THE INSTITUTIONS OF PHYSIOLOGY

BY

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TRANSLATED FROM THE LATIN OF THE THIRD AND LAST EDITION,

AND

Supplied with numerous and extensive Notes,

BY

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SECOND EDITION.

Quæramus optima, nec protinus se offerentibus gaudeamus; adhibeatur judicium inventis, dispositio probatis.

Quintilian.

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1817.

TO

HIS ROYAL HIGHNESS

PRINCE AUGUSTUS FREDERICK

DUKE OF SUSSEX,

EARL OF INVERNESS,

Baron of Arklow,

KNIGHT OF THE MOST NOBLE ORDER OF THE GARTER,

&c. &c. &c. &c.

THE STRENUOUS SUPPORTER OF EVERY THING WHICH CAN EXALT THE CHARACTER OR AUGMENT THE HAPPINESS OF MANKIND,

AND

THE FRIEND OF PROFESSOR BLUMENBACH,

The following Pages

ARE,

WITH HIS ROYAL HIGHNESS'S PERMISSION,

MOST RESPECTFULLY INSCRIBED.

THE

TRANSLATOR'S PREFACE.

The highly flattering manner in which the Edition which I last year published of this work, was received, has both encouraged and compelled me this year to prepare a second Edition.

The translation has been revised, all Blumenbach's references inserted, and my own notes and references increased to a considerable extent. In the latter, the progress of Physiological science since 1810, when the last Edition of Blumenbach's work was published, is detailed, and many points are treated of at large which could not, consistently with Blumenbach's design, be more than briefly mentioned in the original. The last note,—upon the characteristics and varieties of mankind, is an independent addition.

No one can be more sensible than myself to the imperfections of my performance. In excuse I must urge the prodigious extent and variety of my subject, and the short period allowed me through the rapid sale of the first Edition and the importunities of my Bookseller for the second.

No one will ever listen more readily to friendly criticism, or more readily smile at and forgive the suggestions of ill nature.

Grafton Street, Bond Street,
Dec. 1816.

P.S. The volume may be considered a typographical curiosity, being the first book ever printed by machinery. It is executed by Messrs. BENSLEY and SON'S patent machine, which prints both sides of the sheet by one operation, at the rate of 900 an hour, and is the only one of the kind ever constructed.

THE AUTHOR'S PREFACE

TO THE

LAST EDITION.

WHENEVER my booksellers have informed me that a new edition of any of my works was required, I have always gladly seized the opportunity of correcting inaccuracies, arising either from carelessness or the imperfection of human nature; of adding in some places and altering in others; in short, of sending forth the production of my abilities in a more finished state.

In preparing this new edition of my INSTITUTIONS of PHYSIOLOGY for the press, the same anxious wish has been considerably heightened by the importance of the subject, and by the approbation evidently bestowed upon the last edition, from its translation into our own language, into Spanish, French, English, Dutch, and Russian, not to mention other proofs of its favourable reception. I have endeavoured, therefore, to enrich it not so much with an addition of pages, as of various matter; to arrange the heads in a more natural order; and to render the whole as useful to students as possible.

September 10, 1810.

THE AUTHOR'S PREFACE

TO THE

FIRST EDITION.

The same considerations which led Boerhaave, and after him Haller, to write their Compendiums of Physiology, induced the Author to compose these Institutions.

The former says, "that a teacher succeeds better in commenting upon his own thoughts, than upon a work written by another:—that his doctrine will be clearer, and his language generally animated," &c.*

The latter, "That although he formerly used Boerhaave's work as a text-book, he afterwards

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* Pref. to the *Institut. Medic.* Leyden. Fourth edition.

lectured upon one written by himself, because, since the time of Boerhaave, anatomy has been so improved as to become almost a new science."*

What Haller said at that period respecting anatomy, will be allowed to apply much more forcibly at present to physiology, by any one who considers the most important parts of the science,—the principal purpose of respiration, animal heat, digestion, the true nature and use of the bile, the function of generation, &c.

More, therefore, must be ascribed to the age than to the author, if in these Institutions, after so many modern physiological discoveries, he delivers doctrines more sound and natural than it was in the power of his most meritorious predecessors to deliver.

Whatever he can claim as his own, whether really new or only explained in a new manner,

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* Pref. to the *Prim. lin. Physiol.* Gottingen. First edition.

will be easily discovered by the learned and impartial reader; especially from the notes, in which he has treated some of these subjects rather more minutely than, in the text, was compatible with the conciseness of his plan.

He has been at great pains in arranging the subjects, so that the sections might succeed naturally and easily, and arise, as it were, one out of another.

He has not quoted a dry farrago of books, but a select number, in doing which, he has wished both to point out to students some excellent authors not commonly known, especially those who have professedly treated on particular branches of the subject, and to open, besides medical sources of information, others not yet applied, he conceives, to Physiology as they deserve.

His grand object has been to deliver, in a faithful, concise, and intelligible manner, the principles of a science inferior in beauty, importance, and utility, to no part of medicine, if the words prefixed by the immortal Galen to his *Methodus Medendi*, are, as they most certainly are, true,—"The magnitude of a disease is in proportion to its deviation from the healthy state; and the extent of this deviation can be ascertained by him only who is perfectly acquainted with the healthy state."

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INSTITUTIONS

OF

PHYSIOLOGY.

SECT. I.

OF THE LIVING HUMAN BODY IN GENERAL.

1. In the living human body, regarded as a peculiar organization, there are three objects of consideration*.

The materials of its subsistence, afforded by the fluids;

The structure of the solids, containing the fluids;

Lastly, and principally, *the vital powers*, by which the solids are enabled to receive the influence of the fluids—to propel the fluids—and perform various other motions;

* Thus, long ago, the author of the book, generally included among the writings of Hippocrates, *Epidemic* VI. Sect. 8. § 19. said "Those things which contain, are contained, or moved in us with force, are to be considered." This celebrated passage gave origin to the excellent work of Abr. Kaau Boerhaave, entitled, "*Impetum faciens dictum* Hippocrati *per corpus consentiens*." L. B. 1745. 8vo.

and which, as they, in a certain sense, constitute the essence of the living machine in general, so also are of very different orders: some being common to animals and vegetables, and some peculiar to animals, and intimately connected with the mental faculties.

2. But these three, although really distinct, and therefore distinctly considered by us, are so closely related in the *living* system, (the phenomena, conditions, and laws of whose functions, in the healthy state, are the object of physiology,) that no one can be contemplated, but in its relation to the rest.

For the materials of the body, although originally fluid, are naturally disposed to become solid; and, on the other hand, the solids, besides having been formed from the fluids, abound, however dry they may appear, in various kinds of fluid constituents, both liquid and aeriform: lastly, it may probably be affirmed, that no fibril, during life, is destitute of vital power.

3. We shall now examine each of these separately; and first, the materials afforded by the fluids, which form both the fundamental and most considerable portion of our bodies.*

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* The great preponderance of the fluids is strikingly exemplified in an entire, bnt perfectly dry mummy of an adult Guanche, one of the original inhabitants of the island of Teneriffe. It was sent to my anatomical museum by the illustrious Banks; and though all its viscera and muscles are preserved, does not exceed 7½lbs. in weight.

SECT. II.

OF THE FLUIDS IN GENERAL, AND PARTICULARLY OF THE BLOOD.

4. The fluids of the body may be conveniently reduced to three classes.

A. The *crude;* viz. the chyle, contained in the primæ viæ, and destined to become blood; also, matters absorbed on the surface, and destined to be conveyed to the chyle.

B. The *blood* itself.

C. Those *secreted* from the blood, whether inert and excrementitious, like the urine; or intended for certain purposes in the economy: the latter may be permanently liquid, as the bile—or disposed to solidity, as the osseous and other plastic juices.

5. Of the first and third of these classes we shall hereafter speak, in treating of chylosis, secretion, and the other functions to which each fluid appertains. At present our attention shall be devoted to the *blood,** the chief and primary fluid—the vehicle of those successions of oxygenous (A) and carbonaceous particles, which cease only with life—the nourisher of the frame—the source of almost every fluid—that *into* which the crude fluid is converted, and *from* which all the secretions are derived; and which, with the exception of some exsangueous parts, as

* J. Hunter's *Treatise on the Blood, Inflammation,* &c. London, 1794, 4to.

the epidermis, the arachnoid, the amnion, &c. the vitreous substance of the teeth, the body of the chrystalline lens, &c. is universally diffused through the system, in various proportions, indeed, according to the various natures of the similar parts, to use the language of the ancients,* v. c. abundantly in the muscles and glands, sparingly in the tendons and cartilages.†

6. The blood is a peculiar fluid, of a well known colour and remarkable odour; its taste rather salt and nauseous; its temperature about 96° of Fahrenheit; glutinous to the touch; its specific gravity, though different in different individuals, may be generally estimated as 1050, water being 1000; when fresh drawn, and received into a vessel, it exhibits the following appearances.‡

7. At first, especially while still warm, it emits a vapour which has of late been denominated an animal gas, and shewn to consist of hydrogen and carbon, suspended by caloric.§ This, if collected, forms drops re-

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* They divided the body into *similar* or homogeneous parts, as the bones, cartilages, muscles, tendons, &c.; and *dissimilar*, composed of the similar, as the head, trunk, limbs, &c.

† Physiologists have variously estimated the quantity of the blood in a well formed adult. Allen, Mullen, and Abeildgaard, make it scarcely more than 8 pounds; Borelli, 20; Haller, 30; Hamberger, 80; J. Keil, 100. The former are evidently nearer the truth.

‡ J. Martin Butt. *De spontanea sanguinis separatione.* Edinb. 1760, 8vo. reprinted in Sandifort's *Thesaurus*, vol. ii. J. H. L. Bader. *Experimenta circa sanguinem.* Argent. 1788, 8vo.

§ The *elements* of aeriform fluids of course exist in the blood; that they are not, however, in the *elastic state*, as so many physiologists formerly believed, was clearly shewn in some experiments made by me during the year 1812, upon other mammalia. I found that a small portion of the purest air infused into the jugular vein, excited palpitations, drowsiness, convulsions; and if the quantity was rather insembling dew, of a *watery* nature, but endowed with a nidorous odour, most remarkable in the blood of carnivorous animals, peculiar and truly animal. Much of this watery liquor still remains united with the other parts of the blood.

8. In the mean time the blood, when its temperature has fallen to about 78°, begins to separate into two portions. A coagulum is formed, from the surface of which, as it were, exudes a fluid of a yellowish slightly red colour, denominated *serum*: the more abundantly this exudes, the greater is the contraction of the glutinous coagulum, which has received the appellations of *crassamentum*; and, from some resemblance to the liver, in colour and texture, of hepar sanguineum; of placenta; and from the circumstance of its being surrounded by the serum, of insula.

9. The crassamentum may, by agitation, or repeated ablution, be easily separated into two constituent parts: into the cruor, which imparted to the blood its purple colour, and into the *lymph*, which on washing is forsaken by the cruor, and called, from its greater solidity, the basis of the crassamentum. The stronger affinity of the cruor for the lymph than for the serum, is proved by the necessity of violence to effect their disunion (B). By the removal of the cruor the lymph becomes gradually paler, till it is at length merely a white tenacious coagulum.

10. Besides the watery fluid first mentioned, there are the three constituents of the blood, viz. the *serum*, the *cruor*, and the *lymph*: we shall presently treat of each

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creased, even death ensued. I have detailed these experiments in the *Medic. Biblioth.* vol. i. 177. The illustrious Bichat observed the same effects in his experiments. *Journal de Santé, &c. de Bordeaux*. T. 11. 61.

more particularly. These, however, while recent, and in possession of their native heat, are intimately mixed, and form an equable, homogeneous fluid. Their relative proportion is astonishingly diversified, according to age, temperament, diet, and similar circumstances, which constitute the peculiar health of each individual.

11. The *serum* is a fluid, sui generis; the chief cause of the viscidity of the blood, and easily separable by art into different constituent principles. If subjected to a temperature of 150° Fahr. a portion is converted into a white scissile substance, resembling boiled *albumen*: the rest exhibits besides the watery fluid so often mentioned, a turbid fluid of a *gelatinous*, or rather *mucous** nature, which on cooling appears a tremulous coagulum. The serum is remarkable for the quantity of soda (mineral alkali) which it contains (C).

12. The *cruor* is marked by many irregularities, both in the colour and the figure of its particles. It consists of *globules*, which in recent blood are of a constant form and size, and said to be $\frac{1}{3300}$ of an inch in diameter. Their form, indeed, has been a subject of dispute; but I am disposed to consider it as much more simple than some writers of great celebrity have imagined. I have always found it globular, and could never discover the lenticular shape, which some have asserted that they remarked.

It has been likewise advanced, that the globules change their form, while passing through a vessel of very small capacity; that, from being spherical, they become oval; and when they have emerged into a vessel of larger area,

* J. Bostock, in *The Medico-Chirurgical Transactions, published by the Medical and Chirurgical Society of London*, vol. i. 1809. p. 46.

that they again resume their globular shape.* This, although I would by no means deny it, I cannot conceive to occur during the tranquil and healthy motion of the blood, but should refer it to a spasm of the small vessels.

Their globular figure can be seen in a living animal only, or in blood very recently drawn: for they are soon unobservable, becoming a shapeless mass which resembles serum in every circumstance, excepting colour.

13. Their *colour* is red, and from it is derived the colour of the blood. In intensity it varies infinitely; paler in animals which have been poorly nourished or have suffered from hæmorrhage; more florid, when oxygenized,† (or rendered arterial, to use the common phrase) by exposure either to atmospheric air, or more especially, to oxygen; darker when carbonized (in common language rendered venous) by exposure to carbonic acid gas, or to hydrogen.‡ The redness is most probably to be ascribed

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* G. Chr. Reichel, *De Sanguine ejusque motu experimenta.* Lips. 1767, 4to. p. 27, fig. 3, g. g.

† Unwilling as I am to follow the example of those, who especially in modern times, delight in changing scientific terms, I cannot but think that the words *oxygenized* and *carbonized* may be advantageously substituted for arterial and venous: because arterial blood is contained in some vessels called *veins*, v. c. the pulmonary and umbilical; while, on the other hand, venous blood is contained in the pulmonary and umbilical *arteries*. In the same manner, the veins of the chorion in the incubated egg contain arterial, the arteries venous, blood, to use these expressions in their common acceptation.

‡ Consult among others whom we shall recommend in the chapter on respiration, Chr. Girtanner in the *Journal de Physique*, August 1790.

to the oxide of iron,* the quantity of which, however, is so minute, that it has been most variously estimated (D).

14. The last constituent principle of the blood to be noticed, is the plastic *lymph*, formerly confounded with the serum. This has been called the basis of the crassamentum, the glutinous part, the fibre or fibrous matter of the blood, and, like the caseous part of milk, and the gluten of vegetables, been discovered by late analysis to abound in carbon and azote (E).

15. It is properly denominated plastic, because it affords the chief materials from which the similar parts, especially the muscles, are immediately produced; nourishes the body throughout life, repairs wounds and fractures in an extraordinary manner, fills up the areæ of large divided blood vessels, and forms those concretions which accompany inflammations†, and that remarkable deciduous membrane found in the recently impregnated uterus for the attachment of the ovum.

16. Thus much have we said, respecting the constituent parts and nature of the blood, the most important fluid of the animal machine,—a fluid, which *excites the heart* to

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Fourcroy in the *Annales de Chemie*, T. vij.

Hossenfratz, ibidem. T. ix.

J. Ferd. H. Autenreith, *Experimenta et observata de sanguine præsertim venoso.* Stuttg. 1792, 4to.

* By Will. C. Wells, *Philos. Trans.* 1797, the redness of the blood in general is rather ascribed to the peculiar fabric of the globules, and its various degrees and changes simply to the reflection of light.

† Such are those *spurious membranes* found exuded on the surface of inflamed viscera, v. c. those cellular connections between the lungs and pleura after peripneumony, and the tubes observed within the bronchiæ after croup: such also are those artificial ones called, after their inventor, Ruyschian, and made by stirring fresh blood about with a stick,

contraction, which distributes *oxygen* to every part, and conveys the *carbon* to the excretory vessels, giving rise by this change, to *animal heat*; which originally supplies the *materials* of the *solids*, and afterwards their *nourishment*; from which all the *fluids*, with the exception of the crude (4.) are *secreted* and derived. Of the multifarious importance of the blood, we shall speak particularly hereafter.

NOTES.

(A) The blood is not at present believed to absorb any oxygen durinng respiration. See note (C) to Sect. viii.

(B) The red particles or cruor, are merely suspended in the serum, as Leeuwenhoek and Hartsoeker long since proved, for if, when separated, they are triturated in serum, part of them is taken up and the serum assumes a red colour; but if the fluid is allowed to settle in a cylindrical glass, they slowly precipitate themselves to the bottom, and the serum above becomes clear, as before. The serum easily separates on the coagulation of the lymph; the colouring part does not fall to the bottom before the lymph coagulating envelopes it and prevents its separation: but if the lymph coagulate slowly, as in the phlogistic diathesis, the greater specific gravity of the cruor detaches it very considerably from the lymph, which remains colourless above, constituting what is called the inflammatory coat, crust or buff. Berzelius even believes the lymph to be in a state of solution in the serum, while the cruor is simply suspended in this solution, but the separation of the serum in dropsy, vesication, &c. led Mr. Hunter to a different conclusion. *View of the present State and Progress of Animal Chemistry* by Jöns Jacob Berzelius, M. D. &c. Translated by Dr. Brunnmark, 1813, p. 23. Hunter *On the Blood*, &c. 4to. p. 18.

(C) The coagulable part of serum is albumen; that which remains fluid is called serosity,—a name given it by Cullen, and contains no jelly as the French chemists asserted, but an animal matter different from both jelly and albumen, with a minute portion of albumen and fibrin, a little free soda, muriate, lactate,* and phosphate of soda, and muriate of potash, with $\frac{905}{1000}$ of water.†

(D) It has been generally supposed that iron existed in the red particles of the blood as a subphosphate. Berzelius informs us that serum, although able to dissolve a small portion of the oxides, not indeed of the phosphates of iron, does not acquire a red colour by their addition; and that he has never discovered iron nor lime in the entire blood, although both are so abundant in its ashes; and concludes that the blood contains the elements of phosphate of iron and of lime, and of carbonate of lime, and also of phosphate of magnesia, united in a manner different from their combination in the salts.

(E) Oxygen and hydrogen also exist in fibrin. The fibrin, albumen and colouring matter afford, on decomposition, the same saline and gaseous products. Berzelius

* Berzelius discovers lactic acid free or combined in all animal fluids. It was first noticed by Scheele, but is generally regarded as a combination of acetous acid with animal matter.

† See Dr. Bostock's papers in the first, second, and fourth volumes of *The Medico Chirurgical Transactions*, and Berzelius in the third,

views them all three as modifications of the same substance. Albumen has a greater proportion of oxygen than fibrin, and has sulphur for a constituent part, which consequently cannot be detected while the albumen is entire, any more than the iron while the cruor is entire. The chief differences between the colouring matter and fibrin are colour; the spontaneous coagulation of fibrin at all temperatures, while the colouring matter may be dried without losing its solubility in water, and becomes insoluble only at a certain temperature; and the peculiarity of the latter of not diminishing in volume, like fibrin, during exsiccation.—*Berzelius*, l. c.

SECT. III.

OF THE SOLIDS IN GENERAL, AND OF THE MUCOUS WEB IN PARTICULAR.

17. The solids* are derived from the fluids. In the first rudiments of the gelatinous embryo, they gradually commence in their respective situations, and differ infinitely in their degrees† of cohesion, from the soft and almost pulpy medullary matter of the brain, to the vitreous substance of the corona of the teeth.

18. Besides the gelatinous (11) and glutinous (15) parts of the solids, earth enters more or less into their composition, and is principally lime united with phosphoric acid. The bones possess this in the greatest abundance, particularly in advanced age, whereas in childhood the gelatinous matter abounds.

19. With respect to texture, a great part of the solids consist of *fibres* more or less parallel. This may be observed in the bones, especially of fœtuses,‡ in the mus-

* Hier. Dav. Gaubius' *Spec. exhibens ideam generalem solidarum c. h. partium*. Lugd. Bat. 1725, 4to.

† Abr. Kaau Boerhaave, on the cohesion of the solids in the animal body, in the *Nov. Comm. Acad. Petropolit.* T. iv. p. 343, sq.

‡ The parallel and reticulated bony fibres are most striking in the radiated margins of the flat bones, as we find these in young heads much enlarged by hydrocephalus. I have, in my museum, a preparation of this kind, where in the sphenoid angles of the parietal bones, the fibres are an inch or two in length, distinct and delicate. The hardest parts, the bony and vitreous portions of the teeth, exhibit a structure similar to that which in the zeolite, malachite, hematite, &c. all mineralogists call *fibrous*.

cles, tendons, ligaments, aponeuroses, and in certain mem branes, as the dura mater, &c.

