warm water being administered, he vomited up the greater part of the camphor, which had been swallowed three hours previously; and from this time he gradually recovered."

3. Morphia. "Physiological action of morphia. —When the dose is increased the effects become somewhat alarming. Great cerebral excitement is produced, vision is disordered and obscured, there is singing in the ears, and the patient, *when lying*

* "Three drachms of camphor dissolved in oil and given to a dog, the œsophagus being tied, caused violent convulsions, somewhat analogous to those of epilepsy, followed by insensibility and death."—Ibid. p. 792.

horizontally, experiences sudden convulsive movements, like those produced by the electric shock. When a fatal dose has been swallowed, the stomach sometimes manifests irritation, but this is soon followed by great disorder of the cerebro-spinal system, which ultimately assumes an apoplectic character. The sight becomes dim, excessive weakness is experienced, gradually all consciousness is lost, and coma supervenes, attended usually with contracted though sometimes with dilated pupils, coldness of the surface, frequent and small pulse, hurried stertorous respiration, and *occasionally with convulsions*. Not unfrequently lividity of the skin is observed."—Ibid. vol. 2, p. 1317.

4. Ergot of Rye. In the first part of Mr. Wright's Essay on the physiological action of this substance are some remarks on Spasmodic Ergotism, a disease which has very rarely occurred in this country, but which at different times has devastated whole districts on the continent of Europe. In this disease, which is induced by eating bread containing ergotted grain, but more especially rye, we are informed that the chief symptoms are *convulsions alternating with lethargy*. The following passage is from the first part of Mr. Wright's Essay, published in No. 141 of the Edin. Med. and Surg. Journal:—

"In 1722 Silesia, in 1723 the environs of Berlin, and in 1736 Wurtemberg, in Bohemia, sustained the disastrous effects of ergotism. The symptoms of the first epidemic have been ably described by M. Vater, and those of the latter with equal pre-

cision by J. A. Scrinc, who alone saw five hundred individuals the subjects of its virulence. He describes the disease as commencing with a disagreeable sensation in the feet—a tingling or itching; a violent cardialgia then came on, and the disease ascended to the hands and the head. The pains in a short time subsided, the head became heavy, and vertigo prevailed, the eyes appearing to have a thick mist before them. The patient then complained of extreme heat, which was attended with diaphoresis. The fingers and hands were so spasmodically contracted that no ordinary force could straighten them, and the pain was described as equalling that of luxation. Some of the patients became totally blind, and others had double vision. The memory also failed, the conversation was wild and unintelligible, and the movements staggering and awkward. Some became maniacal, some melancholic, and others comatose. The disease was usually accompanied with opisthotonos, and an abundance of saliva tinged with blood, or coloured greenish-yellow, poured from the mouth. The tongue was frequently so much swollen as to impede articulation. The greater part of those who had *epileptic fits* died, and such as experienced sensations of coldness and rigidity in the limbs consequent upon the subsidence of the itching, had less distension of the hands and feet."

The preceding description of the symptoms of spasmodic ergotism shews that the cerebro-spinal system is more especially subject to the ergotic in-

fluence, and from the last sentence it appears that even "epileptic fits" are very frequent consequences of that influence. But we have still more striking evidence of the power which ergot possesses of producing, I will not say epilepsy, but paroxysms of insensibility and convulsions; and in which paroxysms there are also, as in epilepsy, lividity and turgescence of the face and hands. In No. 151 of the Edin. Med. and Surg. Journal is contained a paper by Dr. Catlett, pointing out some of the injurious effects of this substance when employed in obstetric practice; and among others three cases of *puerperal convulsion* are recorded which were obviously induced by its administration. It is unnecessary to quote these cases: that they were, however, fairly attributable to the deleterious agency of ergot is shewn by the following passage, which I therefore extract:—"In aiding the determination as to how far ergot was truly efficient in the convulsions of these three females, it may not be out of place to hint that seven-eighths of the cases of idiopathic convulsion are considered as occurring in first deliveries, or as taking place in those more especially who have been the subjects of them in their preceding labours, or in cases of twins, and when the uterus is greatly distended from an unusual quantity of the liquor amnii. None of these concomitants were present in any of the three cases that are now cited."

But the deleterious agency of ergot is not limited to the mother, for it has also the power of inducing similar consequences in her offspring. "It has

happened to me" (says Dr. Ramsbotham, op. cit. p. 638), "in four different cases to witness the death of the fœtus a few hours after birth by *convulsions*, postquam partus prematurus inductus fuerat ope solum secalis cornuti. Three of these cases occurred in the children of the same woman, and in all four the medicine had been administered for four or five days in full doses."

5. Hydrocyanic Acid. The following remarks are extracted from Dr. Pereira's Elements of Materia Medica and Therapeutics. "Post mortem appearances of poisoning by hydrocyanic acid.—The venous system is usually gorged with blood, while the arteries are empty: the blood is in many cases fluid, dark, or bluish black, and viscid or oily: *the vessels of the brain and spinal marrow are frequently gorged with blood;* and the cerebral ventricles sometimes contain a serous or sanguineous liquor; the lungs are, in some instances, natural—in others turgid with blood:* the internal lining of the stomach is sometimes red."—P. 244.

Organs affected.—"The parts specifically affected by this acid are the brain and true spinal system. The pain in the head, the insensibility, and the coma, are evidence of the cerebral affection; while the tetanic convulsions depend on the disorder of

* If the body be opened *immediately* after death, the lungs will be found to contain very little blood; but if a certain time be allowed to elapse, the blood escapes from the right cavities of the heart into the lungs; and which then consequently become more or less turgid.—J. J.

the true spinal system. Marx (*die Lehre von d. Giften*, 1er. Bd. 2e. Abt. S. 154) mentions the following experiment performed by Wedemeyer (*Versuche über das Nervensystem*, S. 241, Vers. 7), and which shews the independent action of the acid on the spinal marrow. The spinal cord of a dog was divided between the last dorsal and first lumbar vertebræ, so that the hind legs were completely paralyzed and insensible to mechanical irritants; hydrocyanic acid was then introduced into one of the hind legs; in one minute, symptoms of poisoning commenced, the hind as well as the fore legs were convulsed, and in twelve minutes the animal was dead. The affection of the respiratory and circulatory organs produced by hydrocyanic acid is probably only secondary; that is, is the result of the influence of this agent over those parts of the nervous system from which the respiratory organs and heart derive their nervous power. The insensibility caused by hydrocyanic acid occurs too rapidly, in many cases, to be the result of asphyxia caused by paralysis of the muscles of respiration."

"Condition of the brain and spinal marrow.—The precise pathological condition of the brain and spinal cord of an animal under the influence of hydrocyanic acid cannot be positively determined, and is, therefore, a matter of conjecture. *Whatever it may be, it is probably identical with that which occurs during an epileptic paroxysm, and with that produced by loss of blood*, for the essential symptoms (insensibility and convulsions occurring suddenly) are the

same in all three states, and ammonia has been found to relieve them (see p. 171). Dr. Hall (Lectures on the Nervous System, p. 139) has shewn that the convulsion from hæmorrhage is spinal. Dr. Holst, Professor of Materia Medica in the University of Christiana, in Norway, told me of a case of epilepsy under his care, in which it was observed that the pulse in one arm was always imperceptible during the paroxysm. On a post mortem examination it was discovered that an anomalous distribution of the arteries existed, so that this arm was supplied with blood which had circulated through the brain; hence it would appear, that during the epileptic paroxysm the cerebral circulation was impeded: does this happen in poisoning by hydrocyanic acid?"*

The preceding observations shew that all the poisons in question (and there are some others,) have the power of inducing paroxysms of insensibility and convulsions very similar to epilepsy; and the opinion generally entertained is, that poisons which act upon the cerebro-spinal system, affect that system by a peculiar 'irritation' which they produce on the nerves of the part to which they are directly applied, and which irritation is in some incomprehensible manner conveyed or 'reflected' by the nerves to the ner-

* There must be some inaccuracy in the above statement of Dr. Holst, as to the anomalous distribution of vessels; for how could "the arm be supplied with blood which had circulated through the brain"? Nevertheless, the surmise which Dr. Pereira throws out, reasoning from this supposed fact, is, I believe, an approximation to the truth, as will subsequently appear.

vous centres. But the recent experiments of Mr. Blake prove that this opinion is no longer tenable; and that it is not through the medium of the *nerves*, but the *circulation*, that poisons affect the cerebro-spinal system. The following account of one of Mr. Blake's experiments is extracted from No. 142, p. 45, of the Edin. Med. and Surg. Journal:—

"The abdomen of a dog was laid open; a ligature was passed under the vessels entering the liver, and tied. Three drachms of hydrocyanic acid of Scheele's strength, containing 3·3 per cent. of acid, were introduced into the stomach through an opening made into the parietes. The poison was thus brought into contact with a large surface freely supplied with nerves, at least with those nerves on which poisons are supposed more particularly to produce their impressions. (See Addison and Morgan on Poisons, p. 35.) Under these circumstances, the poison remained in the stomach ten minutes without producing the slightest general effect. The ligature on the vena portæ was then removed, so as to restore the circulation over the viscera. One minute after the removal of the ligature the animal began to experience the effects of the poison. The ligature was again replaced; but before this could be effected, a sufficient quantity of the poison had been absorbed to arrest the respiratory movements, and the animal must have speedily died, had not artificial respiration been had recourse to. After this had been continued eight minutes, the animal had sufficiently recovered to continue the respiratory movements

itself. After a short interval, the ligature from the vena portæ was again removed: the animal was dead in two minutes.—This experiment (Mr. Blake observes) affords a strong proof of the non-action of poisons when merely applied to the extremities of the nerves, for not only did the poison produce no effect before it entered the circulation, but we find the animal recovering from the effects of the poison with three drachms of hydrocyanic acid in its stomach."