20. In other parts no fibres can be discovered, but the texture is peculiar, called *parenchyma*, from the time of Erasistratus, and differing in different viscera, especially the secreting,—of one kind in the liver, of another in the kidneys.

21. But in all the structures, whether fibrous or parenchymatous, there is interwoven a general *mucous web*,* commonly but improperly styled cellular, because it rather is continuous, equal, tenacious, ductile, sub-pellucid, and glutinous.† By handling, it is easily converted into a cellular and vesicular membrane, and demands a place among the most important and remarkable constituents of the body. (A)

22. For, in the first place, many solid parts, v. c. most membranes and cartilages, may by long continued maceration be resolved into it alone. With some it is so intimately united, as to afford a receptacle and support for other constituents: v. c. the hardest bones consisted at first of cartilage, which was originally condensed mucous membrane; but since become distended by the effusion of bony matter into its substance, which is rendered more lax and cellular. In fact, it is universally present in the solids, if we except the epidermis, nails, and hairs, and the vitreous exterior of the corona of the teeth, in which I have never been able to discover it by employing the strongest acid.

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* Dav. Chr. Schobinger (Præs. Hallero) *De telæ Cellulosæ in fabrica c. h. dignitate*, Gotting. 1748, 4to. Sam. Chr. Lucæ at the end of his *Observ. Anatom. circa nervos arterias adeuntes.* Francof. 1810, 4to.

† Casp. Fr. Wolff in the *Nov. Act. Petropol.* T. vi. p. 259.

23. To the muscles and membranes especially it serves for separation from other parts; to the vessels and nerves for support; and to every part it acts as the common medium of connection.

24. From these facts, two inferences may be drawn. First: That this membrane is so fundamental a constituent of our structure, that, were every other part removed, the body would still retain its form.

Secondly: That it forms a connection between all parts of the system, however different from each other in nature, or remote in situation:—a circumstance worthy of attention, as putting an end to the verbal disputes respecting the continuation of membranes, and affording an explanation of many morbid phenomena.

25. As most of the solids owe their existence to this membrane, so again its origin is derived from the lymph of the blood. I have found the lymph changed into this membrane, when transuded on the surface of inflamed lungs, and by forming false membranes, it afterwards unites these organs to the pleura.

26. We shall now consider some varieties of this membrane. In general, it is more *delicate*, cæteris paribus, in *man* than in animals,—a distinguishing prerogative, by which our sense is rendered more delicate, and our motions and other functions more perfect.* Among different individuals, it varies much in laxity and firmness, according to age, sex, temperament, mode of life, climate, &c.

Finally, it varies in different parts; more lax in the pal-

* I have treated this point at large in my work, *De Generis humani varietate nativa*, p. 46, edit. 3.

pebræ and preputium, and behind the frænum of the tongue; less so around the ears.

27. Besides the purposes before mentioned, (22, 23) it is destined for the reception of several kinds of fluids. Its chief use in this respect is to receive that serous halitus which moistens and lubricates every part. This, when formed by the blood vessels, it imbibes like a sponge, and delivers over to the lymphatics, thus constituting the grand connection between these two systems of vessels.

28. In certain parts its office is to contain peculiar fluids, v. c. in the eye, existing as the vitreous membrane, it contains the vitreous humour: in the bones, as the medullary membrane (improperly denominated internal periosteum), the marrow; in soft parts, it is in great abundance, and contains the rest of the fat, of which we shall speak hereafter.

NOTE.

(A) The generally received appellation of *cellular membrane* appears preferable to that of *mucous web* adopted by Blumenbach from Bordeu (*Recherches sur le tissu Muqueux*), and especially in this work, as our author (par. 40) suggests the title of *vis cellulosa* for the contractile power of the membrane.

SECT. IV.

OF THE VITAL POWERS IN GENERAL, AND PARTICULARLY OF CONTRACTILITY.

29. HITHERTO we have spoken of the solids, as the constituents of the system; we now shall view them as endowed with *vitality*,—capable of receiving the agency of stimuli, and of performing motions.

30. Although vitality* is one of those subjects which are more easily known than defined, and usually indeed rendered obscure rather than illustrated by an attempt at definition, its effects are sufficiently manifest and ascribable to peculiar *powers* only. The epithet *vital* is given to these powers, because on them so much depend the actions of the body during life and of those parts which for a short time after death preserve their vitality, that they are not referrible to any qualities merely physical, chemical, or mechanical.

31. The latter qualities, however, are of great importance in our economy. By physical powers, dependent on the density and figure of the humours of the eye, the rays of light are refracted to the axis; by mechanical, the epiglottis is elastic; by chemical affinity, the changes of respiration are effected. But the perfect difference of

* A host of authors on the vital powers will be found in Fr. Hildebrandt's *Lehrbuch der Physiologie*, p. 54, sq. edit. 2, 1809, to whom we may add E. Bartel's *Systemat. Entwurf einer Allgemeinen Biologie*. Francof. 1808, and J. B. P. A. Lamarck's *Philosophie Zoologique* Paris, 1809, 11 vols. 8vo.

these *dead powers* from those which we are now about to examine, is evident from the slightest comparison of an organized economy with any inorganic body, in which these inanimate powers are equally strong.

32. Indeed the *vital powers* are most conspicuously manifested by their resistance and superiority to the others; v. c. during life, they so strongly oppose the chemical affinities which induce putrefaction, that Stahl and his followers referred their notion of life to this antiseptic property;* they so far exceed the force of gravity, that, according to the celebrated problem of Borelli, a dead muscle would be broken asunder by the very same weight, which, if alive, it could easily raise, &c.

33. As on the one hand, the vital properties are completely different from the properties of dead matter, so, on the other, they must be carefully distinguished from the *mental faculties* which will form the subject of the next chapter: between them, however, there exists an intimate and various relation observable in many phenomena, but especially in the diversity of temperament.

34. The vital energy is the very basis of physiology, and has therefore been always noticed, though under different *appellations*. The titles of impetum faciens, innate heat, archæus, vital spirit, brute life, head of the nervous system, active thinking principle, vital tonic attraction, have been bestowed upon it by different authors.

35. Nor has there been less variety in the *notions* and

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* "Life formally is nothing more than the preservation of the body in mixture, corruptible indeed, but without the occurrence of corruption." STAHL.

"What we call life is opposite to putridity." J. JUNKER.

definitions to which it has given rise; though in this one point all have agreed,—that its nature and causes are most obscure. (A.)

36. As to the question so long agitated by physiologists, whether the diversity of the phenomena exhibited in the similar parts of the living solid, are to be attributed to modifications only, or to distinct species, of the vital energy, we think it best to establish *distinct orders of the vital powers*, according to the variety of phenomena by which they are manifested.

37. These phenomena are threefold. Organic *formation* and increase; *motion* in the parts when formed; *sensation* from the motion of certain similar parts.

38. The first requisite involved in the name and notion of an organized body, is a determinate *form* designed for certain ends. That species, therefore, of the vital powers is most general, which produces the genital and nutritive fluids, and prepares them for organic nature. This species we have denominated the *nisus formativus*, since it is the source of all generation, nutrition, and reproduction, in each organized kingdom.

39. Those vital powers which are manifested (37) by *motion*, properly so called, in parts already formed, may be divided into common and proper. The *common* are those belonging to similar parts which are widely distributed; v. c. contractility to the mucous structure; irritability to the muscular fibre. (B.) The *proper* are those possessed only by individual organs, whose motions are peculiar and characteristic.

40. *Contractility* is as generally distributed as the mucous structure, which it may be said to animate; and therefore would perhaps not improperly be called the *vis cellulosa*. It is characterized by a simple and not very

sensible effort to contract and react upon its contents, especially upon its source of moisture,—the serous vapour, and to propel this into the lymphatic system.*

41. *Irritability*, we mean the irritability of Haller, is peculiar to the muscles, and may be called the *vis muscularis*. It is marked by an oscillatory or tremulous motion, distinguished from the action of simple contractility, by being far more permanent, and by occurring far more easily on the application of any pretty strong stimulus.†

42. Such are the *common* (39) moving vital powers. But some organs differ from the rest so much in their structure, motions and functions, as not to come under the laws of the common orders of vital power. We must, consequently, *either* reform the characters of these orders, institute new ones, and extend their limits, *or*, till this be done, separate these peculiar motions from the common orders, and designate them by the name of *vitæ propriæ*.‡ As examples may be adduced, the motions of the iris; the erection of the nipple; the motions of the fimbriæ of the Fallopian tubes; the action of the placenta, and of the womb during labour; and probably the greater part of the function of secretion.§

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* That Haller and Theoph. de Bordeu, the chief writers on the mucous tela, did not form a just conception of this vital power, will be evident from the latter's *Recherches sur le Tissu Muqueux*, Par. 1767, 8vo. and the dissertation of the former on Irritability in the *Dictionnaire Encyclopedique d'Yverdun*. T. xxv.

† Haller *De Partibus Corp. Hum. irritabilibus* in the *Nov. Comm. Soc. Reg. Scient.* Gotting. T. iv.

‡ I have spoken of these at large both in my treatise *De Iridis Motu* 1784, and my programma *De Vi Vitali Sanguini deneganda* 1795.

§ On the vita propria of the absorbent vessels consult Seb. Justin. Brugmans, *De Causa Absorptionis per Vasa Lymphatica*. Lugd. Bat. 1795, 8vo.

43. So much in regard to the vital powers displayed by motion. (37, 39, 42.) We have now to speak of *sensibility*, which is peculiar to the nervous medulla communicating with the sensorium. It bears the title of *vis nervea*, and is the cause of perception when irritation is excited in parts to which it is distributed. *

44. The *order* which we have followed in enumerating the vital powers, (38, 43,) is that in which they successively arise both during our formation and after birth.

The nisus formativus must take place before we can ascertain the existence of the new conception.

Then contractility is exerted in the gelatinous substance of the embryo.

When the muscular fibres are produced, they acquire irritability.

In those few organs whose motions cannot properly be referred either to contractility or irritability, there next exists a vita propria.

Finally, after birth, sensibility is superadded.

45. Similar also is the *order*, according to which the vital powers, both common and proper, are distributed to the *organized* bodies of each kingdom. †

On the peculiar vital properties of the arteries consult Chr. Kramp, *Kritik der Praktischen Arzneikunde.* Lips. 1795, 8vo.

Many of the phenomena now mentioned are ascribed by others to an orgasm, to use an old expression, struggling from the centre to the circumference, and lately designated vital turgor.

* Fouquet in the *Dictionnaire Encyclopedique de Paris.* T. xv. Art. *Sensibilité.*

† Consult C. Fr. Kielmeyer *Uber die Verhältnisse der organischen Kräfte in der Reihe der verschiedenen organisationen*, 1793, 8vo. H. F. Link *Uber die Lebenskräfte in naturhistorischer Rücksicht. Rostock.* 1795, 8vo.

The formative power must be most universal; without it indeed organization cannot be conceived to exist.

Contractility likewise is common to each kingdom.

Irritability and sensibility, in the sense above explained, are peculiar to animals.

Lastly, the *vita propria* is variously observable in some organs, particularly the generative, both of certain animals and vegetables. (C)

46. It is scarcely necessary to remark, that most of these modes of vital energy, though necessarily distinguished into orders, are *intimately* connected; v. c. the mucous membrane, forming the basis and seat of contractility in so many organs, is interwoven also with the irritable muscular fibres * and the sensible nerves.

47. Whatever may have been the opinions of physiologists respecting the difference or identity of the vital powers, it is universally agreed that they exist in the similar *solid parts*, as the ancients called them, of which the organs or dissimilar parts are composed. But it has been disputed, and particularly of late, whether vitality is peculiar to the solids, or common also to the *fluids*; and the latter being granted, whether or no the *blood* alone is so endowed.

48. As to the *first* question, the whole natural history of each organic kingdom, as far as it has hitherto been cultivated, abundantly shows that those living parts, however delicate, of all known animals and vegetables, are *solid;* a circumstance necessarily implied in their determinate figure destined for certain uses. For, not to speak of entire animals (which, however simple, as worms,

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‡ See Abildgaard in the *Acta Reg. Soc. Med. Havniens.* T. 1.

are nevertheless supplied with enveloping membranes) the newly laid egg, though at first sight merely fluid, on a more careful examination is discovered to consist of different membranes, of the halones, the cicatricula, &c.

Humidity is indeed necessary in the living solid, for the *exertion* of vitality. But that vitality exists in the solid, as solid, is proved by the well known instances of animalcules and the seeds of plants, in which, although long dried, the vital principle is so entire, that they again live and germinate.

49. With respect to the supposed exclusive vitality of the *blood*, I candidly confess that no argument has been adduced in its favour since the time of Harvey, which might not, I think, be more easily, simply, and naturally explained on the contrary supposition.

For example, the incorruptibility of the blood during life, is far more explicable from the perpetual changes which it undergoes, especially in respiration.

That the blood is the material from which the living solids are produced, is no stronger an argument of its vitality, than the formation of nymphææ and so many other remarkable plants, would be for the vitality of water.

It is difficult to comprehend how the coagulation of the lymph of the blood can demonstrate its vitality. The organic formation of this lymph in generation, nutrition, and reproduction, depends not upon the lymph itself, as lymph, but upon the action of the nisus formativus (38) upon it.

50. Those who formerly contended* that the blood

* V. C. Dan. Bernouilli *De Respiratione*, Basil, 1721.

acquires in the lungs from the air a certain principle to be universally distributed during circulation, for the purpose of imparting motion, &c. to the organs, were right, if they regarded that principle (analogous to the *oxygen* of the moderns) as the stimulant of the living solid; wrong, if they regarded it as vitality itself.

51. For it is on all hands agreed, that no motion occurs but upon the action of *stimuli*, to receive which action the vital powers are naturally adapted and intended.

52. These stimuli,* however multifarious, are conveniently reduced to three classes; *chemical*, *mechanical*, and *mental*. For the present, we shall say nothing of their various modes of action, in some instances direct, in others indirect, by sympathy and sensorial reaction. It is sufficient at present to cite a few examples of functions, to which each class of stimuli conspires: such is the increased secretion of tears, saliva, bile, &c. and the venereal turgescence of the genitals.

53. If the nature of stimuli is infinitely various, no less so are their *effects*, according to their nature, intensity, or continued and repeated application to the living solid. Hence they are generally divided into *exciting* and *depressing*.

54. The power of certain stimuli in increasing the effects of others, is very remarkable: v. c. the power of ca-

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"Respiration supplies a very subtle air, which, when intimately mixed with the blood, greatly condensed, conveyed to the moving fibres, and allowed by the animal spirits to exert its powers, inflates, contracts, and moves the muscles, and thus promotes the circulation of fluids, and imparts motion to mobile parts."

* Laur. Bellini *De Sanguinis Missione*, p. 165—193.

Sylvest. Douglas *De Stimulis*. Lugd. Bat. 1766.

loric, upon which probably national temperament chiefly depends.* That of joy, a most energetic mental stimulus, is similar.† Likewise perhaps that of oxygen, (50) by whose chemical stimulus the vital powers, particularly irritability, are greatly excited and more disposed to react, upon the impulse of other stimuli.

55. Not less considerable than the variety of stimuli, is that *more minute* discrepancy of the different organs, and of the same organs in different individuals, according to age, sex, temperament, idiosyncrasy, habit, mode of life, &c., to which are owing the diversified effects of the same stimuli upon different organs,‡ and even upon the same in different individuals, and upon which depends what the English have lately termed *specific irritability*.§

56. Lastly, the influence of stimuli by means of *sympathy*, is very extraordinary: by its means, if one part is excited, another, frequently very remote, consents in feeling, motion, or some peculiar function.||

The primary and most extensive cause of sympathy

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* Montesquieu *De l'Esprit des Lois*. T. ii. p. 34. London, 1757, 8vo.

† Jo. Casp. Hirzel *De Animi læti et erecti efficacia in Corpore sano et ægro*. Lugd. Bat. 1746.

‡ Called *Le Tact ou le Gout particulier de chaque Partie*, by Theoph. de Bordeu, in his *Recherches Anatomiques sur les Glandes*, p. 376, sq.

§ Sam. Farr *on Animal Motion*, 1771, 8vo. p. 141.

Jo. Mudge's *Cure for a recent catarrhous Cough*. Edit. 2. 1779, 8vo. p. 238.

Gilb. Blane *On Muscular Motion*, 1788, 4to. p. 22.

J. L. Gautier *De irritabilitatis Notione*, &c. Hal. 1793, 8vo. p. 56.

|| J. H. Rahn *De Causis Physicis Sympathiæ*. Exerc. I.—vii. Tigur. from 1786, 4to.

Sylloge selectiorum opusculor de mirabili sympathia quæ partes inter diversas c. h. intercedit. Edited by J. C. Tr. Schlegel. Lips. 1787, 8vo.

must be referred to the *nerves*,* and indeed chiefly to the *sensorial reaction*;† so that if one nervous portion is excited, the sensorium is affected, which, reacting by means of the nerves on another part, draws it into consent with the first, although there exist between them no immediate nervous connection. Such is the sympathy of the iris, when the retina is stimulated by light; and of the diaphragm during sneezing, when the Schneiderian membrane is irritated.

There are other examples of sympathy, in which the nerves, if they have any, have a more remote and accessory share;‡ among these must be placed the sympathy along the *blood vessels*, strikingly instanced between the internal mammary and epigastric arteries, especially in advanced pregnancy: that along the *lymphatic vessels*,§ also most remarkable during pregnancy and suckling: and again, that dependent on *analogy of structure and function*, v. c. the sympathy of the lungs with the surface and intestines. (E)

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* G. Egger (the author Lawr. Gasser) *De consensu nervorum*. Vindob. 1766, 8vo.

† J. G. Zinn's Observations on the different Structure of the Human Eye and that of Brutes. Diss. ii. 1757. in the *Comment. Soc. Reg. Scient. Gotting. antiquiores*. T. I.

‡ Consider the constant sympathy of heat between certain parts of some animals, v. c. of the hairs with the fauces, in variegated rabbits, sheep, dogs, &c. of the feathers with the covering of the bill and feet in varieties of the domestic duck. That many such instances are not referable to the influence of nerves, I contended in my *Comm. de Motu iridis*, p. 12, et seq. and also in my work *de Generis humani varietate nativa*, p. 364, et seq.

§ Innumerable pathological phenomena will be found explained by this sympathy in S. Th. Soemmerring's *De Morbis Vasorum Absorbentium Diss. quæ præmium retulit*. Francof. 1795. 8vo.

57. The vital powers will be hereafter separately considered, under the distinct heads of our subject. The nisus formativus under the head of Generation; irritability under that of the Muscles; sensibility under that of the nervous System; the *vita propria* when occasion requires.

58. Besides our former brief remarks (40) upon *contractility*, a few more minute will at present be very opportune.

It prevails universally, (40) wherever the mucous tela is discoverable.

It is consequently most abundant in parts destitute of proper parenchyma, but composed almost entirely of mucous tela, v. c. in certain membranes: for no one will deny their contractility, who reflects upon the spastic motions of the dartos, the male urethra, or the gall bladder, which during death is always closely contracted upon any calculi it may contain.

It appears also in those viscera which consist chiefly of this tela, v. c. in the lungs, whose external surface we have found on living dissection very contractile; but by no means, as Varnierus asserts, truly irritable. (F)

The presence of contractility even in the bones, is demonstrated by the shrinking of the alveoli after the loss of the teeth, and by the process of necrosis, by which the new bone, when the dead portion is extricated from its cavity, contracts to its natural size and figure. (G)

The vitreous substance of the teeth being destitute of this tela (22) possesses no contractility, as I think appears from the circumstance of its not shrinking, like the alveoli, if a portion is separated by caries or fracture.

59. This contractility of the mucous tela is the chief cause of strength, health, and beauty; since on it depend

the vital elasticity and fulness,* and indeed the *tone* of parts, so elegantly described by Stahl; for by its means, the mucous tela, to mention one only of its functions, absorbs, during health, the serous fluid (27) like a sponge, and propels it into the lymphatic vessels: in disease, on the contrary, having lost its tone, it is filled with water, giving rise to œdema and similar cachexies.

60. Finally, the great influence of this contractility in producing the peculiar constitution and temperaments of individuals, is manifest from its universal presence, its close union with the other vital powers, and from its infinite modes and degrees in different persons.

NOTES.

(A.)
(B.)
(C.)
(D.) } See Note to Sect. VI.

(E) Mr. Hunter divides sympathy into general and partial; such as fever from a wound, and convulsion of the diaphragm from irritation in the nose. Partial sympathy he subdivides into remote, contiguous and continuous,—Where there is no evident connection between the sympathising parts, sufficient to account for the circumstance,—where there is proximity of the sympathising parts,—and where, as most commonly, the sympathising parts are continuous.†

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* Hence after death, even in young subjects full of juices, the back, loins, and buttocks, having for some time lost their vital tone, are, if the body is supine, depressed and flattened by the superincumbent weight, which now is not resisted: this appearance I regard among the indubitable signs of death.

† *Treatise on the Blood, &c.* Introduction.

Bichat's division is much better.* It cannot be understood, indeed, till after the perusal of the note to the sixth section. He considers sympathy as affecting either animal sensibility or contractility, or organic sensibility or contractility. Sympathy does not arise from nervous communication, because it frequently happens that no particular nervous communications of sympathising parts are discoverable, while remarkable ones exist between other parts not disposed to sympathise.† Sympathy of animal contractility occurs only when the nerves, connecting the affected muscles with the brain, are entire; when they were divided by Bichat, the convulsions in the corresponding muscles ceased. The sympathies of the organic functions are never ascribable, as many might imagine, to continuity of surface; for after dividing the œsophagus of a dog, Bichat produced vomiting equally as before, on irritating the fauces.

(F) Our author here, as in paragraph 135, means the pulmonary portion of the pleura, and very properly regards this and other serous membranes, as condensed cellular substance; that is, as a substance not originally cellular and now condensed, but of the same nature with the cellular membrane, though much more compact. Consult Bichat's *Traité des Membranes*.

(G) See note to sect. 6.

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* *Anatomie Generale*. T. i. p. 183, sq.

† Consult Whytt's *Observations on Nervous Diseases*. Ch. i.

SECT. V.

OF THE MENTAL FACULTIES.

61. MAN, whom we have found possessed of a body, answering completely both in matter and texture, as well as vital powers, the purposes of its formation, is endowed likewise with a *mind*, a "divinæ particula auræ," intimately connected with the body, and developing by education and exercise various kinds of faculties, which we shall concisely enumerate, as far as they belong to our subject.*

62. The sensibility of the nerves, mentioned above among the vital powers, (43) constitutes, as it were, the medium which propagates the impressions of stimuli upon sensible parts, and especially upon the organs of sense (to be hereafter examined), to the sensorial portion of the brain, in such a manner that they are perceived by the mind.

63. The mental faculty to be first enumerated, and indeed to be placed at the bottom of the scale, is the faculty of *perception*, by means of which the mind takes cognizance of impressions made upon the body, and chiefly upon the organs of sense, and becomes furnished with ideas.

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* Consult Alex. Chrichton's *Inquiry into the nature and origin of mental derangement, comprehending a concise system of the Physiology and Pathology of the human mind.* Lond. 1798, 2 vols. 8vo. Imm. Kaut's *Authropologie in pragmatischer Hinsicht.* Könisb. 1798, 8vo. Chr. Meiner's *Untersuchungen über die Denkkräfte und Willenskräfte des Menschen nach Anleitung der Erfahrung.* Gött. 1806, 2 vols. 8vo.

64. This faculty is assisted by another of an higher order,—*attention*, which so directs the mind when excited to any idea, that it dwells upon that idea alone, and surveys it fully.

65. To preserve and recall the marks of ideas, is the office of *memory*, that part of the mind, which, in the language of Cicero, is the guardian of the rest.

66. *Imagination**, on the contrary, is that faculty of the mind, which represents not merely the signs, but the very images of objects in the most lively manner, as if they were present before the eyes.

67. *Abstraction* forms general notions more remote from sense.

68. *Judgment* compares and examines the relations of the ideas of sense and of abstract notions.

69. Lastly *reason*,—the most noble and excellent of all the faculties, draws inferences from the comparisons of the judgment.†

70. The combination of these constitutes the *intellec-*

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* The difference, analogy, and relation of memory and judgment, have given rise to various controversies. Some celebrated psychologists have included both under the word *imagination* taken in its most comprehensive sense, and have divided it into two species; *memory*, representing former ideas, and the *facultas fingendi*, representing such ideas only as are formed by abstraction. They again divide memory into *sensitive* (imagination in a stricter sense) and *intellectual*.

Their *facultas fingendi*, they also subdivide into *intellectual* (the more excellent), and *phantasy*, obeying mechanical laws. Feder's *Grundsätze der Logik und Metaphysik*. GÖTTING. 1794, p. 20.

† Of this the highest prerogative of the human mind, by which man exerts his dominion over other animals, and indeed over the whole creation, I have fully treated in my book *De Gen. Hum. Var. Nat.* p. 32, ed. 3.

tual faculty; but there is another order, relating to *appetency*, to take the word in its most extensive meaning.

71. For since we are impelled by various internal stimuli to provide food and other necessaries, and also to satisfy the sexual instinct, and are impelled the more violently, in proportion as imagination inflames our wishes, *desires*, properly so called, are thus produced; and if, on the other hand, the mind becomes weary of unpleasant sensations, *aversions* occur.

72. Finally, that faculty which selects out of many desires and aversions, and can at pleasure determine to perform functions for certain purposes, is denominated *volition*.

73. Our order of enumeration corresponds with that of the development of the faculties, and with the relation in which those termed brute,—common to man and animals, and those more or less peculiar to man, stand to each other.

NOTE.

The great peculiarities of Gall's Metaphysics are, that the faculties usually regarded as distinct, are considered common; and certain faculties established which were not regarded as distinct. Spurzheim enumerates thirty-three distinct faculties, and the various modes of operation common to all these, constitute judgment, memory, &c.—the distinct faculties of former metaphysicians.

SECT. VI.

OF HEALTH AND HUMAN NATURE.

74. SINCE *health,** which is the object of physiology, depends upon such an harmony and equilibrium of the matter and powers of the system, as is requisite for the due performance of its functions, it is very evident how the four principles examined above, contribute to its support.

75. *Fluids* properly prepared are the first requisite; in the next place, *solids* duly formed from the fluids; then the invigorating influence of the *vital powers;* lastly, a sound *mind* in this sound body.

76. These four principles *act* and *react* perpetually upon each other: the fluids are stimuli to the solids; these again are calculated by their vital powers to experience the influence of these stimuli, and react upon them. In reference to the intimate union of the mind with the body, suffice it at present to remark, that it is far more extensive than might at first be imagined. For instance, the influence of the will is not contained in the narrow limits of those actions designated voluntary in the schools of physiology; and the mind, on the other hand, is influ-

* Theod. G. Aug. Roose *Uber die Krankheiten der Gesunden,* Gotting, 1801, 8vo.

G. Chr. Klett, *Tentamen evolvendi notionem de sanitate hominis,* Wirceb. 1794, 8vo.

enced by the affections of the body, in many other ways than by the perceptions of sense.*

77. From the endless variety and modification of the conditions belonging to these four principles, it may be easily understood, what great *latitude* † must be given to the notion of health. For since, as Celsus long ago observed, every one has some part weaker than the rest, Galen may in this sense assert with truth, that no one enjoys perfect health. And even among those whom we commonly regard as in good health, this is variously modified in each individual.‡

78. Upon this endless modification is founded the difference § of *temperaments;* or, in other words, of the mode and aptitude of the living solid || in each individual, to

* Galen, *quod animi mores corporis temperaturas sequantur.*

St. J. Van Geuns, *De corporum habitudine animæ hujusque virium indice ac moderatrice.* Harderv. 1789, 4to.

† Galen, *De sanitate tuenda,* L. 1.

‡ W. F. Ad. Gerresheim, *De sanitate cuivis homini propria.* Lugd. Bat. 1764, 4to.

§ Lavater's *Physiognomische Fragmente.* T. iv. p. 343.

W. Ant. Ficker's *Comment. de temperamentis hominum quatenus ex fabrica et structura corporis pendent.* Gott. 1791, 4to.

J. N. Hallé in the *Mem. de la Soc. Médicale d'Emulat.* T. iii. p. 342.

|| To the numerous arguments by which the moderns have overthrown the doctrine of the ancients, and proved that the temperament depends on the living solids, rather than on the nature of the blood, I may add the celebrated example of the Hungarian sister twins, who, at the beginning of the last century, were born united at the lower part of the back, and attained their twenty-second year in this state. They were, as is well known, of very different temperaments; although dissection discovered, that their sanguiferous systems anastomosed so considerably, that the blood of both must have been the same.

be affected by stimuli, especially the mental; and again, of the mental stimuli, to be excited with greater or less facility.

79. So various are the differences of degree and combination in the temperaments, that their *divisions* and orders may be multiplied almost without end. We shall content ourselves with the four orders commonly received.* The *sanguineous*—excited most readily, but slightly: The *choleric*—excited readily and violently: The *melancholic*—excited slowly, but more permanently: And the *phlegmatic*—excited with difficulty.

This division, although built by Galen upon an absurd foundation borrowed from an imaginary depravation of the elements of the blood, appears, if made to stand alone, both natural and intelligible.

80. The predisposing and occasional *causes* of the diversity of temperaments are very numerous; v. c. hereditary tendency, habit of body, climate, diet, religion, mode of life, and luxury.†

81. Besides the variety of temperaments, circumstances peculiar to every individual, by influencing the *number*, as well as the *energy* and *vigour* of the *functions*, increase the latitude (77) in which the term health must be received. In regard to age, the health of a new-born infant is different from that of an adult; in regard to sex, it differs in a marriageable virgin and an old woman past child-bearing, and during menstruation and suckling; in regard to mode of life, it is different in the barbarous tribes of North America, and in effeminate Sybarites.

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* Kant, l. c. p. 257, sq.

† Feder in the *Untersuchung über den menschlichen Willen*. T. ii. p. 49.

Moreover, in every person, custom has an extraordinary influence* over certain functions, v. c. sleep, diet; and has therefore acquired the name of second nature.

82. The more functions flourish simultaneously in the body, the more considerable is its *life;* and *vice versâ.* Hence life is greatest, when the functions have attained their highest perfection in adult age; and least, when the functions, although very perfect, are fewer and more sluggish, v. c. in the newly conceived embryo; life is for the same reason less vigorous during sleep than during the opposite state.

83. The functions have been long divided by physiologists into four classes. This division, although not unexceptionable, nor exactly conformable to nature,† may assist the memory.‡

1. The first class comprehends the *vital* functions, so termed, because their uninterrupted and complete performance is necessary to life. Such are the circulation and respiration.

2. The second comprehends the *animal* functions, by which animals are chiefly distinguished from vegetables.

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* Galen *De Consuetudine.*

G. E. Stahl. *De consuetudinis efficacia generali in actibus vitalibus.* Hal. 1700, 4to.

H. Cullen, *De Consuetudine.* Edinb. 1780, 8vo.

C. Natorp, *De vi consuetudinis.* Gott. 1808, 4to.

† See Platner's *Quæst. physiol.* p. 31. *Versuch einer Anthropologie.* T. i. p. 100, 222, and my own remarks on the bad foundation of this division, in the preface to my *Enchiridion Anat. Comparatæ,* p. xi. sq.

‡ J. J. Bernhard's *Versuch einer Vertheidigung der alten Eintheilung der Functionen, und einer Classification des organisirten Körper, nach denselben,* Erf. 1804, 8vo.

Such is the connection of the mind with the body, especially sense and muscular motion.

3. The third is the *natural,* by means of which the body is nourished.

4. The fourth, the *genital,* intended for the propagation of the species.

We shall now examine each of these separately, beginning with the vital. (A)

NOTES.

(A) The consideration of a division as ancient as Aristotle, and much preferable to that which Blumenbach adopts, will perhaps form an useful note to the eighty-third paragraph and the greater part of the fourth section.

In this, the functions are arranged in two classes; the animal constituting one peculiar to animals; and the vital and natural united into another, common to vegetables and animals, under the title of organic or vital. The generative relating in their object to the species rather than to the individual, and of but temporary duration, may be thrown into a separate and inferior division.

We owe the revival of this classification, and our knowledge of the characteristics of each class of functions, to Dr. Philip Wilson* and Xavier Bichat,† al-

* *Treatise on Febrile diseases.* Ch. iii. Sect. 3. First Edition, 1799. *Paper read to the Royal Med. Society of Edinburgh,* 1791, *or* 1792, *and inserted in its Records. Essay on Opium,* 1795.—*Edinburgh Med. and Surgical Journal,* July, 1809, p. 301, sq.

† *Recherches Physiologiques sur la Vie et la Mort.*

though the latter, from having published a work expressly on the subject, has received the whole honour, both in Great Britain and on the Continent.*

The *animal* functions render us feeling, thinking and willing beings; they are the actions of the senses which receive impressions, of the brain which perceives them, reflects upon them, and wills, of the voluntary muscles which execute the will in regard to motion, and of the nerves which are the agents of transmission. The brain is their central organ. The *vital* or *organic* functions are independent of mind, and give us simply the idea of life: they are digestion, circulation, respiration, exhalation, absorption, secretion, nutrition, calorification. The heart is their central organ.

The organs of the animal functions are double and correspondent, there being on each side of the median line of the body, either two distinct organs, as the eyes, ears, extremities; or two correspondent halves, as is the case with the brain, spinal marrow, nose, tongue, &c.

The organs of the vital or organic functions, are in very few instances double, or situated with their centres in the median line and possessed of symmetrical halves; witness the heart, stomach, liver. There are indeed two kidneys, but they continually differ in size, figure, and situation: the two lungs are very dissimilar.

Hence Bichat infers, that in the animal functions a harmony of action in each organ, or each half of the organ, is indispensable to perfection, when both organs or sides act together; and that if such harmony do not

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* Bichat's *Anatomie Generale*, Tom. 1, cii. et ciii.

occur, it would be better, were one organ or one half to act alone. This is unquestionably true of the eye, but can be supposed by analogy only with regard to the brain, ears, &c. It certainly does not hold good in the action of the voluntary muscles, or in the operations of the brain or spinal marrow in willing their actions. From the duplicity of the organs, it also happens that one side may cease to act without detriment to the function of the other, while in the vital or organic class no harmony of action is possible, and the derangement of any one part of an organ generally affects the whole; an obstruction in the colon disturbs the functions of the whole alimentary canal.

The animal functions experience periodical intermissions—sleep. The organic or vital continue incessantly, suffering merely remissions. The blood constantly circulates, the perspiratory fluid is constantly secreted, the stomach has no sooner digested one meal than we commit another to it: yet we shall hereafter see that the actions of the heart, lungs, &c. have daily intervals of relaxation.

The animal functions are much influenced by habit; the vital or organic are considered by Bichat as removed from its influence. The effects of habit on our sensations and voluntary motions are manifest: yet I think them equally great upon the organic functions. The operation of food and all descriptions of ingesta is most remarkably modified by habit; through it poisons become comparatively innoxious, and divers bear a long suspension of respiration.

Bichat regards the passions as directly influencing the organic functions only, and springing from the state of the organs of that class. Here he is to me perfectly un-intelligible. Vexation indeed disturbs the stomach, and fear augments the quantity of urine; but does not vexation equally and as directly disturb the mind? Are not, in fact, the passions a part of the mind?—a part of the animal functions? They powerfully affect, it is true, the organic or vital functions, but this shows the close connection merely between the two classes of functions.

This connection is conspicuous in respiration, the mechanical part of which belongs to the animal functions, the other to the organic; and in the alimentary actions, in which the food is swallowed and the fæces rejected by volition, and the digestion, &c. performed independently of our influence, by the powers of simple life. So close indeed is this connection, that every organ of the animal class is the seat of organic functions: in the voluntary muscles, the organs of sense, and even in the brain, circulation, secretion, and absorption are constantly carried on. This connection is likewise apparent in the property of sensibility. The vital or organic properties of the machine are fundamentally sensibility and contractility. In the language of Bichat there are *animal sensibility and contractility*, and *organic sensibility and contractility*, besides the common extensibility of matter, which he terms *extensibilité de tissu*, and common contractility upon the removal of distention,—*Contractilité par défaut d'extension*, confounded by Blumenbach (58. clause 5 and 6) with purely vital contractility, and indeed greater during life than afterwards.* *Animal sensibility* is accompanied by

* The following is Bichat's table of the properties of the living body.

a perception in the mind, as in seeing, hearing, tasting, smelling, feeling: *animal contractility* is excited by the volition of the mind conveyed to the voluntary muscles by means of the nerves. *Organic sensibility* is attended with no perception, and is followed by contraction totally independent of the will; the heart feels, if we may so speak, for physiology has no proper term for the idea, the stimulus of the blood, and, without our influence, forthwith contracts; the lacteals feel the stimulus of the chyle without our knowledge, and propel it without our assistance. But although we never acquire the least direct voluntary power over the actions of organic contractility,

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	Classes.	*Genera.*	*Species.*	*Varieties.*
Properties.	1 Vital	1 Sensibility	1 Animal	
			2 Organic	
		2 Contractility	1 Animal	
			2 Organic	1 Sensible. Such as the motion of the heart and *alimentary* canal.
				2 Insensible. Such as the motion of the *capillaries*.
	2 Structural	1 Extensibility		
		2 Contractility		

Although these are the general properties of the living frame, yet each part has besides some peculiarity, altogether inexplicable, not in the least, I think, to be accounted for on Bichat's supposition of eaeh part possessing a certain *degree* of organic sensibility in relation to its fluids. What causes the vessels of muscle to produce muscle; of bone, bone; of membrane, membrane; what causes the secreting vessels of the liver to form bile, and of the testes semen, we know not. These circumstances may be called by Blumenbach after Bordeu *vitæ propriæ*; but it must be carefully remembered that this expression simply denotes a fact, and affords no explanation.

—over the peristaltic motion of the intestines, or the contractions of the blood vessels, yet every organ of the organic functions may have its organic sensibility heightened into animal sensibility, as inflammation, for instance of the pleura and the joints, daily demonstrates; indeed, in some organs of that class of functions, we invariably have sensation; the stomach is the seat of hunger; in the lungs we experience an uneasy sensation the moment their air is expelled.

The nerves of the animal functions run to the brain or spinal marrow; those of the organic chiefly to ganglia; but, as might be expected, the two nervous systems have abundant communications.

The animal functions have not only a shorter existence than the organic from their necessity of alternate repose, but they flourish for a shorter duration,—they do not commence till birth; they decline, and in the natural course of events, terminate earlier; the organs of sense and the mental faculties fail before the action of the heart and capillaries. The decay of the animal functions must, in truth, be the consequence of the decay of the organic, because there are fundamentally in every part organic functions,—circulation, nutrition, &c. and the perfect performance of these in the organs of the animal functions is indispensable to the perfect performance of the animal functions. Hence the impairment of these organic functions, even to a small extent, will derange or diminish the animal functions, which thus will decline while the organic functions are still in sufficient strength for the parts to remain alive.

We thus find in every living system a class of functions, not in themselves dependent upon mind, as perfect in the vegetable as in the animal, and pervading every part of the system. In animals there further exist certain parts which when endowed with the common life of other parts,—with the organic properties, are able to perform peculiar functions to which we give the appellation of mind: the organ of these functions is termed brain, and by means of nerves and medullary prolongations, it maintains a correspondence with the whole machine, influenced by and influencing the most distant parts. The phenomena of the mind have been metaphysically considered in the fifth section; they will be examined as functions of the nervous system in the twelfth.

The ORGANIC FUNCTIONS constitute life in the proper acceptation of the word. The word life should be regarded, like the word attraction or repulsion, as merely an expression of a fact. In this point of view it may be as easily defined as any other expression. By life we generally mean the circumstance of organized matter preserving its particles in such chemical relations as to prevent other chemical relations from inducing disorganization, or even increasing or decreasing, by internal appropriation and separation; greatly inclining to preserve a temperature distinct from that of the surrounding medium; moving certain parts of itself sensibly (as muscles) or insensibly (as the capillaries) independently of mere impulse, attraction, or repulsion, or able (as seeds) to do these things under favourable circumstances: or if not organized (as the fluid which becomes the embryo, the blood,) the circumstance of matter produced by an organized body endowed with the properties above mentioned, resisting the ordinary chemical influences, and being capable of directly becoming (as the female genital fluid) an organized system so endowed, or of directly contributing (as the blood) to the organized substance of an already formed system so endowed.

That fluids are as susceptible of life as solids I cannot doubt. There is no reason why they should not be so, although a person who has not thought upon the subject may be as unable to conceive the circumstance as a West Indian to conceive that water may by cold become solid. It is impossible to deny that at least the fluid which becomes the embryo, possesses life, because it becomes an organized being: although some may perhaps contend that the male semen acts simply the part of a peculiar stimulus to the living fluid of the ovarian vesicle, others that the life of the fluid of the ovarian vesicle is afforded by the male semen. However, Blumenbach in his *Commentatio de vi vitali sanguinis,** grants both male and female genital fluids to be alive, notwithstanding that he fancies his victory over the defenders of the blood's life so complete, that like that of the unfortunate Carthaginian Dido, "*in ventos vita recessit.*" It is as easy to conceive the blood to be alive as the ovarian fluid. The great asserter of the life of the blood is Mr. Hunter,† and the mere adoption of the

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* In universum sane post omnia quæ super hoc argumento sive meditando sive experiundo hactenus elicere licuit, nulli humorum nostri corporis genuina vis vitalis tribuenda videtur, si unice a genitali utriusque sexus latice discesseris, utpote cui jam arte quam uterino cavo exceptus et intime mixtus in fœtus formationem abit, vitales inhærere vires formativas, præter alia paterni vultus in nepotes propagata similitudo, aliaque id genus phænomena haud infitianda demonstrare videntur. *Comment. Soc. Reg. Societ. Gotting.* vol. ix. p. 12.