In a subsequent contribution to the same Journal (No. 149, p. 417), Mr. Blake says, "It is evident that should the action" (of a poison which affects chiefly the nervous system) "be due to an impression produced on the nerves of the part to which it is directly applied, no appreciable interval should elapse between its application and the appearance of symptoms of its action. *If, on the contrary, a poison affecting the nervous system, only acts when applied directly to the nervous centres,* it is equally evident, that no symptoms of its action should manifest themselves until at least sixteen seconds after its application, this being the shortest period in which blood with which it has been mixed (supposing the poison has been injected into the jugular vein) can be brought into *contact* with any of the nervous centres. The substance I made use of was *strychnia,* as I have found it to act more rapidly than any other poison, not excepting woorara and conia."

Mr. Blake has, beyond question, succeeded in overthrowing the opinion of those physiologists who

suppose that the effects of poisons which "act upon the nervous system are due to an impression produced on the nerves of the part to which they are directly applied;" and the opinion which he endeavours to establish in its stead is, that such poisons only produce their effects when they come into *actual contact* with the nervous centres; or, in other words, that the insensibility and tetanic convulsions produced by strychnia (the substance usually employed by him in his experiments) are attributable to the brain and spinal cord being supplied with a poisoned fluid instead of healthy blood. Now this opinion of Mr. Blake's is, I conceive, not less unsatisfactory than its dethroned predecessor; for it does not explain how the insensibility and convulsions are produced, nor why the respiration becomes arrested, nor what is the cause of the turgescence and lividity of the face and hands: but a further, and indeed fatal, objection to it is, that precisely the same group of symptoms occurs in epilepsy, when no poison has been administered. In both cases, however, outward evidence of the existence of cerebro-spinal congestion is afforded us by the lividity and turgescence of the face and hands; and which congestion, we have already seen, is alone adequate to the production of insensibility and convulsions.

When a dog is destroyed by strychnia, hydrocyanic acid, or probably by any other poison which kills by producing insensibility and tetanic convulsions (of which latter the arrested respiration is only a part), and is examined immediately after death, we

have then inward evidence afforded us of the existence of cerebro-spinal congestion, by the right cavities of the heart and the venæ cavæ (and, consequently, the jugular and vertebral veins, and cerebral sinuses—the vena azygos, intercostal veins, and vertebral sinuses) being found enormously distended; whereas the lungs are exsanguine and contracted; and although the left cavities of the heart may contain either a small or considerable quantity of blood, the large arteries are always comparatively empty.

But these post mortem appearances do more than merely prove the existence of cerebro-spinal congestion. They not only reveal the effect, or pathological condition, or proximate cause (which I maintain cerebro-spinal congestion to be) of the two essential symptoms, namely, insensibility and convulsions, but also the *way* in which that effect, or pathological state, or proximate cause, is produced. The proper stimulus to the right cavities of the heart is venous blood; but if that blood be impregnated with certain poisons, its vitality or stimulating property is destroyed—it is rendered incapable of exciting the efficient contraction of those cavities, and therefore is not propelled by the right ventricle through the lungs (*hence their exsanguine appearance when examined immediately after death*); both auricle and ventricle consequently become excessively distended, the further ingress of blood is denied, its return from the brain and spinal cord is prevented, and cerebro-spinal congestion is produced.

Dr. Pereira (see last quotation from) very justly remarks, that whatever the precise pathological condition of the brain and spinal cord of an animal under the influence of hydrocyanic acid may be, it is probably identical with that which occurs in epilepsy, and with that produced by loss of blood; for the essential symptoms (insensibility and convulsions occurring suddenly) are the same in all three states: and subsequently he observes, reasoning from the supposed fact communicated to him by Dr. Holst, "hence it would appear that during the epileptic paroxysm the cerebral circulation was impeded: does this happen in poisoning by hydrocyanic acid?" and, he might have added, *in articulo mortis* from hæmorrhage. Instead of the *cerebral* circulation being simply *impeded* in the paroxysm consequent on poisoning by hydrocyanic acid—in the epileptic paroxysm—and also in the death-struggle from loss of blood, the *cerebro-spinal* circulation is *arrested;* and to which state of arrest or stagnation is superadded that of congestion, more or less excessive. That cerebro-spinal congestion exists in the paroxysm consequent on poisoning by hydrocyanic acid, and in the epileptic paroxysm, has been already shewn; and there is also, if not positive evidence, every reason to believe, and none to doubt, that it is also produced by excessive loss of blood. That *cerebral* congestion, at least, is so produced, we well know; for, "in animals which have been bled to death" (observes Dr. Abercrombie),* "when all the

* Treatise on the Pathology of the Brain and Spinal Cord, 2nd

other organs of the body have been found completely blanched and drained of blood, the brain has in general presented in this respect its usual appearance; and in some cases, the superficial cerebral veins have even been found in so distended a state, that one writer has proposed the paradox, that animals which have been bled to death die of apoplexy." * Convulsions, however, are not symptomatic of apoplexy, but of epilepsy: and although cerebral congestion only has been observed, that is no proof of the absence of spinal congestion; on the contrary, it materially strengthens the probability of its existence—nay, renders it almost certain; for as the brain and spinal cord are very similarly circumstanced, both as regards their envelopes and vessels, we can hardly conceive it possible that fatal hæmorrhage should produce cerebral congestion, and not at the same time produce spinal congestion in a corresponding ratio; and, as the experiments of tying the superior cava alone, and conjointly with the vena azygos, prove insensibility to be the immediate con-

Edition, p. 301.—" Conjectures in regard to the circulation in the Brain."

* We ought not to infer from this quotation that the pathological condition of the brain produced by fatal hæmorrhage is not always the same, or that cerebral congestion is only its occasional and not invariable consequence. It is manifest, that there is nothing to prevent the venous distension which exists just before death from diminishing after death; and therefore, if a considerable time be allowed to elapse before the dissection is made, and no great venous distension is found, that ought not to be regarded either as proof or indication that such distension has never existed.—J. J.

sequence of cerebral, and convulsions of spinal congestion; and, as insensibility and convulsions are the symptoms produced by fatal hæmorrhage, it is little less than certain that they are the effects of the same proximate cause which gives rise to them in poisoning by hydrocyanic acid, and in the epileptic paroxysm, namely, cerebro-spinal congestion.

The way in which cerebro-spinal congestion is produced by hydrocyanic acid is sufficiently manifest, and has been already pointed out; but the mode of its production by loss of blood is not very apparent. It certainly cannot be owing to the right cavities refusing to propel through the lungs the blood which is returned to them. Stagnation of the circulation through the head and spine (the proximate cause, probably, of the insensibility and muscular relaxation attendant on syncope) no doubt precedes the congestion; the latter being, as the convulsions indicate, nearly the last effect consequent on the loss of blood.

We have now to endeavour to ascertain in what way the cerebro-spinal congestion is produced which gives rise to the insensibility and convulsions of epilepsy. It was formerly observed, that if the quantity of blood supplied to the right auricle, and the force with which it enters it by the inferior auricular opening, were suddenly and temporarily augmented by a force greater than that with which the blood descends into that cavity from the superior cava (and which sudden and temporary augmentation could only be the effect of an inordinate rush of blood from the hepatic veins), the right cavities,

but more especially the auricle, would suffer undue distension, ingress by the superior cava would be prevented, and cerebro-spinal congestion would ensue, and endure so long as the rush into the auricle from the hepatic veins continued. We then considered the peculiarities of the hepatic and portal veins, and the cæliac and mesenteric arteries, from which it was inferred that the vis à tergo of the heart's action is inadequate duly to propel the portal blood through the capillaries of the liver and the hepatic veins to the right auricle; and subsequently, for reasons which it is unnecessary to recapitulate, we assigned to the spleen the power by which that propulsion is effected.

Viewing the spleen, therefore, as the organ by which the portal blood is propelled through the grand percolator, the liver, to the heart; considering the peculiar properties of the spleen,—its elasticity and contractility; considering the immense size of the hepatic veins, and the proximity of their orifices to the auricle,—a rush of blood entering this cavity from these veins, and preventing ingress by the superior cava, no longer appears an impossible, or indeed an improbable, occurrence. The spleen is, no doubt, like all other organs, liable to functional derangement; and what is more probable than that in certain individuals it should suffer undue distension; that then, from the influence of some exciting cause, as fear, or other depressing mental emotion, it should act, or contract, either irregularly, or suddenly and with too great force? that the former

(the irregular action) by *disturbing the equilibrium of ingress* into the auricle, should cause more or less derangement of the cerebro-spinal circulation, and thus give rise to the numerous forms and gradations of that Protean malady, hysteria? that the latter (the sudden and violent action), by *preventing ingress* by the superior cava, should induce cerebro-spinal congestion, and be therefore the *primary* cause of the epileptic paroxysm?