† The doctrine of the life of the blood was maintained by Harvey (Exercit. L. *De generationis ordine,* &c.) Glisson (*De ventriculo et intestinis*) and Albinus (Blumenbach's *Commentat.* l. c.) I am sur-

opinion by Mr. Hunter would entitle it to the utmost respect from me who find the most ardent and independent love of truth, and the genuine stamp of profound genius in every passage of his works. The freedom of the blood from putrefaction, while circulating, and its inability to coagulate after death from arsenic, electricity and lightning, may, like its inability to coagulate when mixed with bile, be simply chemical phenomena, independent of vitality. But its inability to coagulate after death from anger or a blow on the stomach, which deprive the muscles likewise of their usual stiffness; its accelerated coagulation by means of heat; perhaps its diminished coagulation by the admixture of opium; its earlier putridity when drawn from old than from young persons; its freezing, like eggs, frogs, snails, &c. more readily when once previously frozen (which may be supposed to have exhausted its powers); its directly becoming the solid organized substance of our bodies, while the food requires various intermediate changes before it is capable of affording nutriment; the organization (probably to a great degree independent of the neighbouring parts) of lymph effused from the blood; and finally the formation of the genital fluids, one at least of which must be allowed by all to be alive, from the blood itself; do appear to me very strong arguments in favour of the life of the blood.† I am inclined with Mr. Hunter to believe that

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prised that Moses should be adduced as authority for this opinion. When he says (*Leviticus*, ch. xvii. 11, 14.) "For the life of the flesh is in the blood"—"For it is the life of all flesh," he can mean only that when it is withdrawn, life ceases,—that it is necessary to the life of animals. He says (v. 14.) "the blood of it is FOR the life thereof."

* Consult Hunter's *Treatise on the Blood*, &c. p. 1, ch. 1.

the chyle is alive, and that vivification commences even in the stomach, although I should be sorry to go the same lengths with Albinus, who was willing to grant life even to the excrement. For the excretions must be regarded as dead matter, useless and foreign to the system, and they all run with the greatest rapidity into decomposition. In retention of urine, the surgeon always finds this fluid abominably fœtid; the fæces become so when not discharged in due time, and the neglect of washing the surface is the source of filthiness and disease.

The essential nature of life is an impenetrable mystery, and no more a subject for philosophical enquiry than the essential nature of attraction or of matter. We have reason to believe that life never originates, but was granted at the creation, and is propagated from parent to offspring; it is the property of organized systems, producing various effects by various kinds of organization, but not quite peculiar to organized matter, because capable of being possessed by matter in a fluid state.

The ANIMAL FUNCTIONS demonstrate mind. This is seated in the brain, to which the spinal marrow, nerves, and voluntary muscles are subservient. Mind is the function of the living brain. As I cannot conceive *life* any more than attraction unless possessed by matter, so I cannot conceive *mind* unless possessed by a brain endowed with life.* I speak of terrestrial or animal mind; with angelic and divine nature we have nothing to do, and of them we know nothing. To call the human mind a ray of the divinity appears to me absolute nonsense. Animals are as fully endowed with mind,—with a

* See note (E) to Sect. 44.

consciousness of personality, with feelings, desire and will, as man. Observation shows that superiority of mind in the animal creation is exactly commensurate with superiority of brain; that activity of mind and brain is proportional; and that as long as the brain is endowed with life, and remains uninjured, it, like all other organs, can perform its functions, and mind continues; but, as in all other organs, when its life is gone, its function, mind, is gone; when causes of disturbance affect it, its function, mind, is affected; if originally constituted defective, its function, mind, is defective; if fully developed, and properly acted on, its function, mind, is well performed; accordingly as it varies, is the mind also varied; and the character of the mind agrees with the character of the body, being equally irritable, languid, or torpid, evidently because the brain is of the same character as the rest of the body to which it belongs: the qualities of the mind are also hereditary,* which they could not be, unless they depended, like our other qualities, upon corporeal conditions; and the mind is often disordered upon the disappearance of a bodily complaint, just as other organs, besides the brain, are affected under similar circumstances; the retrocession of an eruption may affect the lungs, causing asthma; the bowels, causing enteritis; or the brain, causing insanity; insanity and phthisis sometimes alter-

* Parentibus liberi similes sunt non vultum modo et corporis formam, sed animi indolem, et virtutes, et vitia.—Claudia gens diu Romæ floruit impigra, ferox, superba: Eadem illachrymabilem Tiberium, tristissimum Tyrannum produxit: tandem in immanem Caligulam et Claudium, et Agrippinam, ipsumque demum Neronem, post sexcentos annos desitura. Gregory's *Conspectus Medicinæ Theoret.*

nate with each other, just like affections of other organs.* The argument of the pious and acute Bishop Butler that the soul is immortal and independent of matter, because in fatal diseases the mind often remains vigorous to the last,† is perfectly groundless, for any function will remain vigorous to the last if the organ which performs it is not the seat of the disease, nor much connected by sympathy or in other modes with the organ which is the seat of the disease. The stomach often calls regularly for food, and digests it vigorously, while the lungs are all but completely consumed by ulceration. As Physiologists we should say, that the mind must perish with the brain, as much as the secretion of bile with the liver; and the consciousness which we have of personality, can give us no reason to believe ourselves distinct from earth, for this, the fly possesses equally with the philosopher about whose head it buzzes. But although I can discover in the human mind nothing necessarily implying immortality more than in the minds of brutes, its immortality I firmly believe, because declared in Revelation, which *reason* compels me to believe. Our immortality, while the beasts of the field utterly perish, I cannot but regard as the free gift of God, perfectly independent of the constitution which he has given us. Our resurrection is not only declared in the sacred scriptures, but with it the moral government and order of the world, and " our innate

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* That evil spirits had never more hand in causing insanity than indigestion, is clearly proved to every *medical man* in Farmer's *Essay on the Demoniacs of the New Testament.*

† *The Analogy of Religion natural and revealed to the Constitution and Course of Nature.* By Joseph Butler, LL. D. Lord Bishop of Durham, p. 33.

pleasing hope, our fond desire, our longing after immortality, our secret dread and inward horror of falling into nought," completely harmonize. As of the essential nature of vitality or attraction, so of the essential nature of animal mind, we are quite ignorant. It may in another order of things exist independently of matter, but we know it only as a function and property of certain living organized matter—brain, and I believe with Paley, that when it revives after death, the brain will equally revive.*

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* The great Paley's sermon on the state after death contains the following conclusions from various intimations in the New Testament. "First, that (at the resurrection) we shall have bodies.

2. That they will be so far different from our present bodies, as to be suited, by that difference, to the state and life into which they are to enter, agreeably to that rule which prevails throughout universal nature, that the body of every being is suited to its state, and that when it changes its state it changes its body.

3. That it is a question by which we need not be at all disturbed whether the bodies with which we shall arise be new bodies, or the same bodies under a new form; for,

4. No alteration will hinder us from remaining the same, provided we are sensible and conscious that we are so, any more than the changes which our visible person undergoes even in this life, and which from infancy to manhood are undoubtedly very great, hinder us from being the same, to ourselves and in ourselves, and to all intents and purposes whasoever.

Lastly, That though from the imperfection of our faculties, we neither are, nor without a constant miracle upon our minds, could be made able to comprehend the nature of our future bodies, yet we are assured that the change will be infinitely beneficial; that our new bodies will be infinitely superior to those which we carry about with us in our present state." *Sermons on Several Subjects*, by the late Rev. W. Paley, D. D. p. 96.

SECT. VII.

OF THE MOTION OF THE BLOOD.

84. The blood, to whose great and multifarious importance in the system we have slightly alluded, (16) is distributed, with a few exceptions, (5) into the most internal and extreme recesses. This is proved by the minute injection of the vessels, and by the well known fact, of blood issuing from almost every part, on the slightest scratch.

85. This purple fluid does not, like an Euripus, ebb and flow in the same parts, as the ancients imagined, but flows in a circular course: so that being propelled from the heart into the arteries, it is distributed throughout the body, and returns again to the heart through the veins.*

86. We shall, therefore, say something at present of the *vessels* which contain the blood; and afterwards, of the *powers* by which they propel and receive it.

87. The vessels which receive the blood from the heart, and distribute it throughout the body, are termed *arteries*. These are upon the whole less capacious than the veins;

* Among warm-blood animals, the egg, especially at the fourth and fifth day of incubation, if placed under a simple microscope, such as the Lyonetian, is most proper to demonstrate the circulation.

Among frogs, the most proper is the equuleus of Lieberkühn, described in the *Mem. de l'Acad. de Berlin*, 1745.

but in adult and advanced age especially, of a texture far more solid and compact, very elastic and strong.

88. The arteries consist of three *coats*:*

I. The exterior, called, by Haller, the *tunica cellulosa propria*; by others, the nervous, cartilaginous, tendinous, &c. It is composed of condensed cellular membrane, externally more lax, internally more and more compact: blood vessels are seen creeping upon it;† it gives tone and elasticity to the arteries.

II. The middle coat consists of transverse fibres,‡ lunated or falciform, and almost of a fleshy nature: hence this has the name of muscular coat, and appears to be the chief seat of the vital powers of the arteries.

III. The inner coat lining the cavity of the arteries is highly polished and smooth. This is much more distinct in the trunks and larger branches than in the smaller vessels.

89. Every artery *originates* either from the pulmonary artery (the vena arteriosa of the ancients), which proceeds from the anterior ventricle of the heart and goes to the lungs; or from the aorta, which proceeds from the posterior ventricle and is distributed throughout the rest of the system. These trunks divide into branches, and these again into twigs.

90. According to the commonly received opinion, the united capacity of the *branches* is greater than that of the

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* For the various opinions respecting the number and differences of the arterial coats consult among others Vinc. Malacarne *Della Osservat. in Chirurg.* Turin. T. 11. p. 103.

† Fr. Ruysch, *Respons. ad ep. problematicam*, iii. Also his *Thesaur. Anat.* iv. tab. 3.

‡ B. S. Albinus, *Annot. Academ.* L. iv. tab. 5. fig. 1.

trunk from which they arise. But I fear that this is too general an assertion; and that the measure of the diameter has been improperly confounded with that of the area. I myself have never been able to verify it, although my experiments have been frequently repeated, and made not on vessels injected with wax, but on the undisturbed vessels of recent subjects—on the innominata and its two branches—the right carotid and subclavian; on the brachial, and the radial and ulnar.*

The inconstancy of the proportion between the capacity of the branches and trunks is clearly shewn by the various size of the vessels under different circumstances, v. c. by the relative capacity of the inferior thyroid artery in the infant and the adult; of the epigastric artery, and also of the uterine vessels, in a virgin and a woman far advanced in pregnancy; of the omental vessels during the repletion or vacuity of the stomach.†

91. The arteries, after innumerable divisions and important anastomoses‡ connecting different branches, *terminate* at length in the beginning of the veins. By this means, the blood is conveyed back again to the heart. The distinction between artery and vein at the point of union, is lost.

In the present state of our knowledge, the umbilical

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* See also J. Theod. van der Kemp, *De Vita*. Edinb. 1782, 8vo. p. 51.

† This is remarkably observable in the adult stag, by comparing the areæ of the external carotid and its branches, during the spring, before the horns have attained their full growth, but are still covered with their downy integuments, (called in our language, *der Bast*) with such as they are after this covering has fallen off.

‡ Ant. Scarpa *Sull' Aneurisma*. Pav. 1804, fol. cap. 4.

vessels are to be regarded as the only exception to the termination of arteries in veins. We shall shew that they are connected with the uterine vessels, by the intervention of a spongy substance, called parenchyma.

92. Another description of vessels arise universally from the arteries, and are called *colourless,* from not containing pure blood, either on account of their minuteness or their specific irritability, which causes them to reject that fluid. These are the *nutrient* and other *secretory* vessels, of which hereafter.

93. The blood conveyed from the heart by the arteries is carried back by the *veins.*

These are very different in function and structure from the arteries, excepting however the minutest of both systems, which are undistinguishable.

94. The veins, excepting the pulmonary, are upon the whole more capacious than the arteries; are more ramified; much more irregular in their course and division; in adult age, softer and more elastic; but still very firm and remarkably expansile.

95. Their *coats* are so much thinner, that the blood appears through them. They are likewise less in number, being solely a cellular external (somewhat resembling the nervous of the arteries) and a very polished internal, also nearly agreeing with that of the arteries.

A muscular coat exists in the largest trunks only.

96. The interior coat forms, in most veins of more than a line in diameter, very beautiful valves, of easy play, resembling bags, generally single, frequently double, and sometimes treble, so placed, that the fundus lies towards the origin of the vein, the limbus towards the heart.

These valves are not found in some parts; not in the brain, heart, lungs, secundines, nor in the system of the vena portæ.

97. The twigs, or, more properly, the radicles of the veins, unite into branches, and these again into six principal trunks; viz. into the two cavæ, superior and inferior: and the four trunks of the pulmonary vein (the arteria venosa of the ancients).

The vena portæ is peculiar in this, that, having entered into the liver, it ramifies like an artery, and its extreme twigs pass into the radicles of the inferior cava, thus coalescing into a trunk.

98. That the blood may be properly distributed and circulated through the arteries and veins, nature has provided the *heart*,* in which the main trunks of all the blood vessels unite, and which is the grand agent and mover of the whole system,—supporting the chief of the vital functions with a constant and truly wonderful power, from the second or third week after conception, to the last moment of existence.

99. The heart alternately receives and propels the blood. Receiving it from the body by means of the superior and inferior vena cava, and from its own substance through the common valvular† orifice of the coronary veins, it conveys that fluid into the anterior sinus and auricle; thence into the corresponding ventricle, which,

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* W. Cowper's *Myotomia Reformata*. (Posth.) Lond. 1724, Fol. Max. Tab. xxxvi—xl.

† Casp. Fr. Wolff on the origin of the large coronary vein, in the *Act. Acad. scient. Petropol.* 1777. P. i.

Petr. Tabarrani on the same subject, in the *Atti di Siena*. Vol. vi.

as well as the auricle, communicates with both orders of its own vessels, by the openings of Thebesius.*

100. From this anterior, or, in reference to the heart of some animals, right ventricle, the blood is impelled through the pulmonary artery into the lungs: returning from which, it enters the four pulmonary veins, and proceeds into their common sinus and the left, or, as it is now more properly termed, the posterior auricle.†

101. It flows next into the corresponding ventricle; and then passing into the aorta, is distributed through the general arterial system and the coronary vessels of the heart.‡

102. Having proceeded from the extreme twigs of the general arterial system into the radicles of the veins, and from the coronary arteries into the coronary veins, it finally is poured into the two venæ cavæ, and then again pursues the same circular course.

103. The regularity of this circular and successive motion through the cavities of the heart is secured, and any retrograde motion prevented, by the *valves* which are placed at the principal openings: viz. at the openings of the auricles into the ventricles, and of the ventricles into the pulmonary artery and aorta.

104. Thus the ring, or venous tendon, which forms the limit of the anterior auricle and ventricle, descending into

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* Respecting these openings consult among others J. Abernethy, in the *Philos. Trans.* 1798, p. 103.

† James Penada, in the *Memorie Della Societa Italiana.* T. xi. p. 555.

‡ Consult Achill. Mieg's *Specimen ii. Observationum Botanicarum,* &c. Basil. 1776, 4to. p. 12. sq.

the latter cavity, becomes three tendinous valves.* These were formerly said to have three apices, and were therefore called trigochline or *tricuspidal:* they adhere to the fleshy pillars, or, in common language, the papillary muscles.

105. In a similar manner, the limits of the posterior auricle and ventricle are defined by a ring of the same kind, constituting two valves, which, from their form, have obtained the appellation of *mitral*.†

106. At the opening of the pulmonary artery‡ and aorta§ are found the triple *semilunar* or sigmoid valves,|| fleshy and elegant, but of less circumference than the mitral.

107. It is obvious how these valves must prevent the retrocession of the blood into the cavæ. They readily permit the blood to pass on, but are expanded, like a sail, against it, by any attempt at retrograde movement.

108. The *texture* of the heart is peculiar: fleshy, indeed, but very dense and compact, far different from common muscularity.** It is composed of fasciculi of fibres, more or less oblique, here and there singularly branching out, curiously contorted and vorticose in their direction,

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* Eustachius. Tab. viii. fig. 6.—tab. xvi. fig. 3. Santorini. Tab. Posth. ix. fig. 1.

† Eustachius. Tab. xvi. fig. 6.

‡ Eustachius. Tab. xvi. fig. 4.

§ Eustachius. Tab. xvi. fig. 5. Morgagni. *Advers. Anat.* i. Tab. iv. fig. 3. Santorini, l. c.

|| Consult Hunter, who treats very minutely of the mechanism of these valves in his work *On the Blood,* &c. p. 159.

** Leop. M. A. Caldani, *Memorie lette nell' Acad. di Padova,* 1814, p. 67.

lying upon each other in strata, closely interwoven between the cavities, and bound by four cartilaginous bands to the basis of the ventricles, which are thus supported and distinguished in their texture from the fibres of the auricles.*

109. These fleshy fibres are supplied with very soft nerves † and an immense number of blood vessels, which arise from the coronary arteries, and are so infinitely ramified,‡ that Ruysch described the whole structure of the heart as composed of them.§

110. The heart is loosely contained in the *pericardium*.|| This is a membraneous sac, arising from the mediastinum, of the same figure as the heart, very firm, and moistened by an exhalation from the arteries of the heart. Its importance is evinced by its existence being, in red-blooded animals, as general as that of the heart; and by only two instances being recorded of its absence in the human subject.**

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* Casp. F. Wolff, in the *Act. Acad. Scientiar. Petropol.* for the year 1780, sq. especially 1781, P. i. p. 211. sq. on the cartilaginous texture of the heart, or of the cartilagineo-osseous fibres, and their distribution at the basis of the heart.

† Scarpa's *Tabulæ Neurologicæ ad Illust. Hist. Anat. Cardiac. Nervor.* Tab. iii. iv. v. vi.

‡ Ruysch. *Thesaur. Anat.* iv. Tab. iii. fig. 1, 2.

§ Brandis has proposed an ingenious hypothesis to explain the use of so great an apparatus of coronary vessels. *Versuch über die Lebenskraft*, p. 84.

|| Haller. *Elementa Physiol.* T. i. tab. 1.

Nicholls in the *Philos. Trans.* Vol. lii. P. 1. p. 272.

** Littre in the *Hist. de l'Academie des Sc. de Paris*, 1782, p. 37. Baillie, in the *Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge.* T. i. p. 91.

111. By this structure, the heart is adapted for perpetual and equable motions, which are an alternate systole and disastole, or contraction and relaxation of the auricles and ventricles in succession.

112. Thus, as often as the auricles contract to impel the blood of the venæ cavæ and pulmonary veins into the ventricles, these are at the same moment relaxed, to receive the blood: immediately afterwards, when the distended ventricles are contracting to impel the blood into the two great arteries, the auricles relax, and receive the fresh venous supply.

113. The systole of the ventricles, upon which is said to be spent one third of the time of the whole action of the heart, is performed in such a way, that their external portion is drawn towards their septum, and the apex of the heart towards the base.* This at first sight seems disproved by the circumstance of the apex striking against the left nipple, and consequently appearing elongated: a circumstance, however, to be attributed to the double impetus of the blood flowing into the auricles and expelled from the ventricles, by which the heart must be driven against that part of the ribs (A).

114. The impulse imparted by the heart to the blood, is communicated to the arteries, so that every systole of the heart is remarkably evident in those arteries which can be explored by the fingers and exceed $\frac{1}{8}$ of an inch in diameter, and in those also whose pulsation can be otherwise discovered, as in the eye and ear. The effect upon the arteries is called their diastole, and is correspondent and synchronous with the systole of the heart.

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† Consult Ant. Portal's *Memoires sur la Nature & la Traitement de plusieurs Maladies*. T. ii. 1800. p. 281.

115. The quickness of the heart's pulsations during health, varies indefinitely; chiefly from age, but also from other conditions, which at all ages form the peculiar health of an individual; so that we can lay down no rule on this point. I may, however, be permitted to mention the varieties which I have found in our climate* at different ages; beginning with the new-born infant, in which, while placidly sleeping, it is about 140 in a minute.

Towards the end of the first year, about	124
- - - - - - - - second	110
- - - - - - - - third and fourth	96
When the first teeth begin to drop out	86
At puberty	80
At manhood	75
About sixty	60

In those more advanced, I have scarcely twice found it alike.

116. The pulse is, *ceteris paribus*, more frequent in women than in men, and in short than in tall persons. A more constant fact, however, is its greater slowness in cold climates.† Its greater frequency after meals and coition, during continued watchfulness, exercise, or mental excitement, is universally known. (B)

117. The heart rather than the arteries is to be regarded as the source of these varieties.

Its action continues in this manner till death, and then

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* My observations differ but little from those made by Heberden in England. *Med. Trans.* vol. ii. p. 21. et seq.

† J. H. Schonheyder *De Resolutione et Impotentia motus Muscularis.* Hafn. 1768, p. 15. With which work compare the observations of F. Gabr. Sulzer in the *Naturgesch. des Hamsters,* p. 169.

all its parts do not, at once, cease to act; but the right portion, for a short period, survives the left.*

For since the collapsed state of the lungs impedes the course of the blood from the right side, and the veins must be turgid with the blood just driven into them from the arteries, it cannot but happen that this blood, driving against the right auricle, must excite it to resistance for some time after the death of the left portion of the heart.

118. This congestion on the right side of the heart, affords an explanation of the small quantity of blood found in the large branches of the aorta. Weiss,† and after him Sabatier,‡ ascribe to this cause likewise the comparatively larger size § of the right auricle and ventricle in the adult dead subject especially.

119. The motion of the blood is performed by these two orders of vessels, in conjunction with the heart. Its celerity in health cannot be determined: for it varies not only in different persons, but in different parts of the same person. Generally, the blood moves more slowly in the veins than in the arteries, and in the small vessels

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* Stenon in the *Act. Haffniens.* T. ii. p. 142.

Sometimes, though rarely, it happens that the right portion of the heart, oppressed with too much blood, becomes, contrary to what usually takes place, paralyzed before the left. This I have more than once observed on opening living mammalia, particularly rabbits.

† J. N. Weiss *De Dextro Cordis Ventriculo post mortem Ampliori.* Altorf. 1767, 4to.

‡ Ant. Chaum. Sabatier, *In Vivis Animalibus Ventriculorum Cordis eadem Capacitas.* Paris, 1772, 4to.

§ Sam. Aurivilius, *De Vasorum Pulmonal. & Cavitat. Cordis inæquali Amplitudine.* Gotting. 1750, 4to.

than in the large trunks. But these differences have been overrated by physiologists.

The mean velocity of the blood flowing into the aorta, is usually estimated at eight inches for each pulsation, or at fifty feet in a minute.

120. Some have affirmed that the globules of the cruor move more in the axis of the vessels, and with greater rapidity, than the other constituents of the blood. I know not whether this rests on any satisfactory experiment, or whether upon an improper application of the laws of hydraulics; improper, because it is absurd to refer the motion of the blood through living canals, to the mere mechanical laws of water moving in an hydraulic machine. I have never observed this peculiarity of the globules. My persuasion is still more certain that the globules pass on with the other constituents of the blood, and are not rotated around their own axis,—that besides the *progressive*, there is no *intestine* motion in the blood; although indeed there can be no doubt, that the elements of this fluid are occasionally divided, where it is variously impelled according to the different direction, division, and anastomoses of the vessels.

121. The *powers* of the sanguiferous system are now to be examined: first, those of the heart, by far the greatest of all; afterwards, those which are only subsidiary, though indeed highly useful.

122. That the powers of the heart cannot be accurately calculated is clear, upon reflecting that neither the volume of the blood projected at each pulsation, nor the celerity nor distance of its projection, much less the obstacles to the powers of the heart, can be accurately determined.

123. A rough calculation may be made by comparing

every probable conjecture; v. c. if the mean bulk of the blood is considered as 10 pounds, or 120 ounces; the pulsations 75 in a minute, or 4500 in an hour; and the quantity of blood expelled from the left ventricle on each contraction, as two ounces; it follows that all the blood must pass through the heart 75 times every hour. The impetus of the blood passing from the heart, may be conceived by the violence and altitude of the stream projected from a wounded artery, large and near the heart. I have seen the blood driven to the distance of at least five feet from the carotid of an adult and robust man.*

124. This wonderful, and, while life remains, constant, strength of the heart, is universally allowed to depend on its *irritability*, (41) in which it very far surpasses, especially in continuance,† (98) every other muscular part.‡

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* The experiments of Hales, in which the blood was received into very long glass tubes fixed to the arteries of living animals, and measured with respect to the length of its projection, are indeed beautiful, like every thing done by this philosopher, who was by nature calculated for such disquisitions. But if the force of the heart is to be estimated in this way, we must take into account the pressure of the column of blood contained in the tube and gravitating upon the left ventricle. The result of Hales' calculations was, that the blood being projected from the human carotid seven feet and a half, and the surface of the left ventricle being fifteen square inches, a column of blood, weighing 51lb 5oz. was incumbent upon the ventricle and overcome by its systole. *Statical Essays*, vol. ii. p. 40. London, 1733, 8vo.

† Thus, to say nothing of the phenomena so frequently observed in the cold blooded amphibia and fishes, I lately found the heart of the chick beat for twelve hours, in an egg, on the fourth day of incubation.

‡ Consult Fontana, who treats of this prerogative of the heart minutely in his *Ricerche sopra la Fisica animale*, and limits it too much. Haller answered him in the Literary Index of Gottingen.

That the parietes of the cavities are excited to contraction by the stimulus of the blood, is proved by the experiment of Haller, who lengthened at pleasure the motion of either side of the heart, by affording it the stimulus of the blood for a longer period than the other.*

125. Since a supply of nerves and blood is requisite to the action of the voluntary muscles, it has been inquired whether these are requisite to the heart also.†

The great influence of the *nerves* over the heart, is demonstrated by the size of the cardiac nerves, and by the great sympathy between the heart and most functions, however different. A convincing proof of this, is the momentary sympathy of the heart during the most perfect health‡ with the passions, and with the *primæ viæ* under various disorders. But the great importance of the blood to the irritability of the heart, is evident by the great abundance of vessels in its muscular substance.

Nevertheless it is very probable, that the importance of the nerves in this respect is greater in the voluntary muscles, and of the blood in the heart.

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* Haller on the motion of the heart from stimulus, in the *Comment. Soc. Scient. Gottingens.* Tom. i.

G. E. Remus, *Experimenta circa circulat. sanguin. instituta.* Gotting, 1752, p. 14, 4to.

† On this dispute consult R. Forster's *Quæstion. select. Physiol.* Ludg. Bat. 1774, 4to.

J. B. J. Behrend's *Dissert. qua demonstratur cor nervis carere.* Mogunt. 1792, 4to. and on the other side, J. Munnik's *Observationes variæ.* Groning. 1805, 4to. Lucæ, l. c. p. 37, p. ii.

‡ And how much more so when the heart is diseased, is shewn in Caleb Hill Parry's *Inquiry into the Symptoms and Causes of the Syncope Anginosa, commonly called Angina Pectoris.* p. 114, Bath. 1799, 8vo. p. 114.

126. Besides these powers of the heart, there is another, which is mechanical, dependent on structure, greatly contributing, in all probability, to sustain the circulation. For when the blood is expelled from the contracted cavities, a vacuum takes place, into which, according to the common laws of *derivation*, the neighbouring blood must rush, being prevented, by means of the valves, from regurgitating.* (D)

127. We must now inquire, what powers are possessed by other organs in assisting the circulation. The existence and ability of some *secondary* powers to assist, or even in some cases to compensate for the action of the heart, are proved by several arguments: v. c. the blood moves in some parts to which the influence of the heart cannot reach,—in the vena portæ and placenta; not to mention instances of the absence of the heart.†

128. The principal of these powers is the function of the *arteries*, not easy indeed to be clearly understood and demonstrated. 1. They have a muscular coat (E). 2. That they are irritable, has been proved by repeated experiments.‡ 3. The size of the soft nerves arising from the

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* Andr. Wilson's *Inquiry into the moving powers employed in the Circulation of the Blood.* Lond. 1774, 8vo. p. 35, sq.

† See v. c. C. W. Curtius, *De monstro humano cum infante gemello,* Lugd. Bat. 1762, 4to. p. 39, W. Cooper, in the *Philos. Transac.* vol. lxv. p. 316. Haller's *Opera Minora.* T. iii. p. 33. C. Chr. Klein's *Descriptio Monstrorum quorundam,* Stuttg. 1793, 4to.

‡ Walter Verschuir, *De arteriar. et venar. vi irritabili; ejusque in vasis excessu; et inde oriunda sanguinis directione abnormi.* Groning. 1766, 4to.

Rich. Dennison, *Diss. arterias omnes et venarum partem irritabilitate præditas esse.* Edinb. 1775, 8vo.

Chr. Kramp, *De vi vitali arteriarum.* Argent. 1785, 8vo.

sympathetic, and surrounding the larger arterial branches, particularly in the lower part of the abdomen,* argues the importance of these vessels in assisting the motion of the blood.†

129. The arteries pulsate, and indeed violently, so that if, v. c. we place one leg over the other knee, we find not only that it, but even a much greater weight, may be raised by the pulsation of the popliteal. Hence an alternate systole and diastole, corresponding with those of the heart, have long been assigned to them. But this, although commonly believed on the evidence of sense, is open to much question:‡ it may be asked, especially, whether this pulsation is referable to the power of the artery, or only to the impulse given by the heart to the blood propelled into the aorta.

130. And indeed after all, it appears, that the *diastole* of an artery is owing to the blood,—to a lateral distension given by the impetus of the blood, so that the coats are expanded; and the vessel, by its elasticity, the next moment reacquires its natural thickness. To the same impulse may be ascribed the lateral motion of the axis, observable in the larger arteries, if serpentine and lying in loose cellular substance. (F)

The genuine *systole*, produced by a constriction of their

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* Observe for instance, in Walter's *Tabulæ nervor. thorac. et abdominis*, the right hepatic, Tab. ii. O. Tab. iii. *l.*—the splenic, tab. ii. P. Tab. iii. *m.* tab. iv. *o.*—the superior mesenteric, Tab. ii. Q. Tab. iii. *s.*—the inferior mesenteric, Tab. ii. T.—and many others. Compare Soemmerring *de c. h. fabrica.* T. iv. p. 362.

† Haller *De Nervor. in arterias imperio.* Gotting. 1744, 4to. *Lucæ*, l. c.

‡ Th. Kirkland's *Inquiry into the present state of Medical Surgery.* London, 1783, 8vo. vol. i. p. 306, sq.

usual thickness, scarcely occurs, probably, while the heart acts with sufficient vigor; but when they are unusually stimulated, or if the action of the heart fails or is impeded by severe disease, then indeed the arteries may supply its place and propel the blood by their own vital energy.

131. Since Whytt* and other illustrious physiologists have been convinced that the influence of the heart could not reach the extreme arteries and the origins of the veins, they have ascribed the progression of the blood in those vessels to a kind of *oscillation*, and have happily employed this to demonstrate the nature of inflammation. Many kinds of phenomena, both physiological, as these regarding animal heat, and pathological, as those observed in spasms, and particularly in fevers, favor the supposition of this oscillatory faculty, though it is not demonstrable to the eye.

132. It remains now to inquire into the aid given to the returning blood by the *veins*, not alluding at all to their radicles. We should conclude at first sight that they have less active power† than the rest of the san-

* *Physiological Essays, containing an inquiry into the causes which promote the circulation of the fluids in the very small vessels of animals*, &c. &c. Second Edition, Edinb. 1761, 12mo.

H. v. d. Bosch, *über das Muskelvermögen der Haargefässgen.* Monast. 1786, 8vo.

† What is commonly, but improperly, called the *venous pulsation*, observable on opening living animals and in some morbid affections, and also under a violent effort, does not correspond with the action of the heart, but with respiration; since if an expiration is unusually deep and lengthened, and the reflux of the blood to the lungs thus impeded, the jugular vein swells as far as the brain, the subclavian as far as the basilic, and the inferior cava as far as the crural.

guiferous system, and that the return of their purple blood to the heart is chiefly ascribable to the impetus a tergo of the arterial blood, and to their valvular structure which prevents any reflux. The efficacy of the valves in this point of view, is shewn by those distensions and infarctions of the veins in the lower part of the abdomen, which are found destitute of valves.*

The existence of vital powers in the venous trunks, is probable,† from the example of the liver and placenta (127), and from experiments instituted on living animals. We formerly mentioned the muscular appearance in the extreme veins near the heart (95).

133. These are the chief powers which move the blood and depend upon the structure and vitality of the sanguiferous system: we say nothing of the effect of gravity, attraction, and other powers, common to all matter. The more remote assistance derived after birth from peculiar functions, v. c. respiration and muscular motion, will be manifest in our account of those functions.

NOTES.

(A) Dr. W. Hunter first accounted for this in 1746.

" The systole and diastole of the heart, simply, could not produce such an effect; nor could it have been produced, if it had thrown the blood into a straight tube, in the direction of the axis of the left ventricle, as is the

* G. E. Stahl, *De vena portæ porta malorum*. Halæ. 1698, 4to.

† Lister, *De humoribus*, p. 25

case with fish, and some other classes of animals: but by throwing the blood into a curved tube, viz. the aorta, that artery, at its curve, endeavours to throw itself into a straight line, to increase its capacity; but the aorta being the fixed point against the back, and the heart in some degree loose and pendulous, the influence of its own action is thrown upon itself, and it is tilted forwards against the inside of the chest."*

Dr. Barclay has the following passage on this point.

"When the blood is forced into the arteries, their curvatares, near where they issue from the ventricles, are from their distension lengthened and extended towards straight lines; and, causing the heart to participate in their motions, compel it to describe the segment of a circle, when the apex moving atlantad and sinistrad, is made to strike against the left side. The same kind of motion having also been observed by the celebrated Haller, in distending the left or systemic auricle, it must follow, that the stroke which is given to the side, may be the effect of two distinct causes, either acting separately, or in combination; but acting on a heart obliquely situated, as ours is, in the cavity of the thorax, where the aspect of the base is atlantad and dextrad, and that of the apex sinistrad and sacrad. In combination, as the first of the two, by removing the pressure, will facilitate the influx of the venous blood into the left or systemic auricle, which is situated dorsad; so the second, by the influx of blood into the auricle, will contribute in its turn to facilitate the circular motion of the heart, proceeding from the arteries."†

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* *A Treatise on the Blood, &c.* by John Hunter, p. 146. Note.

* *The Muscular Motions of the Human Body*, by John Barclay, M. D. p. 567.

(B) It is commonly believed, that the pulse of every person is quicker in the evening than in the morning, and some have supposed an increase of quickness also at noon. Upon these suppositions Cullen builds his explanation of the noon and evening paroxysms of hectic fever, regarding them as merely aggravations of natural exacerbations. The existence of the noon paroxysms is doubtful, and the evening one cannot be so explained, if the writer of a paper in a late number of the Edinburgh Journal is correct.* His observations show the pulse to be slower in the evening, and quicker in the morning.

(C) The heart, however, of frogs, for instance, contracts and relaxes alternately, for a length of time, when out of the body and destitute of blood.

(D) The influence of this vacuum first pointed out by Dr. Wilson, has been lately very ably displayed by Dr. Carson of Liverpool.†

The quantity of the blood, the length of its course, and the various obstacles opposed to its progress, render it very unlikely, that the mere propulsive power of the heart is sufficient for the circulation. But great assistance must be given by the vacuum which takes place in all the cavities of the organ, when the contraction of the muscular fibres is over. The blood is thus drawn into each relaxed cavity, and the heart performs the double office of a forcing and a suction pump. The rapid but quiet motion of the blood in the veins, is thus accounted for, which would otherwise be inexplicable. The situation

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* *Edinburgh Medical and Surgical Journal*, 1815.

† *An Inquiry into the Causes of the Motion of the Blood*, by James Carson, M. D. 1815.

of the valves of the heart is also accounted for. There are valves between the auricles and ventricles, and at the mouths of the two great arteries, because behind each of these four openings is a cavity of the heart, alternately dilating and affording a vacuum, into which, without valves, the blood would be drawn retrograde. At the venous openings of the auricles no valves exist, because they do not open from a cavity of the heart,—from a part ever experiencing a vacuum, and therefore the blood cannot, when the auricles contract, move retrograde, but will necessarily pass forwards into the ventricles, which at that moment are affording a vacuum. The inferior elasticity and muscularity of the veins are also accounted for. If veins were capable of contracting equally with arteries, on the diminution of their contents, the suction influence of the heart would constantly reduce their cavities to a smaller capacity than is requisite for their functions. The collapse of the veins by pressure, during the suction of the heart, is prevented by the fresh supply of blood afforded by the vis-a-tergo, which does exist, although it cannot be considered as of itself adequate to convey the blood back to the right auricle. The reason appears why a tied vein is emptied in the part nearest the heart; its blood is drawn forwards by suction. We see why a punctured vein does not bleed, if there are other veins to convey the blood discharged from the arteries. The puncture necessarily removes the suction influence of the heart, and the great cause of the progress of the blood in the vein is taken away, while it exists in full force in the other veins of the limb. Were it not for this circumstance, a punctured vein should afford blood very readily. If the main vein of a limb is wounded, the blood will flow, because it receives the whole blood of the arteries, transmitted by the vis-a-tergo, no other veins existing into which it can be drawn when the vacuum occurs in the right auricle: what is a parallel circumstance, if all the veins of a limb are tied, they swell, whereas the ligature of one causes no tumefaction in it. These circumstances are no proof that the vis-a-tergo is sufficient of itself to bring back the blood, because it is certain that such a vacuum exists, and that such must be the effects of this vacuum upon the movement of the blood: the hemorrhage in the former instance, and the tumefaction in the latter, show a certain force only in the blood, which, were it even sufficient to bring the blood back to the heart, could not long continue after the assistance of suction was removed.

From the structure of the heart it is clear, that the mere alternate relaxation of its parietes, enlarges its cavities and forms a vacuum. Experiment proves the same. Dr. Carson put the hearts of some frogs just extracted into water, blood-warm. They were thrown into violent action, and, upon some occasions, projected a small stream of a bloody colour though the transparent fluid. It was supposed that a stream of the same kind continued to be projected at every succeeding contraction; but that, after the first or second, it ceased to be observable, in consequence of the liquid supposed to be imbibed and projected, losing its bloody tinge and becoming transparent, or of the same colour with the fluid in which the heart was immersed. The organ was felt by the hand to expand during relaxation. He accounts, however, for the full dilatation of the heart upon another principle; upon which it will be impossible to enter into detail before the next section.

(E) Most Physiologists grant to the capillaries irritability, tonicity, or organic contractility; but some deny that *arteries* possess muscular properties. Bichat's objections are the absence of contraction on the application of stimuli to them; the much greater resistance of the middle coat to a distending force, than that of muscular parts; and lastly, the difference of the changes which it and muscles undergo, both spontaneously and by the action of other substances.* Berzelius has multiplied the latter description of proofs.† However this may be, they have certainly vital powers of contraction as fully as any parts of the body. This appears in their various degrees of local dilatation and contraction, under inflammation, passions of the mind, &c.: and if the capillaries alone are allowed to possess organic contractility, it is impossible to say in which point of the arterial track it began.

Dr. Parry has lately instituted a number of experiments upon this question. After ascertaining exactly the circumference of arteries in animals, he killed them, and again measured the circumference; and after the lapse of many hours, when life must have been perfectly extinguished, he measured the circumference a third time. Immediately after death, the circumference was found greatly diminished, and on the third examination, it had increased again. The first contraction arose from the absence of the blood which distended the vessel, and antagonized its efforts to contraction; and this contraction was evidently muscular, or to speak more correctly, organic contraction; because when vitality was gone, and this kind of contraction could no longer take place, the vessel was, on the third examination, always found enlarged.

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* *Anatomie Generale*, T. ii. † *Animal Chemistry*, p. 25.

The forced state of distension in arteries was proved by the contraction, immediately occurring on making a puncture in a portion of vessel included between two ligatures. The capacities of arteries are thus always accommodated to the quantity of blood, and this circumstance gives the arterial canal such properties of a rigid tube as enable an impulse at the mouth of the aorta to be instantly communicated throughout the canal. And this appears the great office of the contractile powers of arteries, for,

(F.) They do not incessantly dilate and contract as many imagine. Dr. Parry, on the most careful examination, could never discover the least dilatation in them, during the systole of the ventricle, when the pulse is felt. He very properly remarks, that the pulse is felt only when arteries are more or less compressed; by which the motion of the blood onwards, by the impulse of a fresh portion from the left ventricle, is impeded: and this effort of the fluid against the obstructing cause, gives the sensation called the pulse.*

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* *An Experimental Enquiry into the Nature, Causes, and Varieties of the Arterial Pulse,* &c. by Caleb Hillier Parry, M. D. F. R. S. 1816.

SECT. VIII.

OF RESPIRATION AND ITS PRINCIPAL USE.

134. THE *lungs*,* closely connected with the heart, both by proximity and by relation of function, are two viscera, large after birth, so light as to swim in water, and composed of a spongy, and, as it were, spumous, but pretty tenacious, parenchyma.†

135. They fill each cavity of the chest, are contiguous to the sacs of the pleuræ, to which, as well as to the other contents of the thorax, they model and apply themselves. (A)

136. They, in a manner, hang from the wind-pipe usually called the aspera arteria, which, besides its interior coat always smeared with mucus, and the subjacent very sensible nervous coat, consists of another which is muscular, surrounding the latter, and divided, except posteriorly, by an indefinite number of cartilaginous falciform arches.