Before we speculate upon the phenomena which take place in the right auricle from the constant ingress into its cavity of two opposing and commingling currents, it is necessary, in the first place, to consider, what are the powers or forces by which the blood is returned to the heart by the two venæ cavæ. To begin with the superior: they are, 1stly, the vis à tergo; 2ndly, in the erect posture, the force of gravitation; 3rdly, inspiration; 4thly, muscular contraction.

It is less certain what are the forces which return the blood to the auricle by the inferior cava (exclusive of the hepatic veins, the blood through which is propelled *entirely* by the spleen); there is, 1stly, the vis à tergo; 2ndly, muscular contraction of the lower limbs. Inspiration, too, is commonly supposed to have the effect of facilitating ingress into the auricle by the inferior as well as by the superior cava. It appears, however, not very comprehensible, indeed to carry with it a contradiction, that inspiration should facilitate the ingress of blood by *both* venæ cavæ; that the same act should increase the

impetus of two conflicting currents; that it should cause *descent* of the one and *ascent* of the other. For one and the same cause to produce two such very opposite effects, the expansion of the chest during inspiration ought to be attended by an active dilatation of the auricle; we have, however, no reason for believing the auricle to be possessed of an active power of dilatation.

Magendie (Précis Elémentaire de Physiologie, tome 2, p. 422), says, that as the chest dilates during inspiration, it attracts the blood of both venæ cavæ, and also "de proche en proche" of the veins which contribute to form these trunks; that, on the other hand, by the contraction of the chest in expiration, the blood is thrown back (refoulé) into the venæ cavæ by the pressure which all the thoracic organs then undergo; and that this influence also extends to the veins which terminate in the two venæ cavæ. He introduced a gum-elastic catheter into the external jugular vein of a living animal, and passed it as far as the superior cava, and even to the auricle itself; and he observes, that during expiration only did the blood flow from the upper extremity of the catheter, while during inspiration it was forcibly drawn towards the heart. He says also that similar effects are produced by introducing a catheter into the femoral vein, and directing it towards the abdomen.

Forcible expiration, he states, increases the force and rapidity of the arterial current (which effect is probably owing to the contraction of the chest pro-

pelling the blood with increased force, and in greater quantity, from the pulmonary veins to the left side of the heart); and he further observes (tome 2, p. 425), that upon tying the femoral vein and then pricking it beneath the ligature, the jet which takes place is sensibly increased by forcible expirations, or during manual compression of the chest; and that this effect is produced by the increased flow of blood through the arteries. Thus we are told, firstly, that inspiration facilitates ingress into the auricle by both venæ cavæ: secondly, that ~~the~~ expiration causes the blood to flow back again into these vessels; and that on introducing a tube towards the heart from the jugular, and also from the femoral vein, it is during expiration only that the blood flows from the upper end of the tube: thirdly, that expiration, from its influence on the arterial current, increases the flow of blood towards the heart by the femoral vein. But, if expiration cause a reflux of the blood to take place from the auricle into the inferior cava, or even if it impede ingress by the latter into the former, how can the same act facilitate ascent into the cava by the femoral vein? It is not easy to reconcile these statements with each other; or to conceive how when ingress into the auricle by the inferior cava is denied, the blood can at the same time ascend by the femoral vein.

There are tolerable grounds for entertaining an opinion the reverse of Magendie's as to the influence of forcible expiration upon the ascending

current, and that instead of opposing it facilitates ingress into the auricle by the inferior cava. Indeed, what is more probable, *primâ facie*, than that the alternate acts of inspiration and expiration should, the one favour descent of blood into the auricle by the superior cava, and the other ascent by the inferior?

Experiments and observation prove, that during inspiration the blood flows with increased rapidity into the auricle by the superior cava; and it is equally certain that expiration has the opposite effect as regards this vessel and its tributary veins: now *forcible* expiration is effected by the contraction of the abdominal muscles, and during this contraction, the inferior cava, until it passes under the pancreas and becomes lodged in the excavation or canal in the posterior part of the liver, must be subjected to more or less pressure against the spine from the intestines:* and inasmuch as it is perfectly certain that in other parts of the body the ordinary effect of muscular contraction is compression of the veins, and a consequent increased rapidity of the venous current, it seems very reasonable to suppose that a similar result takes place here; and therefore that

* Whatever influence this pressure may have upon the capacious trunk of the inferior cava, it can very little, if at all, affect the veins contributing to form the vena portæ; and, as this vessel commences under the pancreas, and then proceeds enclosed within the layers of the lesser omentum to the liver, where it divides and becomes lodged in the transverse fissure, it cannot be at all subjected to pressure from contraction of the abdominal muscles.

forcible expiration facilitates the ascent of the venous blood, and its ingress into the auricle by the inferior cava; to which effect, indeed, the impeded ingress by the superior cava is probably attributable. If it were true that inspiration facilitates ingress by both venæ cavæ, and that forcible expiration has the effect of altogether preventing it, how are the heart and lungs supplied with blood during any long continued and forcible expiratory act—as when playing on certain wind instruments, as the clarionet, French horn, cornet à piston, &c., or during the paroxysms of hooping-cough?

That the muscular contractions of the legs, as in running, or walking up stairs, increase the rapidity of the current ascending by the femoral and iliac veins, and its force of ingress into the auricle by the inferior cava, we can have no doubt; but if ingress into the auricle by the inferior cava be also favoured by inspiration, why the urgent necessity for deep and rapid inspirations during, or immediately after, these exertions of the lower limbs? These inspirations are certainly not required to *facilitate* the ascent, or the entrance of blood into the auricle by the inferior cava, as well as by the superior, because the current ascending by the former is already greatly quickened by the muscular contractions, but, on the contrary, to *oppose* the too great rapidity of ingress into the auricle by the inferior cava, by increasing the force and rapidity of the current descending by the superior; and, what is of still greater moment, these rapid inspirations enable the

blood of the superior cava, and its important tributary veins—azygos, jugulars, and vertebral—to gain admission into the auricle, which would either be impeded, or altogether prevented, if the force of the descending current were not simultaneously increased with that of the ascending.

The superior and inferior cavæ return the blood from all parts of the body, and it is said to enter the auricle by jets. We cannot ascertain the precise force with which the blood enters this cavity by each of these vessels, nor the exact quantity it receives from each; we only know that it must enter in a certain quantity, and with a certain force, and that both vary. Before we attempted to estimate how many ounces or pounds this combined force of ingress may, under ordinary circumstances, be equal to, it would, in the first place, be necessary to have some fixed and certain data, in order to commence our calculation; but these data we do not possess; however, there can be no doubt that less blood is supplied by the superior cava than by the inferior, because the superior cava is smaller than the inferior, and the combined area of the arteries, the blood from which is returned by the former, is less than that of the arteries supplying the abdominal viscera and the inferior extremities.

For the sake of illustration, let us suppose that the blood supplied to the auricle by the two venæ cavæ enters its cavity in a quantity and with a force represented by the figure 7—the inferior cava contributing 4, and the superior 3; and that, under

ordinary circumstances, whatever the precise quantity entering the auricle may be, it is in the proportion of 4 and 3. Now, if from some cause the blood were propelled through the inferior auricular opening with a force and in a quantity equal to 5, and the force of ingress by the superior cava were not at the same time, and in the same ratio, increased, the blood would then enter by the superior auricular opening with a force and in a quantity only of 2; of 6 : 1; and if the force of ingress by the inferior auricular opening were augmented by a force equal to, or greater than, the force of ingress by the superior auricular opening, it is evident that no blood at all could then enter the auricle from the superior cava; and consequently none could enter this vessel from its tributary veins—the vena azygos, the subclavian, jugular, and vertebral veins. The effect of this arrested ingress by the superior cava would be sudden stagnation of the blood in the veins of the head, spine, neck, and arms, which, owing to the arteries continuing to pour their blood into the veins until they became distended, would be speedily followed by excessive venous congestion.

The symptoms observable during an epileptic paroxysm, coupled with the experiments of tying the superior cava and the vena azygos, lead to the inference that the congestion of epilepsy, and also (as was before observed) of the asphyxiæ, is cerebro-spinal and not simply cerebral. In the asphyxiæ the alternate actions of inspiration and expiration are prevented; and as the former renders essential

assistance in facilitating the return of the blood and its ingress into the auricle by the superior cava, the mere circumstance of its interruption is capable of inducing, although not very rapidly, this state of cerebro-spinal congestion. In the asphyxiæ, however, there is always an obvious physical cause for the cessation of the respiratory function; but we cannot for a moment attribute the epileptic paroxysm to interrupted respiration, which is clearly only a consequence, and not a cause of the seizure. Nevertheless, Dr. M. Hall appears to be of opinion that epilepsy is consequent upon interrupted respiration, for in his recent Treatise on the Diseases and Derangements of the Nervous System, he more than once intimates his belief that *tracheotomy* would prevent it. At page 327, he observes, that "a spasmodic affection of the larynx has obviously much to do in this disease, as well as in the crowing inspiration or croup-like convulsion of infants; so much so, indeed, that I doubt whether convulsion could occur without closure of the organ. Convulsion is frequently prevented for hours together, by continuously watching the threatenings of it, and dashing cold water on the face. Now, the action of cold water upon the trifacial nerve effects, by a reflex influence, the opening of the larynx and an act of inspiration, and thus prevents the series of muscular actions, which constitute convulsion; viz. closure of the larynx, forcible efforts of expiration, and general spasmodic contraction of the muscles. It is a singular idea, that tracheotomy would probably prevent the epi-

leptic convulsion." To these observations it may be replied, that closure of the glottis is the consequence of spasm or convulsion of the laryngeal muscles, and that it is erroneous to attribute to convulsion of one set of muscles, the production of convulsions of the muscles of all other parts; for the same proximate cause (cerebro-spinal congestion) which gives rise to the latter, also produces the former. The reason that the glottis is more or less *closed* instead of *widened* during the paroxysm of epilepsy, and also of hydrophobia, is, because the contractor muscles of the rima glottidis, the arytenoideus, the thyro-arytenoidei, and crico-arytenoidei laterales, are more powerful and numerous than the dilators, namely, the crico-thyroid, and crico-arytenoidei postici. A similar explanation may be given of the flexed state of the thumbs, which is so constantly observed in the epileptic paroxysm, and is therefore regarded by some as a characteristic symptom,—namely, the adductor and flexor muscles of the thumb are far more powerful than the abductors and extensors. The reason that respiration is interrupted during the epileptic paroxysm is because its chief agent, the diaphragm, as well as the subordinate muscles concerned in the performance of that function, are equally and similarly affected with the muscles of other parts of the body, and, like them, are first in a state of relaxation, then of tetanic spasm, and lastly of convulsion—in accordance, probably, with the three successive states of stagnation, slight, and excessive congestion of the

veins of the spinal cord, and vertebral sinuses. The difference, therefore, between epilepsy and asphyxia, is, that in the former the cerebro-spinal congestion interrupts the respiratory movements, and is rapidly induced; whereas, in the latter, it (the cerebro-spinal congestion) is slowly and gradually induced, and is the effect of the interrupted respiration.

Not only is the cerebro-spinal congestion of epilepsy rapidly induced, but, as the paroxysms indicate, its duration is short. It begins suddenly, quickly arrives at its height, and its termination is as sudden as its commencement. That it exists during the seizure there can be no doubt. That it is capable of producing the two essential symptoms, and is therefore to be regarded as their proximate cause, has been shewn by experiments; and nothing can be more certain than that it is the effect of some cause suddenly and temporarily preventing ingress into the auricle by the superior cava. Now, this suddenly and temporarily prevented ingress, which takes place in epilepsy, it has been already intimated, is probably owing to the sudden and forcible contraction of an engorged or distended spleen, causing an inordinate rush of blood to enter the heart from the hepatic veins; during which the right cavities have more blood supplied to them through the inferior auricular opening, than the ventricle is able duly to propel through the lungs; the action of the right ventricle consequently becomes embarrassed, and as the contraction of the two ventricles is synchronous, that of the *left* also;

both auricle and ventricle are, as it were, flooded, and suffer undue distension; ingress by the superior cava is prevented, and cerebro-spinal congestion (followed by lividity and turgescence of the face and hands) is produced, and gives rise to its usual effects,—insensibility and convulsions,—of which latter, the closed glottis and interrupted respiration form only a part:* and these symptoms continue until the too forcible supply by the hepatic veins ceases,—when the ventricle is enabled to resume its action,—the distension of the right auricle is rapidly diminished,—ingress by the superior cava is no longer prevented,—the cerebro-spinal congestion is consequently relieved, and with it the paroxysm terminates.

But what *evidence* is there that this excessive distension of the right cavities of the heart takes place in the epileptic paroxysm, or that more blood is forcibly returned to them than the right ventricle can duly propel through the lungs? To say nothing of the outward lividity and turgescence of the face and hands, there is in the first place the suspension, or greatly enfeebled action of the heart, which is the first symptom of the paroxysm; secondly, dilatation of the right cavities of the heart has frequently been observed after death in persons who

* Ordinary respiration is performed by the regular and alternate contraction and relaxation of the muscles of *inspiration;* but when these muscles as well as those which are concerned in *forcible expiration* are convulsed, the respiratory function is necessarily interrupted.

have long been the subjects of epilepsy,—and even rupture of the right auricle has been known to occur in the paroxysm; thirdly, firm compression of the inferior cava, which is effected by "pressing the closed hand forcibly on the soft part of the abdomen towards the spine, while the patient is firmly supported on the back with the head and shoulders raised," causes the paroxysm instantaneously to cease. It is to Dr. Reid (whose paper on the pathology of Epilepsy has been already alluded to), that we are indebted for the knowledge of this singular, yet highly important procedure, which he remarks is attended with the "utmost success." He does not, however, assign the beneficial operation of this measure to its true cause, namely, that compression of the inferior cava, by arresting the ascending venous current (except by the hepatic veins, which it does not influence), has the effect of greatly diminishing the force of the demand for ingress at the inferior auricular opening, and thereby of relieving the distension of the right cavities, and of lessening the opposition to the admission of blood from the superior cava, and which admission consequently then takes place, and the cerebro-spinal congestion is at once relieved,—but to an imaginary "sympathy between the peritoneum and the nervous apparatus of the spine," and that pressure on the former relieves the latter. Nevertheless, Dr. Reid's idea of the proximate cause of epilepsy is perhaps nearer the truth than that of any previous or subsequent writer upon its pathology; for he attributes

the *convulsions* of epilepsy (and also of hydrophobia, and the spasm of tetanus), to "*a morbid accumulation of blood*, or other irritation in the spinal nervous mass:" but what this other irritation in the spinal nervous mass could possibly be, we are not informed,—probably because it was no easy matter to define.

It has long been known, although no explanation of the fact has been hitherto offered, that a tight ligature placed around the thigh will succeed in preventing, arresting, or mitigating, the epileptic paroxysm; it affords the same relief also in hydrophobia, and would probably be beneficial in violent hysteria. The effect of this procedure is the same in kind, and only differs in degree, from compression of the inferior cava against the bodies of the lumbar vertebræ; both measures in the manner above explained relieving the cerebro-spinal congestion.

There may nevertheless be some doubt still entertained, whether a rush of blood into the heart from the hepatic veins can prevent the ingress of blood into the auricle by the superior cava; whether the spleen, after all, is to be regarded as the offending organ in the production of epilepsy, even admitting that in abortion the offending organ is the placenta; or whether epilepsy is to be viewed as a kind of attempt, or mock effort at abortion on the part of the spleen. It must, however, be remembered that both epilepsy and abortion are induced by exactly the same exciting causes, and that there is the closest similarity in the organization of the

placenta and the spleen; and that the former before birth performs the function which after birth devolves upon the latter. If it be not a deranged action of the spleen which gives rise to the symptoms ushering in the cold stage of intermittent fever, it is at least the organ which is peculiarly liable to a morbid change consequent upon that affection, namely, hypertrophy. Now epilepsy is, like ague, an intermittent affection, and its accessions often recur with singular regularity; and it has even occasionally been remarked that epilepsy has ceased, never to return, after a severe attack of ague; which circumstance is perhaps owing to the change which the latter disease had effected in the spleen. Typhus fever has not the same curative influence over epilepsy; for, in the year 1814, when upwards of 50 epileptics in the Salpêtrière were attacked by it, and but few died, little or no amelioration was observed in any; and probably because the spleen is not especially affected in this disease. Night-mare, which is believed to be of an epileptic nature—as Dr. Elliotson observes, "a little degree of epileptic affection," invariably occurs when the portal system is distended, and the body is in the horizontal posture; which is the position most *unfavourable* for the return of blood to the auricle by the superior cava, and, at the same time, most *favourable* for its return by the hepatic veins. Even epilepsy itself, in a majority of cases, occurs only when the individual is in the horizontal posture; to which circumstance, and not to the "absence of the

sun from the hemisphere," its more frequent occurrence at night than during the day, may reasonably be attributed.

If we admit that the symptoms of an epileptic paroxysm are simply the consequences of excessive cerebro-spinal congestion, and that this congestion is always owing to the ingress by the superior cava being prevented, we shall have no difficulty in accounting for the production of all those morbid changes which are occasionally observed after death in the heads and spines of persons who have been the subjects of epilepsy.

In a paper by Dr. John Sims, read before the Medico-Chirurgical Society (see Medical Gazette, vol. 7, p. 374), it is stated that the following are the appearances described by the German pathologists as found in 20 cases of epileptic individuals. "A peculiar thinness of the sphenoid bone; variations in the position, shape, &c., of the clinoid apophyses, producing some change in the size and form of the sella turcica. The pineal gland was frequently changed in colour; in ten cases it was pale, and in all softened; but it was in the pituitary gland that the principal changes were perceived. Among the morbid phenomena which it presented were, an uneven, furrowed, or muscular appearance of the surface—sometimes a kind of excavation—changes of colour, as red, yellow, and brown, of various shades; in some cases it was softer than natural, in others it was indurated; in seven cases it was much enlarged, with lymph between the lobes.

Internally there existed, in ten cases, a yellow, solid matter at the point of union between the two lobes ; in five cases there was a viscid semi-fluid lymph in the above situation. In some cases the infundibulum was preternaturally firm, occasionally with some appearance of lymph. Caries of the bones at the base of the skull, exostosis, and other morbid changes of the osseous structure, were met with in several instances, with some effusion about the dura mater, or arachnoid. In fifteen cases out of twenty the cerebrum and cerebellum were perfectly sound."