137. The aspera arteria, having entered the thorax, is bifurcated into the two bronchiæ, and these, the more deeply they penetrate into the lobes and lobules of the lungs, are the more and more ramified, losing both their

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* Soemmerring und Reisseisen, *über die Structur, die Verrichtung und den Gebrauch der Lungen. Zwey Preischriften.* Berol, 1808. 8vo.

† Respecting all the organs concerned in respiration, consult Corn. J. Van Der Bosch's *Anatomia Systematis Respirationi Inservientis Pathologica.* Harlem, 1801, 4to. p. 1—44.

cartilaginous rings and muscular coat, until their extreme divisions terminate in those *cells* which form the chief part of the substance of the lungs and alternately receive and emit the air we breathe.

138. The shape and magnitude* of the air cells are various. The former is generally polyedrical. The latter, in regard to surface, is scarcely to be defined :† though, indeed, the *capacity* of the lungs of an adult, during a strong inspiration, is about 120 cubic inches. The immense size to which the lungs may be inflated, when the chest has been opened, has no relation to our present subject.

139. The cells are invested and connected by the common but delicate mucous web,—the general vinculum of the body. The texture of each must be carefully distinguished. In healthy and very recent lungs, I have found the cells so unconnected, that they were distended in one insulated spot by air cautiously inflated into a fine branch of the bronchiæ, while neither the neighbouring cells nor the cellular membrane which lies between the cells, admitted a single portion. If air is forcibly thrown in, the air cells are ruptured and confounded with the cellular membrane, and both parts distended.

140. The mucous web surrounding the air cells of the lungs is supplied with innumerable blood vessels,—divisions of the pulmonary artery and four pulmonary veins, the branches of which accompany the ramifications of the bronchiæ,‡ and, after repeated division, form at

* Keil indulging his luxuriant iatro-mathematical genius, assigned more than 1744,000,000 cells to each lung.

† Lieberkühn, with equal exaggeration, made the surface of the cells equal to 1500 square feet.

‡ Eustachius. Tab. xxvii. fig. 13.

length a most delicate and immense collection of reticulated anastomoses. This extraordinary net-work, penetrating the mucous web on every side, closely surrounds the air cells, so that the prodigious quantity of blood existing in the pulmonary vessels, is separated from the contact of the air by very fine membranes only which Hales estimated as scarcely $\frac{1}{1000}$ part of an inch in thickness.

141. As each ramification of the bronchiæ possesses a peculiar bunch or lobule of air cells, (139) so again each of these possesses a peculiar system of blood vessels, the twigs of which anastomose in the net-work with one another, but scarcely at all with the blood-vessels of the other lobules, as is proved by microscopic observations on living frogs and serpents, by minute injections, and by the phenomena of vomicæ and other local diseases of the lungs.

142. The common membrane investing the lungs is the chief seat of a remarkable net-work of lymphatic vessels* which run to numerous lymphatic or conglobate glands,† carefully to be distinguished from a neighbouring order of glands called bronchial, supplied with an excretory duct, and of the conglomerate kind.‡

143. The *thorax*, which contains the lungs, has an osseous and cartilaginous base, somewhat resembling a bee-hive, throughout very firm and stable, but in every part more or less moveable for the purpose of respiration.§

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* Mascagni. *Histor. vasor. lymphatic.* Tab. xx.

† Ibid. Tab. xxi.

‡ Consult Portal in the *Mém. de l'Acad. des Scienc. de Paris*, 1780.

§ J. G. Amstein (Præs. Oetinger) *De usu et actione musculor.*

This holds good chiefly with the six pairs of true ribs below the first pair, each of which is more moveable both than the one above and in proportion to the greater length both of their own bodies and of their cartilaginous appendices, which are united by a kind of amphiarthrosis to the margin of the sternum on each side.

144. Between the edges of the ribs lie two strata of intercostal muscles, differing in the direction of their fibres, but conspiring to produce the same motion.

At the base of the thorax, the diaphragm* is subtended in the form of an arch. It is a considerable muscle, and, in the words of Haller, next in importance to the heart. Its utility in the mechanical part of respiration was long since shewn, by the excellent experiments of Galen † upon living animals, to depend chiefly on the phrenic nerve.‡

Its antagonists are the abdominal muscles, especially the two oblique and the transverse.

145. The thorax thus constituted, is, after birth, di-

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intercostal. Tubing. 1769, 4to. Theod. Fr. Trendelenburg, Jun. *De sterni costarumque in respiratione vera genuinaque motus ratione.* Gotting, 1779, 4to. Bordenave and Sabatier, in the *Mém. de l'Acad. des Scienc. de Paris,* 1778.

* Haller, *Icon. Anat.* fascic. 1, Tab. 1.

B. S. Albinus. *Tab. musculor.* Tab. xiv. fig. 5, 6, 7.

J G. Röderer, *De arcubus tendineis muscul.* progr. 1. Gotting 1760, 4to.

Santorini, Tab. Posth. x. fig. 1.

† *De Anatomicis Administrationibus,* L. viii. cap. 8. The whole book is full of experiments on respiration.

‡ Ephr. Krüger, *De nervo phrenico.* Lips. 1759, reprinted in Sandifort's Thesaurus, Tom. iii.

Walter's *Tab. nervor. thorac. et abdominis,* Tab. 1, fig. 1, n. 1.

lated by inspiration, and subsequently reduced to a smaller capacity by expiration.

During the former act, the thorax is enlarged laterally and inferiorly, so that the bodies of the six ribs mentioned above (143) are elevated, and their inferior margin drawn somewhat outwards, and the arch of the diaphragm at the same time rather depressed and flattened.

I have never observed the inferior extremity of the sternum, in tranquil respiration, to be thrust forwards, as some have asserted. (B).

146. This alternate motion of the chest continues during health and freedom from restraint, from the hour of birth till death. Its object is, that the lungs may be expanded to admit the air and contracted to expel it, in perpetual alternation. This alternation occurs, in an adult at rest, about 14 times in a minute,—once to about five pulsations of the heart.

147. For man, in common with all warm-blooded animals, cannot long retain the inspired air, but is compelled to discharge it and take in a fresh supply of this pabulum of life, as it always has been denominated.* Common observation teaches, that however pure may be the air entering the lungs, it instantly undergoes remarkable changes, by which it is contaminated and rendered unfit for another inspiration, unless it is renewed.†

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* The antiquity of the notion that air is the *pabulum vitæ*, is seen in the book *de Flatibus*, usually ascribed to Hippocrates. The author regards the aliment as threefold—victuals, drink, and air: but the latter he calls *vital*, because we cannot dispense with a perpetual supply of it, without danger to life.

† Consult Harvey's Dispute upon the necessary renovation of the aerial *uccus alibilis*, with the celebrated Astronomical Professor, J. Greaves,

148. It may be asked what are the changes which the air experiences during inspiration, and which consist not in the loss of elasticity, as was formerly supposed, but in the decomposition of its elements.* For the atmospheric air which we breathe, is a singular mixture of constituents, differing very much in nature from each other; and, not to mention heterogeneous matters, such as odorous effluvia, various exhalations, and innumerable others which are generally present, is always impregnated with aqueous vapour, electric and magnetic matter, and generally with carbonic acid gas; and is itself composed of unequal parts of two aeriform fluids, viz. 79 of azotic gas, and 21 of oxygen gas in 100.

149. In the first place we know for certain, that at every inspiration, (the fulness of which varies infinitely in different men of the same age, breathing placidly,†) besides the quantity of azotic gas being somewhat diminished,‡ the oxygen gas is in a great measure converted into carbonic acid gas, or fixed air; so that the air of expiration, if collected, instantly extinguishes flame and live coals, precipitates lime from lime water, and is specifically heavier than atmospheric air, and rendered unfit for respiration;§ it also contains much aqueous vapour, which

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in the latter's *Description of the Pyramids in Egypt*, p. 101, sq. Lond. 1646, 8vo. Also Edm. Halley's immortal popular *Discourse concerning the Means of furnishing Air at the Bottom of the Sea in any ordinary Depths*. Phil. Trans. vol. xxix. No. 349, p. 492, sq.

* Fr. Sromeyer, *Grundiss der Theoretischen Chemie*. P. ii. p. 619.

† Consult for instance Abildgaard in the *Nordisch. Archiv. für Naturkunde*, &c. T. 1. P. i. and ii.

‡ Consult, besides Priestley and others, especially C. H. Peaff, ib. .iv. P. ii.

To discover how frequently an animal could breathe the same is condensed in a visible form by a temperature of 60° of Fahr.*

150. It is therefore probable, that, during inspiration, the base of the oxygenous portion is set at liberty, and being united with the arterial blood, is conveyed throughout the system; while the carbon and hydrogen are brought back with the venous blood to the right side of the heart, and thrown off like smoke, as the ancients expressed it, in the lungs.†

The more florid colour of the arterial blood,‡ the darker of the venous, and the analogous appearance of the blood, if exposed to the gases in question, (13) correspond admirably with this theory. Some difficulties,

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portion of air, I took three dogs equal in size and strength; and to the trachea of the first, by means of a tube, I tied a bladder, containing about 20 cubic inches of *oxygen* gas. He died in 14 minutes.

With the second, the bladder was filled with *atmospheric* air. He died in 6 minutes.

With the third, I employed the carbonized air expired by the second dog. He died in 4 minutes.

Upon afterwards examining the air of the bladder, it gave the common signs of carbonic acid gas. The instruments which I employed are described and illustrated by a plate in the *Medic. Biblioth.* Vol. 1. p. 174. et seq. tab. 1.

* J. A. De Luc. *Idées sur la Météorologie*, tom. ii. p. 67. 229.

† Rob. Menzies, *De Respiratione*. Edinb. 1790, 8vo.

H. G. Rouppe on the same subject. Lugd. Batav. 1791, 4to.

J. Bostock's *Versuch über das Athemolen. übers.* von. A. F. Nolde. Erf. 1809, 8vo.

‡ J. Andr. Scherer. *Beweis dass* J. Mayow, *vor* 100, *Jahren den Grund Zur Antiphlogistischen Chemie und Physiologie gelegt hat*, p. 104. Edm. Godwyn's *Connexion of Life, with Respiration*, Lond. 1788, 8vo. J. Hunter, *On the Blood*, p. 68. J. A. Albers in the *Beyträgen zur Anat. und Physiolog. der Thiere*. P. 1, p. 108.

indeed, remain to be solved, v. c. how the carbon can be united in the lungs with the oxygen, so as to fly off in the form of carbonic acid gas. (C)*

151. This perpetual change of elements occurring in respiration after birth, we shall show to be very differently accomplished in the fœtus, viz. by means of the connection of the gravid uterus with the placenta. But when the child is born and capable of volition, the congestion takes place in the aorta, from the obstruction in the umbilical arteries: the danger of suffocation from the cessation of those changes of the blood, in regard to oxygen and carbon, (13) hitherto produced in the uterine placenta; the novel impression of that element into which the child, hitherto an aquatic being, is conveyed; the cooler temperature to which it is now exposed, and the many new stimuli which are now applied, seem to induce new motions in the body, especially the dilatation of the chest and the first inspiration.

The lungs being for the first time dilated by inspiration, open a new channel to the blood, so that, being obstructed in the umbilical arteries, it is derived to the chest.

Since the inspired air becomes hurtful and unpleasant to the lungs by the decomposition which it experiences, we would ascribe to the most simple corrective powers of nature, the subsequent motion by which the poisonous mephitis, as it may be called, is expelled and exchanged for a fresh supply (D).

The consideration of all these circumstances, especially if the importance of respiration to circulation, demon-

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* See J. Brugnatelli's *Elementi di Chimica*. T. 1, p. 155. T. Fr. Gmelin, *De Acidorum origine ex aëre vitali adhuc dubia* in the *Comment. Soc. Reg. Sc. Gotting*. T. xiii.

strated by the well-known experiment of Hooke,* be remembered, will, in my opinion, explain the celebrated *problem* of Harvey† better‡ than most other attempts of physiologists (E). §

NOTES.

(A) A correct notion can scarcely be formed from this description. The pleura is two closed sacs, one of which is interposed between each lung and the parietes of the chest, one portion of the sac adhering to the latter and one to the former; but the internal surfaces of both portions are always in contact, because, if the parietes of the thorax expand and draw with them the external portion, the lungs at the same time expand with air, and force out the internal in the same proportion.

* It bears the epithet Hookian, because it was most adorned by Rob. Hooke. See Th. Sprat's *History of the Royal Society*. Lond. 1667, 4to. p. 232. But it was before instituted and very much praised for its beauty by Vesalius. *De c. h. Fabrica.* p. 824.

† Wm. Harvey *De circulat. sanguin. ad* T. Riolan, p. 258. Glasgov. 1751, 12mo. and especially his *Exerc. de genere Animalium*, p. 263. London, 1651, 4to.

‡ See Theod. G. Aug. Roose *Uber das Ersticken neugebohrner Kinder.* in his *Physiologisch. Untersuchungen.* Brunsw. 1796, 8vo. J. D. Herholdt *De vita imprimis fœtus humani, ejusque morte sub partu.* Havn. 1802, 8vo.

§ Cousult, for example, Petr. T. Daoustenc *De Respiratione.* Lugd. 1743, 4to. p. 34, sq. Rob. Whytt on *the Vital and other involuntary Motions of Animals*, p. 222. Edinb. 1751, 8vo.

(B) To Dr. Carson we are indebted for the best account of the mechanical part of respiration.

The substance of the lungs is highly elastic, and constantly kept in a forced state of distension after birth by the pressure of the atmosphere. This is evident, as upon puncturing the walls of the thorax, the lungs instantly collapse,—a circumstance arising from the atmospheric pressure on the one side being counterbalanced on the other, so that their elasticity, experiencing no opposition, becomes effective. During inspiration, the intercostal muscles raise and draw out the ribs, and the diaphragm descends: the enlargement of the thoracic cavity is instantly followed of necessity by the greater distension of the substance of the lungs from the diminished resistance to the atmosphere gravitating in the bronchiæ. The diaphragm and intercostal muscle ceasing to act, the substance of the lungs exerts its elasticity with effect, recovers its former dimensions, and drives out the additional volume of air just admitted, and the passive diaphragm and intercostal muscles follow the shrinking substance of the lungs, offering, from their relaxation, no resistance to the atmosphere pressing on the surface of the chest and abdomen. Thus expiration is produced. The muscular power of the diaphragm and intercostal muscles is far greater than the elastic power of the lungs, and therefore when exerted overcomes it, producing inspiration: but ceasing to be exerted, the elastic power gains efficiency, and produces expiration. "The contractile power of the diaphragm *(and intercostal muscles)* in conformity with the laws of muscular motion, is irregular, remitting and sometimes altogether quiescent. The elasticity of the lungs, on the other hand, is equal and constant. The superior energy of the former is balanced by the permanency of the latter. By the advantage which the inferior power, from the uniformity of its operations, is enabled to take of the remissions of its more powerful antagonist, the ground which had been lost is recovered, and the contest prolonged; that contest in which victory declaring on one side or the other is the instant death of the fabric." p. 223. l. c.

In the common account of respiration, the elasticity of the lungs is unnoticed, and expiration is ascribed to the contractions of the abdominal muscles. Now in the first place, the elasticity of the lungs is of itself sufficient for the purpose, and in the second, there is no proof of the necessity of these muscles in expiration. It proceeds equally well in cases of inanition, when their contraction would rather enlarge than diminish the abdominal cavity, and in experiments when they are entirely removed from animals.

The beautiful contrivance in the shape of the thorax deserves attention: by being conical, every degree of motion in the diaphragm produces a greater effect on the size of the chest than could occur were it of any other shape.

The vacuum constantly threatening in the chest, either from the shrinking of the lungs or the contraction of the inspiratory muscles, and I may add from the expulsion of blood from the ventricles of the heart, will evidently be prevented, not only by the falling of the ribs and the ascent of the diaphragm in the former case, and ingress of additional air into the bronchiæ in the latter, but also by the course of venous blood into the auricles; for the venous blood being subject to the full atmospheric pressure without the chest will necessarily be driven into the chest to prevent a vacuum; the arterial blood is under the same circumstances, but the propelling force of the ventricles prevents its retrogression. The atmospheric pressure on the blood-vessels creates a necessity for greater strength in the ventricles, as it impedes the progress of blood from the heart, but it thus facilitates its return. Thus the smaller pressure on the heart acts by the intervention of the blood, as an antagonist to its contracting fibres, dilating them when they become relaxed.

By the tendency to a vacuum in the cavity of the thorax, what effect the heart loses by atmospheric resistance without the chest, is exactly compensated within, and thus on the whole the heart neither gains nor loses by all the various directions of atmospheric pressure.

In the fœtus the case is precisely the same, although Dr. Carson has imagined it different, and thought it necessary to frame a little hypothesis to reconcile circumstances. The fœtal lungs, experiencing no atmospheric pressure, are contracted to the utmost, and the diaphragm suffering no stimulus from the will on account of uneasy sensation arising from want of breath, is completely relaxed and forced upwards, to remove the vacuum, and the venous blood without the thorax must, for the same reason, be drawn forcibly into the right auricle, preventing the vacuum which the shrunk state of the lungs, and the discharges of blood from the left ventricle tend to produce.

The cause of the first inspiration appears to be the novel impression of cool air upon the surface, for if at any time we are exposed to a cold wind or plunge into cold water, the diaphragm and intercostal muscles instantly contract, and a strong inspiration takes place. The blood rushes into the expanded lungs, and being afterwards obstructed when the inspiratory muscles cease to act and the elastic lungs shrink, gives rise to an uneasy sensation, which is instinctively removed by an other inspiration, and thus respiration afterwards continues through life. The fact of respiration commencing before the chord is tied, shows that neither the conjestion in the aorta, nor the deficiency of chemical changes, is the cause of the first inspiration.

The elasticity of the lungs is not sufficiently great to expel the whole of their air in expiration, whence they remain constantly in a certain degree of distension, and the course of the blood through them is never completely obstructed by expiration.

(C) It is now ascertained, that no oxygen is absorbed in respiration, but that it goes entirely to unite with the carbon of the blood and produce carbonic acid. Mr. Ellis * contends that the carbon escapes from the vessels and unites with the oxygen externally; and my distinguished and excellent friend Dr. Prout thinks this opinion corroborated by a fact stated by Orfila,† that when phosphorous dissolved in oil is injected into the blood-vessels, vapours of phosphorous acid stream from the mouth and nostrils, which would hardly have occurred if the acid had been formed in the vessels, as it would probably have remained in solution in the blood, not being volatile;—the phosphorus was probably excreted from the vessels in minute subdivision, and united with the oxygen of the atmosphere upon coming in contact with it, producing phosphorous acid; and the same may be imagined respecting the carbonic.‡ The quantity of carbon discharged amounts in an adult man to 11 oz. in twenty-four hours, according to the experiments of Messrs. Allen and Pepys.§

* *On Respiration.* † *Toxicologie Generale.* ‡ *Annals of Medicine and Surgery*, vol. i. p. 155. § *Philos. Trans.* 1808. and 1809.

But the capacity of the lungs upon which such calculations are founded, appears to me greatly overrated.

The use of the nitrogen respired is unknown. The universality of respiration or something analogous among living beings, and all the circumstances attending its performance, render it probable, as Dr. Prout justly remarks, that it does something more than discharge a little superfluous carbon. He considers galvanism as an instrument extensively used by the vital principle, and as galvanism must be produced by the combination of carbon with oxygen, as it is in the battery by the union of the metal and oxygen, one great additional purpose of respiration becomes highly probable.

According to Berzelius, the colouring matter alone produces changes upon the air, and that only when mixed with the other constituents of the blood.*

Dr. Prout and Dr. Fyfe have found the quantity of carbonic acid gas experience uniform variations. It is diminished by mercury, tea, substances containing alcohol, depressing passions, and fatigue, and undergoes an increase from day-break till noon, and a decrease from noon till sun-set, remaining at the minimum till day-break.†

(D) On the subject of all this paragraph see note B.

(E) The experiment consisted in laying the lungs completely bare, and supporting life by continuing respiration artificially. Hooke varied it by pricking the surface of the lungs, and forcing a continued stream of air through them. The following are the words of Harvey: "It would appear that the use of expiration is to purify and ventilate the blood, by separating from it these noxious and fuliginous vapours."

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* *Animal Chemistry.* † Thomson's *Annals of Philosophy*, 1814. *Dissert. Inaugur.* &c. Edinb. 1814.

SECT. IX.

OF THE VOICE AND SPEECH.

152. We have described the chief use of respiration. We shall hereafter mention how far it contributes to the conversion of the chyle into blood, and to the support of almost the whole class of natural functions. Its other uses are at present to be considered.