The peculiar thinness of the body of the sphenoid bone, and the alteration in the size and form of the sella turcica and clinoid processes, are simply the consequences of the repeated excessive distension which the cavernous sinuses have suffered during the paroxysms. The changes also which have been observed in the pituitary and pineal bodies of those who have long been the subjects of epilepsy, will readily be accounted for by a consideration of the position of the former of these organs, their structure, their connection with important *veins*, and, as will shortly be explained, their use. The occasional osseous or cartilaginous depositions in the membranes, the hardening or softening of the brain and spinal cord, are doubtless the effects of chronic inflammation induced by the repeated states of excessive cerebro-spinal congestion.

It has been already observed, that a certain distension of the portal vein must take place before

the portal blood can be propelled through the portal plexuses: the action of the spleen, therefore, is not constant, but intermittent, and subsequent to this distension of the portal vein, which is produced partly by the venous blood constantly flowing into the portal trunk from the splenic and great mesenteric veins, and partly by the aqueous and alcoholic fluids entering these veins from their tributary branches, and absorbed by the radicles of the latter from the mucous surface of the stomach and intestines. The quantity of fluid, or diluted venous blood, entering the portal trunk in a given time, will therefore be increased in proportion to the amount of fluid taken into the system by food or drink; and, as all the veins of the stomach, namely, those corresponding to the vasa brevia, to the two gastro-epiploic arteries, and to the coronaria ventriculi, and also the veins of the duodenum, terminate in the splenic vein, it is obvious that very nearly all the fluid which is taken into the system enters the portal vein by the splenic; and, consequently, that the great mesenteric supplies to the portal vein an almost undiluted venous blood.

It is probable that the degree of distension of the spleen, during the intervals of the contractions, bears an exact ratio to the degree of distension of the portal vessels (that is, to the portal trunk and branches,—the roots of the portal vein, the mesenterics, not being surrounded by a sheath of loose cellular membrane, but by adipose substance, not admitting of any considerable amount of distension)

—for we cannot suppose that the spleen ever becomes distended while the portal vein contains its minimum quantity of blood; or, on the other hand, that the spleen can remain contracted when the portal vein is distended; for in proportion as the distension of the latter increases will the resistance offered to the further entrance of blood from the mesenteric and splenic veins also increase; and distension of the spleen must necessarily ensue, when the quantity of blood which it receives by the splenic artery is greater than that entering the portal trunk by the splenic vein.

The blood received by the spleen is arterial, which by passing through the organ is converted into venous; and in its progress through the splenic vein, it necessarily becomes diluted with the more or less aqueous blood entering this vein from the gastric and duodenal veins; and subsequently it commingles with the undiluted venous blood entering the portal trunk by the great mesenteric vein.*

It is usually supposed that the spleen effects some peculiar change upon the blood. "The function of the spleen," says Müller (Bayly's Trans. p. 571), "probably consists in the production of some change, of which the nature is unknown, in the blood which circulates through its tissue, and in thus contributing to the function of sanguification; or, in the secretion of a lymph of peculiar nature, which, being mixed

* The lesser mesenteric vein, which corresponds to the inferior mesenteric artery, may terminate either in the great mesenteric vein, or in the splenic.

with the contents of the lymphatic and lacteal system coming from other parts, tends to perfect the formation of the chyle. There are no other ways than the lymphatics and veins by which any animal matter, modified by the action of the spleen, can be conveyed away from it. Tiedemann believes that the lymphatics perform this office; but whether he is correct or not is quite uncertain, and the nature of the change which the animal matter is supposed to undergo is still less known." The *peculiarity* of the change which the blood undergoes in passing through the spleen, consists simply in its being *less* changed than by passing through most other organs; and there is as good reason for supposing that the venous plexus of the corpora cavernosa penis is concerned in sanguification or secretion, as the venous plexus of the spleen. The blood contained in the latter is observed to be more viscid than other venous blood, and to communicate to the fingers when rubbed between them a soapy or unctuous feel; but as the spleen is of a spongy texture, consisting almost wholly of vessels, very little of the *animal* constituents of the blood are required for its nutrition, which accounts for its venous blood differing from, or being more viscid than the venous blood returned from muscular parts; and, if we regard the spleen as an assistant circulatory organ, and not as a secreting one, we shall naturally expect its venous blood to be possessed of certain *saline* constituents not contained in the venous blood of a secreting organ,—for instance, the kidney, and simply because

they have not been eliminated in any process of secretion.—If indeed, the spleen were "concerned in sanguification, or in the secretion of a lymph of peculiar nature, &c., which tends to perfect the formation of the chyle"—why, in man, is it one-sixth of the weight of the liver, and in the quadruped only one-twelfth, one-fourteenth, or one-sixteenth? If in man, the spleen weigh eight ounces, and the liver less than fifty,—why does the spleen of a hog weigh only four ounces and a quarter, when the liver weighs fifty-one? In an ox, the death of which was accidental and unattended by hæmorrhage, the spleen weighed only eighteen ounces and a half, and the liver, exclusive of gall-bladder, &c., sixteen pounds and three-quarters—or fourteen times and a half heavier than the spleen. In this animal, the spleen, to have borne the same proportion to the liver as in man, ought to have been upwards of forty-four ounces.

The opinion of Müller is not only unsupported by, but is evidently irreconcilable with, the foregoing facts; the simple explanation, however, of which is, —that in man the usual attitude of the trunk is erect—in the quadruped horizontal; and that the former requires a spleen larger in comparison with the liver than the latter, because a greater power is necessary to propel the portal blood through a venous and capillary system the direction of which is vertical, than through one the direction of which is horizontal.

Extirpation of the spleen has frequently been

performed on dogs, and, as has long been known, they thrive nearly as well without this organ as with it. Dunglison (Elements of Physiology, vol. 2, p. 278) says, that "Dupuytren extirpated the spleens of forty dogs on the same day, and without tying any vessel, but merely stitching up the wound of the abdomen, yet no hæmorrhage supervened. In the first eight days, half the dogs operated on died of inflammation of the abdominal viscera induced by the operation, as was proved by dissection. The other twenty got well without any accident at the end of three weeks at the furthest. At first they manifested a voracious appetite, but it soon resumed its natural standard. They fed on the same aliment, the same drinks, took the same quantity of food, and digestion seemed to be accomplished in the same time. The fæces had the same consistence, the same appearance, and the chyle appeared to have the same character. Dupuytren opened several of these dogs some time afterwards, and found no apparent change in the abdominal circulation,—in that of the stomach, epiploon, or liver. The last organ, which appeared to some of the experimenters to be enlarged, did not seem to him to be at all so. The bile alone appeared a little thicker, and deposited a slight sediment." Mr. Mayo (Outlines of Human Physiology, p. 126) states, that he removed the spleen from a dog, and "after recovering from the wound it became fatter than before: in a year's time it had returned to its former condition, and no difference was observed in its appearance or habits

from those of other dogs: it died about three years afterwards of inflammation of the bowels."

Thus it appears from Dupuytren's experiments, that one-half of the dogs which suffer extirpation of the spleen, die of inflammation of the abdominal viscera within eight days after the operation; and it is worthy of remark, that this was also the cause of death in the last related instance, although an interval of three years had elapsed. Now when we consider, that after extirpation of the spleen, the trunk and branches of the portal vein can never be otherwise than distended,—that they cannot then, as in the normal state, contain a varying quantity of blood,—that there must always, in short, be a state of portal congestion,—what consequence can we suppose so natural, so probable, so certain, indeed, sooner or later to supervene, as inflammation of the bowels?—A circumstance, not mentioned in any of the foregoing extracts, but which has been remarked by numerous observers, is, that dogs, after having suffered extirpation of the spleen, micturate oftener than other dogs on which this operation has not been performed. This may be accounted for by the fact, that after the spleen has been removed, the diluted blood filters through the liver and flows into the general system by the hepatic veins as fast as it is admitted into the trunk of the portal system from the mesenteric, gastric, and duodenal veins; and thus the supply to the *general* system from the *portal* system in animals without spleens is necessarily constant; or rather, as it no doubt varies in

rapidity, *remittent;* whereas in animals with spleens, as has already been inferred from the construction of the vena portæ, the flow of blood from the hepatic veins into the auricle is not constant, but *intermittent.* It appears therefore that the secretion of urine is regulated by the action of the spleen,—that there is a kind of antagonism between the function of this organ and that of the kidneys,—that the action of the latter is consecutive and proportionate to the action of the former; and, in animals without spleens, the supply of diluted blood to the general system by the hepatic veins being remittent, the action of the kidneys is also remittent.

This antagonism of function between the spleen and the kidney is not merely interesting in a physiological point of view, but it is also of great pathological importance; for it intimates that in certain cases of suppression of urine the spleen is at least as likely to be the offending organ as the kidney,—that the cessation of the secretion may be owing to inaction of the former more than to any indisposition to act on the part of the latter; and it also tends materially to substantiate our previous conclusions concerning the primary and proximate causes of epilepsy and hysteria, the paroxysms of which are invariably followed by a profuse discharge of limpid urine.

That inefficient action of the spleen induces a corresponding inactivity of the kidneys is well exemplified by a case of partial loss of the organ in the human subject, which was treated by Mr. Fer-

guson, and recorded by him in the 40th volume of the Philosophical Transactions. The following are the chief facts of the case. A man received a wound from a "skane" or long knife through the abdominal parietes on the left side, out of which the spleen immediately protruded. It was not until twenty hours had elapsed that he was first seen by Mr. Ferguson, who then found the organ (to use his own words) "cold, black, and *mortified*." Whether a part of the organ was in a worse state than the remainder we are not informed; but we are led to infer that such was the case, for a portion weighing three ounces and a half was included in a ligature and removed, and the remainder returned into the abdomen, leaving the ends of the threads out of the wound. "What the patient complained of most was that he could not make water;" but this symptom disappeared on the seventh or eighth day; the ligature came away on the tenth; the wound healed without any untoward circumstances occurring, and the man perfectly recovered.

There are a few rare instances recorded of perfect recovery after the removal of the entire organ under circumstances similar to the foregoing; and such facts have led some to suppose, and even to assert, that the spleen has no function; that it is an organ without use or purpose, which Nature might have spared herself the pains to construct;—or, that if it have any office in the economy, it is of the nature of a sinecure,—and that the large size of the splenic artery affords irrefragable proof of the disparity

between the emolument received, and the value of the services performed. Others have viewed the loss of the spleen and the subsequent recovery of the patient as perfectly miraculous. When, however, we reflect, that other organs, as the uterus and kidney, have been lost; that in hernia cerebri a portion of the brain has been sliced off; that one, or more, or even all the extremities have been amputated; and that notwithstanding such mutilations persons have subsequently recovered,—it does not appear so very extraordinary that the loss of the *spleen* is not necessarily a fatal occurrence. The fact, however, that persons have survived the partial or entire removal of the organ, is significant; and while it excites our admiration of the *vis medicatrix Naturæ*, ought to increase our confidence in the resources and capabilities of our art.

An undue degree of distension of the spleen is, in its healthy state, prevented by its elasticity;* for in proportion as it distends is the elastic force of its capsule and internal fibrous net-work called into action; and as the distension becomes greater, so also will the degree of pressure to which the blood contained in the venous plexus of the spleen, and splenic and portal veins, is subjected: it is, however, to its vital contractility, that we must attribute the power of propelling the blood along the splenic

* Is this elastic property diminished, and does the spleen consequently suffer undue distension, in certain individuals, more especially those of the lymphatic and nervous temperaments?

vein, portal trunk and branches, and through the portal plexuses and hepatic veins to the auricle.

As contraction of the spleen alternates with a certain degree of distension, and as its *action* is therefore not constant, but *intermittent*—what is more probable than that in certain individuals it should at times be irregular or excessive? When a sudden or inordinate contraction of the spleen occurs, whether excited by fear or any other agency, the effect must necessarily be a rush of blood into the auricle from the hepatic veins.* Singular, but strongly corroborative evidence that an instantaneous contraction of the spleen is produced by sudden fear, and also that a rush of blood into the auricle from the hepatic veins is the consequence of such contraction, is afforded by the instinctive actions which characterize *terror*—and which actions concur in the production of one general result—*that of increasing the force of ingress into the auricle by the superior cava, and consequently of opposing the too rapid or undue ingress from below.* The forces which assist the vis à tergo in increasing the impetus with which the blood enters the auricle by the superior cava, are, as was previously mentioned, inspiration, gravitation, and muscular action. In terror the vis à tergo is diminished—fear having the

* When Epilepsy is produced by fright, the paroxysm usually occurs, not immediately, but after some hours have elapsed; and this is the case also with abortion. I have, however, known the former to follow a sudden alarm, with an interval of a few minutes only.

effect of enfeebling the force of the heart's action; but all the assistant powers are put into instant operation—there is a sudden, deep, convulsive *inspiration*, similar to hiccup; the arms are raised above the head, and therefore the return of blood from the upper extremities is favoured by *gravitation*;* and at the same instant the lower jaw is depressed by the muscles which connect it with the os hyoides, and this again is drawn downwards by the sterno-hyoid, sterno-thyroid, and omo-hyoid muscles.† The effect of this *muscular action* is pressure on the internal jugular veins in nearly the whole of their course, and thus the blood is more rapidly forced along into the subclavians, superior cava, and auricle.

Very similar to the instinctive actions produced by terror, are those which take place when the *rush into the auricle is not from the hepatic veins, but from the inferior cava.* The sudden application of cold to the lower limbs and lower part of the body, as upon entering a river or cold bath feet foremost, by causing contraction of the veins, and a consequent diminution of their calibre, suddenly increases the rapidity of the current ascending by the inferior cava,

* The *length of the column* of blood is much increased both by throwing up the arms, and deep inspiration. The latter has this effect, because the heart descending with the diaphragm causes an elongation of the superior cava to take place. Perhaps it is simply by *gravitation* that *inspiration* increases the force of ingress into the auricle by the superior cava.

† The descendens noni associates the action of the two sets of muscles.

and its force of ingress into the auricle. Who, under these circumstances, has not remarked the deep, sobbing inspirations—the depression of the jaw—and the throwing up of the arms? These instinctive actions have the same effect, and answer the same purpose in this, as in the former instance—namely, by increasing the force and rapidity of the descending current, they maintain the equilibrium of ingress by the two auricular openings, and thereby obviate the production of cerebro-spinal congestion.

Yawning consists of instinctive actions, which are closely analogous to the above, and their effect is to facilitate the ingress of blood into the auricle by *both* venæ cavæ. The arms are raised above the head, and their muscles put into action; the mouth is widely opened, and there is a deep inspiration, followed by a more or less perfect expiration: or the yawn may be chiefly expiratory: when the mouth is widely opened and the yawn is expiratory, it will have the effect of facilitating ingress by both venæ cavæ. Stretching of the legs, and forcible expiration, which is effected by contraction of the abdominal muscles, will favour ingress by the inferior cava; throwing up and stretching the arms, deep inspiration, and depression of the jaw, ingress by the superior. These instinctive actions do not occur, nor are they needed, when the mind and body are employed, their energy undiminished, and the heart, receiving a due supply of blood, is acting with its ordinary vigour; it is when the for-

mer are in a state of inaction, exhaustion, or fatigue, —when the blood, from the cessation of muscular exertion, and the languid respiratory movements, flags in its homeward course, and the heart is therefore inadequately supplied, that these instinctive actions, or assistant circulatory powers, are summoned into operation to aid and expedite the return of the venous current to the right auricle.

Sighing is a deep inspiratory act, followed by a corresponding forcible expiration. It occurs when the body is in a state of inaction, and the heart is acting languidly, and is usually produced by some depressing mental influence.

That sighing and yawning have the power, and are for the purpose, of expediting the return of blood to the auricle by both venæ cavæ, appears to be indicated by the fact, that when the vis à tergo of the heart's action and the quantity of blood are considerably lessened, whether in man or animals, by bloodletting, these instinctive actions invariably occur; and if the abstraction of blood be continued, are quickly followed by syncope.

Crying consists mainly of expiratory acts, and its accompaniment *sobbing* is a spasmodic, inspiratory act; the latter always begins after the former, and generally towards the end of the *fit*. I suppose no one ever observed a 'fit of crying' commence with sobbing.

Laughing consists of expiratory acts, and therefore impedes ingress by the superior cava, as is shewn by the swelling of the veins of the neck and fore-

head, and the flushed countenance. *Hiccup* is a convulsive action of the diaphragm, and consequently an inspiratory act, and therefore facilitates ingress by the superior cava. It frequently follows immoderate laughter, as sobbing succeeds crying. Both sobbing and hiccup are probably for the purpose of counterbalancing a sudden undue supply to the auricle from the hepatic veins; and their common occurrence, with the alternate laughing and crying, &c., in hysteria, seems to corroborate the opinion that the various forms and symptoms of this affection are owing to derangement of the cerebro-spinal circulation,—which is therefore the *proximate cause*,—the *primary cause* being an irregular action of the spleen, disturbing the equilibrium of ingress into the auricle. Viewing hysteria in this light, it does not appear at all surprising that it should occasionally pass into epilepsy.

The foregoing instinctive actions, as those observed in fright,—also yawning and stretching, sighing, sobbing, and hiccup, appear to be for the sole purpose of facilitating ingress into the auricle by one or both venæ cavæ—*especially the superior;* and the natural inference from which is,—that for the prevention of cerebro-spinal congestion, it is essential for a due equilibrium to be maintained in the quantity of blood admitted into the auricle by the two great venous trunks; and that Nature is unceasingly on the alert to restore that equilibrium when disturbed by any cause.