And first, respecting the *voice*.* This takes place after birth, and proceeds from the lungs, as was observed long ago by Aristotle, who called those animals only vocal, which breathed by means of lungs. The voice is, properly speaking, a sound, formed, by means of expiration, in the *larynx*, which is a most beautifully constructed organ, fixed upon the top of the windpipe, like a capital upon a pillar.†

153. The larynx is composed of various cartilages, which being united together in the form, as it were, of a little box,‡ and supplied with a considerable and wonderful apparatus of muscles,§ may be moved altogether, or separately, according to the variations of the voice.

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* Th. Young in *The Philos. Trans.* 1800. P. 1.

† Jan. Marg. Busch *De Mechanismo Organi vocis hujusque Functione.* Groning. 1770. 4to.

‡ Soemmerring's *Icones Organorum Gustus et Vocis.* Francof. 1808. fol.

§ B. S. Albinus' *Tab. Muscul.* Tab. X. fig. 1—15. Tab. XI. fig. 45—48. Tab. XII. fig. 1—7.

154. The part of the larynx most concerned in producing the voice, is the *glottis*, or narrow opening of the windpipe, having the epiglottis suspended, and, in a manner, fixed upon it. It is clearly ascertained, that the air, expired from the lungs, and striking properly upon the margins of the glottis, becomes sonorous.

155. But it has been disputed what changes the glottis undergoes in modulating the voice. Whether it is alternately widened and constricted, as Galen and Dodart supposed, or whether, according to Ferrein, the variations of voice are effected rather by the tension and relaxation of its ligaments.

The latter, consistently with his opinion, compared the larynx to a violin; the former, more consistently with nature, to a flute.*

Every thing considered, we must conclude that the glottis, when sounding, experiences both kinds of changes; since the grave and acute modulation of the voice must depend very much upon the alterations produced in the glottis by the ligaments, especially the *inferior* thyreo-arytenoids, (the *vocal chords* of Ferrein,) and by the corresponding modification of the *sinuses* or *ventricles of the larynx*.†

* Kratzenstein viewed the glottis and larynx as a kind of drum, with its head bisected. *Tentamen de Natura et Charactere Sonorum Litterarum Vocalium.* Pretop. 1781. 4to. I would, in some sense, compare it to an Eolian harp, particularly one of the description found by Labillardiére in Amboyna. *Voyage à la Recherche de la Perouse.* T. i. p. 326.

† See some experiments made at Gottingen with the view of settling this controversy, in J. G. Runge's Dissertation *De Voce Ejusque Or-*

156. That every degree of motion in the glottis is directed by the numerous muscles of the larynx, is proved by the beautiful experiment of tying or dividing the recurrent nerves, or par vagum,* and thus weakening or destroying the voice of the animal (A).

157. Man and singing birds have the power of *whistling*. In the latter, it is accomplished by a larynx placed at each extremity of the wind-pipe, and divided into two portions. The former, though possessing a single and undivided larynx, has learned, I imagine, to imitate birds, by the coarctation of the lips.†

158. *Singing*, which is composed of speech and an harmonic modulation of the voice, I conceive to be peculiar to man, and the chief prerogative of his vocal organs. Whistling is connate in birds; many of them may easily be taught to pronounce words, and instances have been known of this even in dogs. But it is recorded, that genuine singing has once or twice only, then indeed but indifferently and with the utmost difficulty, been taught

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genis. L. B. 1753. 4to. Also consult Jos. Ballanti, in the *Commentar. Instituti Bonon.* T. vi. Vicq-d'Azyr in the *Mem. de l'Acad. des Sc. de Paris.* A. 1779.

* Respecting this celebrated experiment, anciently made by Galen, consult among others W. Courten, in the *Philos. Trans.* N. 335. Morgagni. *Ep. Anatom.* xii. No. 20. P. F. Molinelli, in the *Comment. Instit. Bonon.* Tom. iii. J. Haighton, in the *Memoirs of the Medical Society of London.* T. iii.

† The larynx, even among the most ferocious people, is capable of imitating the sounds of animals.

Consult Nic. Wisten, *Noord en oost—Tartarye* ed. 2. Amst. 1705. vol. 1. p. 165, respecting the southern inhabitants of New Guinea, called *Papus.* And J. Adair, in his *History of the American Indians,* p. 309, respecting the Chotkah tribe of North America.

to parrots; while, on the other hand, scarcely a barbarous nation exists, in which singing is not common. *

159. *Speech* is a singular modification of the voice, adjusted to the formation of the sounds of letters, by the expiration of air through the mouth or nostrils, and in a great measure by the assistance of the tongue, applied and struck against the neighbouring parts, the palate and teeth in particular, and by the diversified action of the lips. †

The difference between voice and speech is therefore evident. The former is produced in the larynx; the latter by the singular mechanism of the organs above described.

Voice is common both to brutes and man, even immediately after birth, nor is entirely absent in those wretched infants who are born deaf. But speech follows only the culture and employment of reason, and is consequently, like it, the privilege of man in distinction to the rest of animal nature. For brutes, natural instinct is sufficient; but man, destitute of this and other means of supporting his existence independently, enjoys the prerogative of reason and language; and following, by their means, his social destination, is enabled to form, as it were, and manifest his ideas, and to communicate his wants to others by the organ of speech.

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* I have in my hands the testimony of most respectable travellers, in regard, for instance, to the inhabitants of Ethiopia, Greenland, Canada, California, Kamtschatka, &c. and therefore wonder at the assertion of Rousseau, that singing is not natural to man. *Dictionn. de Musique* T. i. p. 170. *Genev.* 1781. 12mo.

† See Rich. Payne Knight's *Analytical Essay on the Greek Alphabet.* Lond. 1791. 4to. p. 3.

160. The mechanism * of speech and articulation is so intricate, and so little understood, that even the division of letters, and their distribution into classes, † is attended with much difficulty.

The division, however, of Ammann, ‡ into vowels, semi-vowels, and consonants, is very natural:

I. He divides the vowels § into *simple, a, e, i, y, o, u,* and mixed, *ä, ö, ü.*

These are formed simply by the VOICE.

The semi-vowels and consonants are articulated by the mechanism of SPEECH.

II. The semi-vowels are *nasal, m, n, ng,* (*n* before *g*, which is nearly related to it,) that is, the labio-nasal *m*; the dente-nasal *n*; and the gutture-nasal *ng*; or *oral* (lingual) *r, l*; that is, *r* with a vibration of the tongue; or *l*, with the tongue less moved.

III. The consonants are distinguished into *hissing* (pronounced in succession) *h, g, ch, s, sch, f, v, ph*; that is *h*,

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* Consult F. Mercur. ab. Helmont's *Alphabeti vere Naturalis Hebraici Delineatio.* Sulzbac. 1657. 12mo.

Joach. Jungii *Doxascopiæ Physicæ Minores* (1662.) 4to. Append. Section i. P. ii. fol. G. ii. g. 3.

J. Wallis' *Grammatica Linguæ Anglicanæ, cui præfigitur de loquela s. sonorum omnium loquelarium formatione tract. grammatico-physicus.* Ed. 6. Lond. 1765. 8vo.

Gottl. Conr. Chr. Storr. *De Formatione Loquelæ.* Tubing. 1781. 4to.

† K. G. Anton, *Uber Sprache in Rücksicht auf Geschichte der Menscheith.* Görlitz. 1799. 8vo.

Er. Darwin's *Temple of Nature. Addit. Notes*, p. 112.

‡ His *Surdus Loquens.* Amst. 1692. 8vo. With the *Dissert. de Loquela.* Ib. 1700.

§ Respecting their formation, consult Chr. Theoph. Kratzenstein's *Tentamen*, recommended above.

formed in the throat, as it were a mere aspiration; *g* and *ch* true consonants; *s*, *sch*, produced between the teeth; *f*, *v*, *ph*, formed by the applicat on of the lower lip to the upper front teeth: and *explosive*, (which are, in a manner, at once exploded, by an expiration, for some time suppressed or interrupted,) that is, *k*, *q*, formed in the throat; *d*, *t*, about the teeth; *p*, *b*, near the lips; and *double* (compound), *x*, *z*.

161. We must just mention certain other modifications of the human voice, of which some, as hiccup and cough, belong more properly to pathology than to physiology, but are very common in the most healthy persons; and others, as weeping and laughing, appear peculiar to the human race.

162. Many of these are so closely allied, as frequently to be converted into each other; most also are variously modified.

In *laughter* there is a succession of short and abrupt expirations.*

Coughing is a quick, violent, and sonorous expiration, following a deep inspiration.†

Sneezing, generally the consequence of an irritation of the mucous membr... of the nostrils, is a violent and almost convulsive expiration, preceded by a short and violent inspiration.‡

Hiccup, on the contr ry, is a sonorous, very short, and

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* Fr. Lupichius *De Risu*. Basil, 1738. 4to. *Traité des Causes Physiques et Morales du rire*. Amst. 1788. 8vo.

† J. Melch. Fr. Albrecht (Præs. Haller.) *Experimenta in vivis Animalibus circa tussis organa exploranda instituta*. Gotting. 1751. 4to.

‡ Marc. Beat. L. J. Porta *De Sternutatione*. Basil, 1755. 4to.

almost convulsive inspiration, excited by an unusual irritation of the cardia. *

Weeping consists of deep inspirations, quickly alternating with long and occasionally interrupted expirations. †

Sighing is a long and deep inspiration, and the subsequent expiration is sometimes accompanied by *groaning*. ‡

Nearest in relation to sighing is *gaping*, § which is produced by a full, slow, and long inspiration, followed by a similar expiration, the jaws at the same time being drawn asunder, so that the air rushes into the open fauces and the Eustachian tubes. It occurs from the blood passing through the lungs too slowly; v. c. when the pressure of the air is diminished, as upon very high mountains. A peculiar feature of gaping is the propensity it excites in others to gape likewise; arising, no doubt, from the recollection of the pleasure it produced.

NOTE.

(A) M. Le Gallois has ascertained that the division of the recurrent nerves frequently proves fatal in animals, and that its effect is to paralyse the arytenoid muscles, thus relaxing the ligaments of the glottis, the aperture of which is therefore diminished. This effect, however, va-

* C. J. Sig. Thiel *De Singulter*. Gotting. 1761. 4to.

† J. F. Schreiber *De Fletu*. L. B. 1728. 4to.

‡ Dav. C. Imm. Berdot *De suspirio*. Basil. 1756. 4to.

§ Just. Godofr. Günz (Præside Walthero) *De Oscitatione*. Lips. 1738. 4to.

ries with the kind and age of the animal. The danger diminishes as the animal is older; and, after a certain age, little inconvenience follows.*

The inferior ligaments of the glottis are the chief source of the *voice*, for in blowing into the trachea and larynx of an animal a slight sound only is heard, unless you approximate the arytenoid cartilages to each other, when a sound somewhat analogous to the voice of the animal will be produced, and more acute in proportion to their approximation: and it will be seen, at the same time, that the sound is caused chiefly by the vibrations of the inferior ligaments of the glottis. Again, an opening below the inferior ligaments destroys the voice, while one above it, even through the epiglottis, superior ligaments and arytenoid cartilages, has no such effect. In grave tones, the whole length of the inferior ligaments may be seen in a dog to vibrate; in more acute, the posterior part only; and in very acute, merely the arytenoid extremity, the opening of the glottis being of course lessened in the same proportion. These circumstances depend upon the thyro-arytenoid muscles, which run on each side from the arytenoid to the thyroid cartilage and from the lips of the glottis (and indeed also the superior ligaments), being covered by an aponeurosis, and this by the mucous membrane. In proportion as these contract, they become shorter and more tense, and lessen the mouth of the glottis; but the complete closure of the glottis at the back part is effected by the arytenoid muscles, which connects the two arytenoid cartilages.† As all these are voluntary

* *Experiences sur le Principe de la Vie.* Par M. Le Gallois.

† These observations of M. Majendie's are contradictory to those of M. Le Gallois.

muscles, the division of their nerves destroys the voice. The division of the recurrents, which supply the arytenoid muscles, is sufficient for this purpose; but, in some instances, a sound still remains similar to what may be produced after death by blowing through the larynx, after approximating the arytenoid cartilages, and must be owing to the action of the arytenoid muscles, which are supplied not by the recurrent but by the laryngeal nerves. As these muscles are the chief means of contracting the posterior part of the glottis, and producing the most acute sounds, the division of the laryngeal nerves destroys almost all acute sounds and renders the voice grave.

"It is therefore evident that the larynx represents a reed with two plates, the tones of which are acute in proportion as the plates are short, and grave in proportion as they are long. But although this analogy is just, we must not imagine that there is a perfect identity. In fact, common reeds are composed of rectangular plates fixed on one side and free on the three others, while the vibrating plates of the larynx, which are also nearly rectangular, are fixed on three sides, and free on one only. Besides, the tones of common reeds are made to ascend or descend by varying their length; but the plates of the larynx vary only in breadth. Lastly, the moveable plates of the reeds of musical instruments cannot, like the ligaments of the glottis, change every moment in thickness and elasticity."* The elongation and shortening of the trachea and of the cavity between the glottis and the lips, and the changes of the epiglottis and of the ventricles of the larynx, must affect the *voice*.

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* *Precis Elémentaire de Physiologie,* par F. Majendie. T. 1. p. 216. seq.

SECT. X.

OF ANIMAL HEAT.

163. MAN, the mammalia, and birds, are distinguished by the natural temperature* of their bodies greatly exceeding that of the medium in which they are accustomed to exist. Man is again distinguished from these classes of animals, by possessing a much lower temperature than they; so that in this climate it is about 96° of Fahr. while in them, and especially in birds, it is considerably higher.†

164. This natural temperature in man, is so constant, equable,‡ and perpetual, that, excepting slight differences from variety of constitution, it varies but little, even in the coldest climate and under the torrid zone. For the opinion of Boerhaave, that man cannot live in a temperature

* W. B. Johnson's *History of Animal Chemistry*. Vol. iii. p. 79.

† The torpid state of some animals, during winter, is of course an exception to this. Most of the functions cease or languish considerably, and the animal heat is reduced nearly to coolness. This well-known circumstance prevents me from acceding to the opinion of the very acute J. Hunter,—that the animals which we call warm blooded, should rather be called animals of a permanent heat under all temperatures. *On the Blood*, p. 15.

‡ J. B. Van Mons in the *Journal de Physique*. T. lxviii. 1809, p. 121.

exceeding his own, has been refuted since the admirable observations* of H. Ellis, the celebrated traveller and formerly the captain of the George, by the remarkable experiments† of many excellent physiologists.‡ This striking prerogative of man is evinced by his being restricted to no climate, but inhabiting every part of the earth from Hudson's bay, where Mercury freezes, and from Nova Zembla, to the scorching shore of Senegal.

165. The explanation of this circumstance is equally simple and natural, and founded on the doctrine which makes the lungs the grand receivers, or focus, and the decomposition of the oxygenised portion of the air (148) the source or fomites of our heat.

166. For, as the oxygenous part of the inspired air is decomposed in the air cells of the lungs, in such a way that its base, which by its union with *latent* caloric was before aëriform, now separates from this caloric, it would appear that, by this decomposition, one portion of the caloric is rendered sensible in the bronchiæ, while the other enters in a latent form into the blood, circulating in the

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* *Philos. Trans.* vol. i. P. ii. 1758. Arn. Dantze had previously made the observation in regard to brutes. *Exper. Calorem Animalem Spectantia.* Lugd. Bat. 1754, 4to. Also Benj. Franklin's *Experiments and Observations on Electricity.* Lond. 1769, 4to. p. 365.

† Duhamel and Tillet, in the *Mem. de l'Acad. des Scienc. de Paris*, 1704.

Blagden and Dobson. *Philos. Trans.* 1765.

‡ The heat of the weather, even in Europe, occasionally exceeds our natural temperature. This was the case on the third of Aug. 1783, at noon, when I was on the Lucern Alps, in company with the excellent Schnyder de Wartensee. The thermometer in the shade stood above 100° Fahr. and when applied to the body, invariably sunk to 97°.

innumerable and delicate net-works of the pulmonary vessels.*

167. When the oxygenised blood thus charged with latent heat circulates through the aortic system, it acquires carbon in the small vessels and sets free much of the latent heat which it had received; in this way is our animal heat principally produced.†

168. Its production and regulation, however, appear much influenced by the *secretion* of fluids from the blood, both those which are liquid and destined to solidify by assimilation and nutrition, and those which are permanently elastic.

169. Since these changes are effected by the energy of the *vital powers*, the great influence of these upon our temperature must be easily perceived.‡

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* See Lichtenberg's Animadversions upon this part of Crawford's Theory, in his notes to Erxleben's *Anfängsgr. der Naturlehre.* p. 447. ed. vi.

† Hence the constant coldness of those wretched beings who labour under the *blue disease*, which arises from a mal-conformation of the heart. Sometimes the septa of the heart are imperfect, sometimes the aorta arises with the pulmonary artery from the right ventricle, as in the tortoise. In such instances, the chemical changes cannot take place in the lungs. Among innumerable instances of this lamentable disease, suffice it to quote J. Abernethy's *Surgical and Physiological Essays.* P. ii. p. 158, and Fr. Tiedemann. *Zoologie.* T. i. p. 177.

‡ I have formerly treated of the influence of the nervous system upon anima lheat, in my *Specimen Physiologiæ Comparatæ Inter Animantia Calidi & Frigidi Sanguinis*, p. 23.

See the same confirmed by many arguments in Magn. Ström's *Theoria Inflammationis Doctrinæ de Calore Animali Superstructa.* Havn. 1795, 8vo. p. 30, sq. and by the much lamented Roose, in the *Journal der Erfindungen*, &c. T. v. p. 17.

Consult also Dupuytrem in the *Analyse des Travaux de l'Institut* 1807, p. 16.

170. Many arguments render it probable, that the action of the minute vessels, and the conversion of oxygenised into carbonised blood, are dependent upon the varied excitement or depression of the vital principle.

For the remarkable phenomena of the stability of our temperature,* (proved by the thermometer, and not by the sense of touch, which may be fallacious,)—that it is scarcely increased by the heat of summer, or diminished by the cold of winter, but found sometimes even to increase on immersion in cold water,† demonstrate that the action of the minute vessels varies according to the temperature of the medium in which we are placed: so that, when exposed to a low temperature (by which their tone is probably augmented) more oxygen is exchanged for carbon and more heat evolved; while in a high and debilitating temperature this exchange is diminished, and less heat evolved.‡

171. The *corium* which covers the body and the internal surface of the *alimentary canal*, eminently contributes, if we are not much mistaken, to regulate our temperature. For both these organs are supplied with an immense number of blood-vessels, being analogous in this respect to the lungs, and are so intimately connected with the lungs by means of sympathy,§ as in some degree to

* See Crawford in the *Philos. Trans.* vol. lxxi. p. ii.

† G. Pickel's *Experimenta Physico-Medica de Electricitate et Calore Animali. Wirceb.* 1788, 8vo. p. 91, sq.

‡ C. Ferd. Becker *De Effectibus Caloris et Frigoris Externi in c. h.* Gott. 1802, 4to. and Wm. Fr. Baur *On the same subject, ib. eod. (both honoured with the Royal Prize).* Mich. Skjelderup. *Dissert. Sistens Vim Frigoris incitantem.* Hafn. 1803, 8vo.

§ J. Chr. Goeschen, (Præs. Ph. Fr. Meckel) *Pulmonum cum Cute* perform a part and occasionally the whole of some of their functions in their room. This is exemplified in adults labouring under nearly total consumption, or other violent affections, of the lungs, and nevertheless existing for a length of time, almost without respiration.*

172. This opinion respecting the action of the *cutaneous* vessels in exciting, moderating, or almost extinguishing our heat, receives much support from the physiological and pathological facts of *some parts* being frequently of a higher or lower temperature than the rest of the system.

Thus we must attribute the coldness of the dog's nose to the specific action of its own vessels being modified differently from that of the rest; so on the other hand, the burning sometimes of the cheeks and sometimes of the palms of the hands in hectic fever, to the locally increased action of the vessels; not to mention other phenomena of the same description, v. c. the heat of the genitals during the venereal œstrum, and the irresistible coldness of the feet in certain diseases.

173. The *alimentary canal* is the only internal part, besides the lungs, exposed to the contact of the atmosphere. There is scarcely occasion to prove that it is so exposed, and that we swallow a considerable quantity of air.

The air, when swallowed, is decomposed in the stomach and intestines, so that, during health, it soon loses its elastic form: not, however, when the capillaries of the canal are debilitated, or when it exists in too great quantity.

The extraordinary congeries of blood-vessels in the

Commercium. Hal. 1789, 8vo. But especially J. D. Brandis. *Pathologie.* Hamb. 1808, p. 316, sq.

* See, for instance, Tacconi in the *Comment. Instit. Bononiens* Vol. vi. p. 74.

intestines, on their internal surface which is usually believed equal to the external surface of the body, agrees very well with this idea. (A)

NOTE.