Throughout the preceding pages the spleen is regarded as an organ attached to the trunk of the portal system, simply for the purpose of propelling the portal blood through the capillaries of the liver and the hepatic veins to the right auricle. It has also been attempted to shew that the closest possible analogy exists between the spleen and the placenta, in structure, in properties, in function, and in disease; and that the latter even performs during fœtal life the function of the former,—teaching it as it were the duties which are to devolve upon it immediately after birth. Should it then be admitted that the above is the *sole* function of the spleen, can the placenta be justly viewed as any thing more than an assistant circulatory organ, or *temporary spleen?* The placenta certainly *propels* the blood through the capillaries of the fœtal liver to the fœtal auricles. But is this all? does it effect no 'peculiar change,' neither on the blood which it receives from the mother by the uterine arteries, nor on that which is returned to it from the fœtus by the umbilical arteries? The blood supplied to the placenta by the uterine arteries, is *deprived*, before it arrives at the placenta, of certain *solid* materials which are deposited in the parietes of the uterus and produce the increased development and growth of the organ which take place during utero-gestation. The uterus therefore receives a richer or more *fibrinous* blood than the placenta,—the fœtal portion of which receives a *thin venous blood.** But does no other

* Thus another interesting point of resemblance between the

change take place in the blood in its progress from the uterus to the fœtal portion of the placenta, than that it is simply converted from arterial to a thin venous blood? What other change can take place? or what reason is there for supposing that either in its progress to, or upon its arrival in, the fœtal portion of the placenta, any peculiar change is required; or that the thin venous blood is not in every way adapted both for the secretion of the liquor amnii, and (after having passed through the capillaries of the fœtal liver) for the development and nutrition of the fœtus?

Nor is there any just ground for believing that the blood returned from the fœtus by the umbilical arteries requires any peculiar change to be effected in it by the placenta; or that any thing more takes place, than that it commingles with the thin venous blood in the placenta, with which it is sent back to the fœtus by the umbilical vein. It is merely the superfluous blood, or that which is not immediately required by the arteries in the process of developing the several fœtal organs: for we cannot entertain the opinion that it is deteriorated in quality, or that the blood passing through the hypogastric or umbilical arteries is at all different from that supplied to the lower extremities by the external iliacs; or from

spleen and the placenta is in *the kind of blood* which each organ propels through the portal plexuses. In both instances it is a thin venous blood. That propelled by the spleen is diluted in the splenic and portal veins; and that propelled by the placenta, by having, previous to arriving at this organ, left a part of its solid constituents in the parietes of the uterus.

that propelled by the fœtal ventricles through the several ramifications of the aorta to every organ and texture in the fœtal system, in which a portion is deposited, and the remainder returned to the fœtal auricles.

There are, however, other organs besides the spleen and placenta which are to be regarded as *assistant circulatory*. They are indeed, when taken collectively, sufficiently numerous to form a class, which may be divided into two orders—active, and passive; and which again may be subdivided into genera, namely,—permanent, and temporary,—as follows :—

THE ASSISTANT CIRCULATORY ORGANS.

Active.

Permanent.	*Temporary.*
The Spleen.	The Placenta.

Passive.

Permanent.	*Temporary.*
The Thyroid, Pituitary, and Pineal Bodies.	The Supra-renal Capsules, The Thymus, and Wolffian Bodies.

The spleen and placenta, by their elasticity and contractility, are the *agents* by which the portal, placental, or diluted venous blood, is propelled through the capillaries of the liver and the hepatic veins to the right auricle; they are, therefore, *active* assistant circulatory organs.

The *Thyroid*, *Pituitary*, and *Pineal Bodies*, are also organs whose use is that of accelerating the venous

currents in those vessels in which their veins terminate, namely, the *subclavian* and *internal jugular veins*, the *cavernous sinuses*, and the *venæ Galeni*. These three organs agree in the following anatomical particulars:—they are of similar texture; their capillary vessels are more capacious than those of other organs; they receive more numerous and larger arteries than are required simply for nutrition; their *function* is not that of secretion, for they have no excretory ducts; and they are especially remarkable for the number and size of their veins. As they resemble each other in so many respects, it is fair to presume that they are all of similar use; and which I shall endeavour to illustrate by a consideration of the largest, namely, the *thyroid body*.

The veins of the thyroid body correspond to the superior and inferior thyroideal arteries. The superior thyroideal vein on each side frequently receives the ranine and lingual veins, and always the *laryngeal;* it then divides into two branches, and thus terminates in the internal jugular vein by *two* openings.* The left inferior thyroideal vein terminates in the left subclavian vein, just after the latter has been joined by the left internal jugular. The right inferior thyroideal vein, which is more than double the size of the left, receives all the blood from the lower part of the right lobe,—all the blood from the isthmus,—and is also joined by one or more branches from the left inferior thyroideal vein,

* The purpose answered by this arrangement will shortly be apparent.

—and consequently receives a part of the blood from the left lobe, and terminates in the left subclavian vein, near its angle of junction with the right. As the thyroid body possesses more capacious capillaries than organs and textures in general, the blood necessarily meets with but trifling resistance in passing from the four thyroideal arteries through the capillaries into the veins, and consequently it flows through the latter with almost arterial rapidity; and, upon arriving at the internal jugular and subclavian veins, communicates to the currents flowing through them, a certain additional impetus, by which their velocity is accelerated. The thyroid body, therefore, may be regarded as a *diverticulum of the vis à tergo* from the subclavian and carotid arteries into the internal jugular and subclavian veins; and as one of the provisions for maintaining the equilibrium of ingress into the auricle, by increasing the force of the descending current.

The rapidity of the circulation through the thyroid body is shewn by the excessive hæmorrhage which ensues when any of its vessels are divided, as sometimes happens in wounds of the neck; but in a more striking manner in those cases of bronchocele in which the enlarged thyroid body has been either wholly or partially excised. The hæmorrhage consequent upon this operation is described as being always most profuse, and often quite uncontrollable. Mr. Samuel Cooper, in his Dictionary of Practical Surgery, relates several cases of this kind. In one instance, he observes, "so copious an hæmorrhage took place

that the surgeon, though equally bold and experienced, was obliged to stop in the middle of the operation. No means availed in entirely suppressing the bleeding, and the patient died in a few days. In another instance the same event nearly took place, the patient's life being saved only by compressing the wounded vessels with the hand, day and night, for a whole week, by persons who relieved each other in turn: this was found the only way of stopping the hæmorrhage, after many fruitless attempts to tie the vessels."—Art. Bronchocele.

"The removal of the thyroid gland was attempted by M. Roux. After an operation which lasted above an hour, and the application of forty-seven ligatures, about one half of the gland, of the size of an orange, was removed; the patient survived fifty-six hours. The Hôpital Interne, who relates this case, remarks, that we may place this amongst the operations which the prudent surgeon will scarcely feel himself justified in undertaking."—Ibid. Art. Thyroid Gland.

I have been induced to make the above extracts, not merely to prove the greater rapidity of the circulation through the thyroid body than through other organs and textures whose capillaries are less; but also because the foregoing view of its use elucidates the pathology, or rather the physiology of bronchocele: why it is endemic in mountainous districts, as in some parts of Switzerland, Wales, and Derbyshire; and also in certain hilly towns,—as Edinburgh and Nottingham; why it is so much

more frequent in females than in males; and why it so rarely occurs in early life, or before the eighth year. It being necessary, as I have already shewn, for a due equilibrium to be maintained in the quantity of blood supplied to the auricle by the two great venous trunks, lest the current entering by the inferior auricular opening, should impede the ingress of the current by the superior auricular opening, and thus induce a greater or less degree of cerebro-spinal congestion,—it follows, that when an increased development of the muscles of the lower extremities and pelvis takes place, and the *habitual* force of ingress into the auricle by the inferior cava is consequently increased, that the habitual force of ingress by the *superior cava* ought also to be proportionably augmented; and which augmentation can only be effected in two ways,—namely, increased development of the muscles of the upper extremities and thorax, or *an enlargement of the thyroid body*. Now, it is certain, that in the beforementioned districts and towns, greater muscular exertion is required for progression than in those localities where the irregularities of the earth's surface are inconsiderable; an extra degree of muscular power is therefore necessary, which demands an increased development of the muscles concerned in progression,—and this increased development is accordingly produced; but no corresponding increased development of the muscles of the upper extremities takes place, and Nature consequently,

to preserve THE EQUILIBRIUM, of which she is ever mindful, effects an enlargement of the thyroid body,—her chief, passive, assistant circulatory organ.

Thus it appears that bronchocele ought rather to be regarded as a prophylactic than a disease (since there is rarely a morbid deposit), and the propriety of any *medicinal* means being adopted to effect its diminution is therefore questionable. It is evidently for the purpose of increasing the force of ingress by the superior cava, and thereby of obviating the injurious consequences which would result, if the current descending by that venous trunk, and returning the blood from organs of such vast importance as the brain and spinal cord, were constantly impeded by a too forcible ingress into the auricle by the inferior cava. Within certain limits the degree of enlargement of the thyroid body is in exact accordance with *the degree of disproportion* between the upper and lower extremities; or rather between the thoracic and brachial muscles on the one hand, and the pelvic and crural muscles on the other; and in this respect the thyroid is resembled in a very singular manner by the erectile crests, cervical and submaxillary appendages of certain birds,—as the turkey and common fowl; which crests and appendages are, like the thyroid body, assistant circulatory; and their greater or less development is also in exact accordance with, and in like manner is regulated by, the degree of disproportion existing between the thoracic and pelvic limbs; and the

injurious operation which this disproportion would have on the *equilibrium* they are intended to prevent. In this curious analogy, however, a somewhat odd contrast presents itself. Enlargement of the thyroid body is all but peculiar to *women;* whereas in the feathered bipeds the development of the erectile crests and appendages is greatest in the *males.* The rationale of both these circumstances I conceive to be as follows:—the disproportion in the muscular development between the legs and the wings of the turkey and common fowl, is great in the *male,*—small in the female; on the other hand, in *women,* the shoulders being narrower, the thoracic muscles smaller, and the arms much less, than the corresponding parts in men,—while the abdomen and pelvis are wider and more capacious, and the pelvic muscles and lower extremities comparatively larger in the former than in the latter, are indications which shew that in this case, from natural conformation, the disproportion is considerably greater in *females* than in males.

But the frequency of bronchocele in females, and its rarity in males, must not be entirely attributed to this disproportion being from natural conformation great in the former and inconsiderable in the latter, inasmuch as in females the disproportion is increased by their habits and mode of life, which usually require greater exertion, and consequently a greater development of the muscles concerned in locomotion, than of the upper extremities; whereas in males,

the disproportion, naturally inconsiderable, is rather lessened than augmented, because their pursuits, whether of business or amusement, demand a more energetic exertion of the muscles of the upper extremities and thorax than of those employed simply in progression ; and, consequently, the force of ingress into the auricle by the superior cava is sufficient without being increased by any enlargement taking place in the thyroid body.

The reason that bronchocele so rarely occurs in early life, or before the eighth or tenth year, probably is, that a certain time must elapse before the development of the pelvis and lower limbs can gain an undue preponderance over that of the thorax and upper extremities.

The right lobe of the thyroid, when this body is of its normal size, is somewhat larger than the left ; and when bronchocele exists, it is the former which commonly, if not invariably, suffers the greatest enlargement ; both circumstances may be accounted for by the right inferior thyroideal vein, from its greater size than the left, and the closer proximity of its termination to the angle of junction of the subclavian veins, being best adapted for increasing the velocity of the descending current and its force of ingress into the auricle.

The *supra-renal capsules, the thymus, and Wolffian bodies*, have been admitted into the class of assistant circulatory organs upon the following grounds :— Their great vascularity indicates that they receive

more blood than is required simply for nutrition; and, as was remarked of the thyroid, pituitary, and pineal bodies, their *function* cannot be that of secretion, for they have no excretory ducts. Now if after birth the blood, which has been propelled by the heart through the arteries and capillaries into the veins, requires the assistance of certain actions, namely, the respiratory movements and muscular contractions of the limbs, to aid in its return to the auricle;—and if there are also, in addition to these actions, certain organs, or diverticula of the vis à tergo, for the purpose of accelerating the venous currents in those parts in which they are unaided by muscular contraction, we may reasonably infer, considering the absence of these actions during fœtal existence, that *more* diverticula of the vis à tergo are then required to assist in returning the blood to the heart by the veins than subsequently to birth; and this view of the use of these organs accounts for their gradual disappearance, or conversion into vestiges, when the respiratory movements, and the muscular actions in general, are established.

The use of the serous cells, or cysts, in the interior of the passive assistant circulatory organs, both permanent and temporary, I conceive to be, that by occupying numerous interspaces in these organs, they not only render less blood sufficient for their nutrition than would be required if they consisted entirely of parenchymatous tissue,—but also, by preventing the arteries from giving off large lateral or nutrient

branches, obviate any material diminution, or (in other words) *minimise* the expenditure, of the vis à tergo.

The *supra-renal capsules* consist of an outer and an inner portion; the former is of a light yellow colour, and can be peeled off from the latter, which is of much darker appearance, and of a spongy texture. These two portions bear a considerable resemblance to the two portions composing a placental cotyledon ;* which corroborates the opinion that they are assistant circulatory, but at the same time renders it doubtful whether their use is strictly passive. Be this as it may,—they probably serve the purpose during fœtal existence of facilitating the return of the blood from the kidneys. But the left supra-renal vein only terminates in the corresponding emulgent vein, the right terminating in the inferior cava, close to the opening of the right emulgent vein. How then can the right supra-renal capsule facilitate the return of blood from the right kidney? and why this difference in the termination of these two veins? It is necessary to bear in mind, firstly, the inverted position of the fœtus; secondly, that the left emulgent vein is *longer* than the right, and that it proceeds from the left kidney *transversely* across the aorta to the inferior cava, which it joins nearly at a *right angle;* thirdly, that the right kidney being situated somewhat lower (nearer the pelvis)

* A placental cotyledon may be regarded as the prototype of a supra-renal capsule; and the placenta as the prototype of the spleen.

than the left, and the cava being on the right side of the aorta, the course of the right emulgent is necessarily very *oblique*, and its termination therefore joins the cava at an *acute angle;* consequently, in the fœtus, the return of the blood from the right kidney is favoured by gravitation; but, owing to the transverse course of the left emulgent vein, this power has no influence whatever upon the return of blood from the left kidney; which organ therefore requires more assistance from its corresponding capsule than the right, and hence the left supra-renal vein terminates in the left emulgent: on the other hand, if the right supra-renal vein terminated in the right emulgent, the blood would be returned with greater rapidity from the right kidney than from the left; and it therefore terminates in the cava, at the point of junction formed by the latter, and the right emulgent vein,—and thus the rapidity of the circulation through the fœtal kidneys during their formation is the same in each; which, if it were not for this difference in the termination of the supra-renal veins, would not be the case.

The *Wolffian bodies*, or *false kidneys*, are of exactly the same texture as the *thymus*.

The veins of the thymus, according to Sir. A. Cooper, have three terminations; namely, in the internal mammary and the inferior thyroideal veins, but principally at the junction of the two subclavian veins.

Two other provisions remain to be mentioned,

whose chief use appears to be to assist in maintaining the equilibrium of ingress into the auricle by the two venæ cavæ, — namely, the communication of these two vessels by means of the vena azygos,—and, during fœtal life, the Eustachian membrane.

"Un des usages de la veine azygos," observes Magendie, Précis Elémentaire, Tome 2, p. 255, "paraît être d'établir une communication facile entre la veine cave supérieure et l'inférieure"—which is merely a simple statement of the fact, and is no explanation of the purpose answered by their communication. Now we cannot suppose that it is for the accommodation of the inferior cava that the vena azygos conveys a portion of blood from that vessel to the superior cava; nor that the blood ever passes in a retrograde direction from the latter into the former: it is however evident that by this communication of the azygos and demi-azygos, the former with the trunk of the inferior cava, or one of the lumbar veins, and the latter with the left renal vein, a certain quantity of blood is conveyed from the inferior cava to the superior; and it is equally evident that the quantity so conveyed varies according to the varying rapidity of the current in the inferior cava,—to which, indeed, it must always be proportionate, being inconsiderable when the current is slow, as during a state of rest of the lower limbs, and greater when its ascent is quickened from muscular exertion, as in running, walking, &c.

The effect of this communication of the two great venous trunks by means of the vena azygos is, therefore, to increase the force of the demand for ingress at the superior auricular opening, in a ratio which always accords with the increased force of the demand at the inferior auricular opening; and thus the vena azygos co-operates with the instinctive actions, and with the thyroid body, in maintaining the equilibrium of ingress by the two venæ cavæ; and, consequently, in preventing the occurrence of cerebro-spinal congestion.

The *Eustachian membrane* is probably the chief provision for maintaining the equilibrium of ingress by the two venæ cavæ previously to birth; and it is essential during fœtal existence, because the superior cava, owing to the inverted position of the fœtus, is then more disadvantageously situated for discharging its contents into the auricle and right ventricle, than subsequently to birth. From this inverted position of the fœtus, it is evident that before birth the influence of gravitation upon the circulation is exactly the reverse of that which it is after birth, and in the erect posture. Now suppose there were no Eustachian membrane in the fœtus, and that the two cavæ penetrated the auricle at precisely opposite points, would not the current descending into the auricle by the cava abdominalis prevent the ingress of the blood from the cava thoracica? and more especially as the blood sent to, and returned from, the fœtal head and arms is pro-

pelled by only one ventricle, whereas the blood sent to, and returned from, the other parts of the fœtal system, has the advantage of the vis à tergo of both? And further, the blood entering the auricle from the hepatic veins is no doubt propelled by some kind of contraction of the fœtal portion of the placenta: the current therefore entering the auricle by the cava thoracica is propelled entirely by the left ventricle, and is an *ascending* current; whereas the blood entering by the cava abdominalis has the advantage of the vis à tergo of both fœtal ventricles and the placenta, and is a *descending* current. What then would be the consequence if the Eustachian membrane were suddenly to disappear during fœtal life? Ingress by the superior cava would be prevented—cerebro-spinal congestion would ensue—and insensibility and convulsions would take place even before birth!

Eustachius, the discoverer of this membrane, did not call it a valve; nor (the circulation being then unknown) did he offer any opinion concerning its use. He merely observes, in his Opuscula Anatomica published at Venice in 1564, that it is "membrana artificii et admirationis plena, nemini anatomicorum hactenus non incognita; quæ, foramini venæ cavæ à jecore ascendentis quum primum hæc in dextram auriculam degenerat, præfecta est, nimirum dimidiatam partem, eamque anteriorem illius occupat; et deinceps reticulum efformat:" but Lancisi, who in the year 1714 republished the plates of Eustachius,

calls it a valve, "quâ impeditur, ne sanguis à jugularibus per superiorem cavam *descendens*, nimio impetu arietet cum sanguine per cavam inferiorem *ascendente*." Now if we regard the Eustachian membrane as a fœtal membrane, which the change it undergoes after birth seems to justify, we have only (bearing in mind the inverted position of the fœtus) to transpose the words 'descending' and 'ascending,' and the opinion of Lancisi and the one above given will be found to be the same.

FINIS.

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