(A) No phenomenon in living bodies is more remarkable than their peculiar temperature, and no one was of more difficult solution before the progress of modern chemistry.

If two different bodies are placed in a temperature, higher or lower than their own, for a certain length of time, they will, at the end of the period, be found not of the same, but of different, temperatures. That which has the higher temperature, is said to have a smaller capacity for caloric; that which has the lower, a greater capacity. To raise the former to a given temperature, therefore, requires less heat than to raise the latter to the same degree.

The temperature of solids is more easily affected by a given quantity of heat, than that of fluids, and the temperature of fluids than that of aeriform bodies: or in other words, solids have a smaller capacity for caloric, than fluids, and fluids than aeriform bodies. If, therefore, a solid becomes fluid, or a fluid aeriform, it absorbs a great quantity of heat, though its temperature remain precisely the same. And the converse holds equally good,—if an aeriform substance becomes liquid, or a liquid solid, the heat which it before contained is now (from the diminished capacity of the body) much more than sufficient for the temperature which before existed, and the temperature of the body accordingly rises.

In respiration, the dark blood of the pulmonary artery darts with a portion of its carbon, and acquires a florid hue. This carbon unites with the oxygen of the inspired air, and forms carbonic acid, which is expired with the other constituent of the atmosphere,—nitrogen or azote, —which appears to have experienced no change from inspiration.

Dr. Crawford rendered it probable, by his experiments, that the arterial blood has a larger capacity for caloric than the venous; and common air, than carbonic acid gas. When, therefore, the carbon of the venous blood unites with the oxygen of the air and forms carbonic acid, the less capacity of this than common air for caloric, must cause an increase of temperature, but the blood having changed from venous to arterial, has acquired a greater capacity than before, and absorbs the heat given out by the carbonic acid. The blood, of course, does not become warmer, because the heat is not more than sufficient to render its temperature equal to what it was previously; and indeed it is not quite sufficient for this, for the arterial blood of the pulmonary veins is generally two degrees lower than that of the pulmonary artery.

The body in this way acquires a fund of heat, and yet the lungs, in which it is acquired, do not experience any elevation of temperature.

The arterial blood, charged with much heat which is not sensible, circulating through the small vessels, becomes venous,—acquires a dark hue, and its capacity for heat is diminished; consequently its temperature rises: the heat which was previously latent, is, from the decrease of capacity, sufficient to raise its temperature, and is evolved. In this mode, the loss of heat which occurs from the inferior temperature in which we live, is compensated. The fresh supply is taken in at the lungs, and brought into use in the minute vessels.

Of late, this theory has been brought into discredit. All experiments upon the capacities of bodies for heat, are very delicate and liable to error; and the opinions of Crawford on this point, with respect to the gases, have been denied by M. M. de la Roche and Berard, and by Dr. Davy, with respect to arterial and venous blood.*

Mr. Brodie cut off the communication between the brain and lungs of animals, and continued respiration artificially.† The usual chemical changes continued in the lungs upon the blood, nevertheless the temperature of the animals diminished, and even more rapidly than if the respiration had not been continued, owing, he says, to the succession of cool air sent into the lungs. He therefore concludes, that animal heat depends much more upon the nervous energy than upon the chemical changes of the blood. But Le Gallois asserts, that under artificial respiration the temperature falls, if every part remain uninjured.

Many circumstances favor the doctrine of Crawford. In high temperatures we have less necessity for the evolution of heat by the chemical changes of the blood and air; whereas, in low temperatures, as more heat is required to sustain the natural degree of temperature, the chemical changes are more necessary; accordingly, in very high temperatures, the arterial blood remains arterial,—is as florid in the veins as in the arteries, and the inspired air is less vitiated; in low temperatures the venous blood is extremely dark, and the inspired air more vitiated.‡

Dr. Crawford states, that the chemical process of respiration may, in certain cases, be the means of cooling the body. If the pulmonary exhalation is in very great

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* *Philos. Trans.* 1814. † *Philos. Trans.* 1812.

‡ Crawford *on Animal Heat.* P. 387, sq.

abundance, it will carry off so much of the heat given out during the change of the oxygen into carbonic acid, that there may not be sufficient to saturate the increased capacity of the arterial blood; this will therefore absorb heat from the system, as it passes along, till its temperature equals that of the other parts.*

The temperature is also regulated by the degree of perspiration, and the momentum of the blood, &c. In proportion as more vapour transpires from the skin, will more heat be carried off: and as the sum of the quantity and velocity of blood in any part is greater, the temperature of that part will be higher. Whether Crawford's theory be correct or not, the production of animal temperature must still be as evidently a chemical process as changes of temperature among inanimate bodies. But this does not prevent it from strictly deserving the epithet vital, because it is regulated by the vital powers of the system, although through the instrumentality of chemical changes. If the high temperature of an inflamed part is owing to the increased momentum of the blood, yet this increased momentum is produced by the vital powers. As there is less vigour in old than in young persons, and in remote parts than in those which are near the centre of circulation, the momentum of the blood is less in the old than the young, and in parts remote than in parts near the heart; hence the temperature of the old falls short of the temperature of the young, and is stated to be in all persons lower in proportion to the distance of parts from the centre of the circulation.†

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* L. c. p. 388.

† Dr. Davy. *Philos. Trans.* 1814.

SECT. XI.

OF THE CUTANEOUS PERSPIRATION.

174. The functions of the skin, which affords a covering to the body, are so extremely various, that they cannot all be easily described with advantage in one chapter, but each will far more conveniently be considered under that class of actions to which it belongs.

For, in the first place, the skin is the organ of touch, and will be examined in this view, under the head of animal functions.

It is an organ of inhalation, and in this point of view belongs to the absorbent system, to be spoken of among the natural functions.

It is likewise the organ of perspiration, and on this account related in many ways to the function of respiration, and may, we think, very properly follow it in this place.

175. The skin consists of three membranes. The *corium*, internal; the *cuticle*, external; and the *reticulum*, intermediate.

176. The *cuticle* or epidermis,* forms the external covering of the body, is separable into lamellæ,† and exposed

* Al. Monro *Primus. Oratio de Cuticula Humana.* Opera. English edition. Edinb. 1781, 4to. p. 54, sq.

† Among others, consult J. Mitchell, in the *Philos. Trans.* Vol. xliii. p. 111.

to the atmosphere, the contact of which can be borne by scarcely any other part, if you except the enamel of the teeth. For this reason, the internal cavities and the canals which communicate with the surface for the purpose of admitting air, especially the respiratory passages, and the whole of the alimentary canal, the tongue, the inside of the cheeks, the fauces, and the organ of smell, are covered by a fine epithelium, originating from the epidermis.*

177. The texture of the epidermis is extremely simple, destitute of vessels, nerves, and of true mucous web, and consequently but little organized; very peculiar, however,† remarkably strong, considering its pellucidity and

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* Abr. Kaau, *Perspiratio Dicta* Hippocrati, p. 7.
Lieberkuhn, *De Fabrica Villor. Intestin. Tenuium*, p. 16.
Cruikshank's *Expts. on the Insensible Perspiration*, p. 5.
Rudolph, *Reisebemerkungen*. T. i. p. 29, 140.
Jens. W. Neergaard, *Vergleichende Anat. der Verdauungswerkzeuge*, p. 21, & alibi.

† The very dense epidermis of some immense animals consists of vertical fibres, which, in arrangement, somewhat resemble the structure of the Boletus igniarius. Its internal surface is porous and penetrated by the filaments, in appearance silken, of the subjacent corium. This is remarkably exemplified in a preparation now before me, taken from the skin of the balæna mysticetus. The human cuticle, in certain diseased states, exhibits the same appearance as in the Englishman called the Porcupine Man, who laboured under a cuticular complaint which he transmitted to his children and grand-children. Vide W. G. Tilesius' *Beschreibung und Abbildung der beiden sogenannten Stachelschwein-Menschen* (Porcupine Men.) Altenb. 1802. fol.

The innumerable polyedrical papillæ and horny warts which I witnessed upon every part of the skin of these brothers, excepting the head, the palms of the hands, and the soles of the feet, bore some resemblance to the skin of the elephant, especially about the vertex and forehead of the animal.

delicacy, so that it resists for a great length of time maceration, suppuration, and other modes of decay, and is reproduced more easily than any other of the similar parts.

178. It is completely sui generis, somewhat like a horny lamella, and adheres to the subjacent *corium* by the intervention of a mucus, and by numerous very delicate fibrils, which penetrate the latter.*

The pores which Leuwenhoek imagined in it, do not exist; but it allows a very ready passage to caloric, carbon, hydrogen, and to matters immediately composed of these, v. c. oil.

179. The importance of the cuticle to organized systems, is demonstrated by its universality in the animal and vegetable kingdoms; and by its being distinctly observable in the embryo from the third month at latest after conception.

180. The inner part of the cuticle is lined by a fine mucous membrane, denominated from the opinion of its discoverer, *reticulum Malpighianum*, and by means of which chiefly the cuticle is united more firmly to the corium.†

Its nature is mucous, it is very soluble, and, being thicker in Ethiopians, may be completely separated in

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Similar also are corns, and the brawny cuticle of the feet, in those who walk barefooted. Vide Carlisle on the Production and Nature of Corns in the *Med. Facts and Observations*. Vol. vii. p. 29.

* W. Hunter, in the *Med. Observations and Inquiries*, vol. ii. p. 52, sq. tab. i. fig. 1, 2. The conjecture of this eminent man, that the fibrils excrete the perspirable matter, is, I think, improbable.

† Hence I have found the Epidermis of Albinos separate easily by the heat of the sun; whereas in negroes, it scarcely does so on the application of a blister. C. F. Mitchell, l. c. p. 108.

them both from the corium and cuticle, and made to appear as a true distinct membrane.*

181. Our colour resides in it. In all persons the corium is white, and in almost all the cuticle white and semi-pellucid; in Ethiopians, indeed, alone, it inclines to grey. But the mucous reticulum varies after birth, with age, mode of life, and especially with difference of climate.

Thus among the four varieties into which I would divide the human race, in the first, which may be termed Caucasian, and embraces Europeans, (except the Laplanders and the rest of the Finnish race,) the western Asiatics, and the northern Africans, it is more or less *white*.

In the second, or Mongolian, including the rest of the Asiatics, (except the Malays of the peninsula beyond the Ganges,) the Finnish races of the north of Europe, as the Laplanders, &c. and the tribes of Eskimaux diffused over the north of America, it is *yellow*, or resembling box wood.

In the third, the Ethiopian, to which the remainder of the Africans† belong, it is of a *tawny* or *jet black*.

In the fourth, or American, comprehending all the

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* B. S. Albinus *De sede & Causa Coloris Æthiopum et Cæteror. Hominum.* Lugd. Batav. 1737, 4to. fig. i.

Sam. Th. Soemmerring *Uber die körperl. Verschiedenh. des Negers vom Europäer.* Ed. 2. p. 46. sq.

Some even of the moderns have assigned many laminæ, and even different kinds of laminæ, to the reticulum; as Lieutaud in his *Essais Anatomiques*, p. 103. ed. 1766; and Cruikshank, l. c. p. 43, 99.

Others make it organic. Vide Mich. Skjelderup, l. c. p. 93.

† Jo. Nic. Pechlin, *De Habitu et Colore Æthiopum, qui Vulgo et Nigritæ.* L. Kilon. 1677, 8vo. Camper's oration on the same subject will be found in his *kleiner Schriften.* Vol. i. P. 1. p. 24—49.

Americans, excepting the Eskimaux, it is almost copper coloured, of a dark *orange* or *ferruginous* hue.

In the fifth, or Malaic, in which I include the inhabitants of all the islands in the Pacific Ocean, and of the Philippine and Sunda, and those of the peninsula of Malaya, it is more or less *tawny*, between the hue of fresh mahogany and that of cloves or chesnuts.

All these shades of colour, as well as the other characteristics of nations and individuals, run so insensibly into one another, that all division and classification of them must be more or less arbitrary.

182. The essential cause of the colour of the Malpighian mucus, is, if we mistake not, the proportion of carbon which is excreted together with hydrogen from the corium; and in dark nations being very copious, is precipitated upon the mucus and combined with it.*

183. The corium, which is covered by the reticulum and epidermis, is a membrane, investing the whole body and defining its surface; tough; very extensible; of different degrees of thickness; every where closely united, and, as it were, interwoven with the mucous tela, especially externally, but more loosely on its internal surface, in which, excepting in certain parts, we generally discover fat.

184. Besides nerves and absorbents, innumerable blood

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* I have given this opinion at some length in my work, *De Gen. Human. Varietate Nativa*, p. 122, sq. ed. 3. Some eminent chemists accord with me, among whom suffice it to mention the celebrated Davy, in the *Journals of the Royal Institution*, vol. ii. p. 30. "In the rete mucosum of the African, the carbon becomes the predominant principle; hence the blackness of the negro." W. B. Johnson, l. c. vol. ii. p. 229.

vessels of which we shall speak hereafter, penetrate to its external surface, upon which they are shewn, by minute injection, to form very close and delicate net works.

185. A vast number of sebaceous follicles also are dispersed throughout it, which diffuse over the skin an oil,* thin, limpid, and not easily drying,† altogether distinct from the common sweat, and from that which possesses an odor resembling the odor of goats, and is peculiar to certain parts only.

186. Lastly, almost every part of the corium is beset with various kinds of hairs,‡ chiefly short and delicate, more or less downy, and found nearly every where but on the palpebræ, penis, the palms of the hand, and the soles of the feet. In some parts, they are long and destined for peculiar purposes; such are the capillamentum, the eye-brows, the eye-lashes, the vibrissæ, mustachios, beard, and the hair of the arm-pits and pudenda.

187. Man is, generally speaking, less hairy than most other mammalia. But, in this respect, nations differ. For, not to mention those nations who to this day carefully pluck out their beard or the hair in other parts, others appear naturally destitute of hair; v. c. the Tunguses and Burats; on the other hand, creditable travellers assert, that some inhabitants of the islands in the Pacific and Indian Ocean, are remarkably hairy.§

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* Chr. Gottl. Ludwig, *De Humore Cutem Inungente.* Lips. 1748, 4to.

† Lyonet, *Lettre à M. Le Cat.* p. 12.

‡ Jo. Ph. Withoff, *De pilo Humano,* Duisb. 1750, 4to. Compare the *Commentar. Societ. Scient. Gotting.* Vol. ii.

Job. Baster, *Verhandel. der Maatsch. te Haarlem,* T. xiv. p. 382.

§ *De Generis Human. Variet. Nativ.* p. 29.

188. Nor is there less variety in the length, flexibility, colour, and disposition to curl, both in each class of men enumerated above (181), and in individuals, especially the Caucasians; v. c. the hair of the head in the Caucasian variety is rather dingy, or of a nut brown, inclined on one hand to yellow, on the other to black; in the Mongolian and American, it is black, stiffer, straight, and more sparing; in the Malay, black, soft, curling, thick, and abundant; in the Ethiopians, black and woolly; in individuals, especially of the Caucasian variety, there are great differences, but chiefly in respect to temperament, which is found intimately and invariably connected with the colour, abundance, disposition to curl, &c. of the hair;* and there also exists a remarkable correspondence between the colour of the hair and of the iris.

189. The direction of the hairs is peculiar in certain parts, v. c. spiral on the summit of the head, diverging upwards on the pubes, on the exterior of the arm, as is commonly seen in some anthropomorphous apes, (v. c. in the satyr and troglodys,) running in two opposite directions towards the elbow, i. e. downwards from the shoulder, upwards from the wrist; to say nothing of the eye-lashes and eye-brows.

190. The hairs originate from the inner surface of the corium, which abounds in fat. They adhere to it pretty firmly,† by a curious bulb, consisting of a double invo-

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* Galen, *Ars Medicinalis*, p. 211—235. M. Ant. Ulm, *Uterus Muliebris*, p. 128, et alibi. Lavater, *Fragmente*, T. iv. p. 112.

† I suspect that the bulb is intended for support rather than for nourishment, from this circumstance, that the locks of hairs sometimes found in melicera and steatomata of the omentum and ovarium, some of which I have now before me, are usually destitute of bulbs,

lucrum;* the exterior vascular and oval, the interior cylindrical, apparently continuous with the epidermis,† and sheathing the elastic filaments of which the hair is composed, and which are generally from five to ten in each.

191. The hairs are almost incorruptible, and always anointed by an oily halitus. Of all parts they appear most truly electrical. They are very easily nourished, and even reproduced, unless where the skin is diseased.

192. Besides the functions ascribed to the integuments in the former Section, must be enumerated their excretory power, by which foreign and injurious matters are eliminated from the mass of fluids.‡

This is exemplified in the miasmata of exanthematic diseases, in the smell of the skin after eating garlick musk, &c. in sweat and similar phenomena.

193. What is most worthy our attention, is the transpiration of an aeriform fluid, denominated, after the very acute philosopher who first applied himself professedly to investigate its importance, the *perspirabile Sanctorianum*,§ and similar to what is expired from the lungs.|| It like-

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because they are not fixed, but lie naked in the honey-like fatty matter.

* Duverney, *Ouvres Anatomiques*, Vol. i. Tab. xvi. fig. 7, 9–14. Tab. xvij. fig. 3, sq.

† B. S. Albinus, *Annotat. Academ.* L. vj. Tab. iij. fig. 45.

‡ Hence the danger of contagion from hairs, to which miasmata very tenaciously adhere for a great length of time. Vide Cartwright's *Journal of Transactions on the Coast of Labrador*, vol. i. p. 273. vol. ii. p. 424.

§ *Ars* Sanctor. Sanctorii, *De Statica Medicina Aphorismor. sectionibus vij. Comprehensa.* Venet. 1634, 16*to.*

|| C. de Milly and Lavoisier, *Memoires l'Acad. des Sc. de Paris,*

wise is composed of various proportions of carbon,* nitrogen, and hydrogen,† precipitates lime from its solution, and is unfit to support either flame or respiration.

194. The *sweat*, which seldom occurs spontaneously during health and rest, unless in a high temperature, appears to arise from the perspirable matter of Sanctorius being too much increased in quantity by the excited action of the cutaneous vessels, and from its hydrogen uniting with the oxygen of the atmosphere and assuming the liquid form.

195. Upon the same hydrogen, variously modified by the accession of other elements and constituents, would seem to depend the natural and peculiar odor perceived in the perspiration and sweat of certain nations and individuals.‡

196. The quantity of matter perspired from the integuments which, in a well grown adult, are equal to 15 square feet, cannot be accurately estimated, but is probably about two pounds in 24 hours.§ (A)

1777, p. 221, sq. 360, sq. J. Ingenhouz, *Expts. upon Vegetables*. Lond. 1779, 8vo. p. 132, sq. J. H. Voight, *Versuch einer neuen Theorie des Fevers*, p. 157, sq.

* W. Basche, *on the Morbid Effects of Carbonic Acid Gaz, on Healthy Animals*. Philadel. 1794, 8vo. p. 46.

† Abernethy, l. c.

‡ Fr. L. Andr. Koeler, *De Odore per Cutem spirante in statu sano ac morboso*, Gotting. 1794, 4to.

§ The balance employed by Sanctorius, to estimate the loss of perspired matter, is described in his *Comm. in Primam Fen Primi L. Canon.* Avicennæ. Venet. 1646, 4to. p. 781.

Another much more simple and better adapted for the purpose, is described by Jo. Andr. Segner, *de Libra, qua sui quisque corporis pondus explorare posset*, Gotting. 1740, 4to. J. A. Klindworth, an excellent Gottingen instrument-maker, at my instigation, altered this, and rendered it more convenient and accurate.

NOTES.

(A) The functions of the skin are but imperfectly known. Besides forming a watery secretion (193, sq.)* and producing changes similar to those which occur in the lungs (171),† it is believed by some to be an organ of absorption, while others deny that absorption ever takes place unless friction is employed, or the cuticle abraded. Dr. Currie's patient labouring under dysphagia seated in the œsophagus, always found his thirst relieved by bathing, but never acquired the least additional weight.‡ Dr. Gerard's diabetic patient weighed no more after cold or warm bathing than previously.§ Seguin found no mercurial effects from bathing a person in a mercurial solution, provided the cuticle remained entire; they occurred, however, when the cuticle was abraded.||

But these are no proofs that water was not absorbed, because the persons immersed did not lose in weight, which they would have done if not immersed, owing to

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* Lavoisier and Seguin (*Mémoires de l'Académie des Sciences*, 1790, p. 610) inclosed the body in a silk bag varnished with elastic gum, having a small opening carefully cemented around the mouth, so that by weighing the body previously and subsequently to the experiment, they were able to ascertain exactly what had been lost by vapour, and by subtracting from this loss the weight of the perspired contents of the bag, they also ascertained how much of this had passed off by the lungs. From repeated trials they found the mean pulmonary discharge in twenty-four hours amounted to 15 oz. and the cutaneous to 1 lb. 14 oz. The quantity of carbon separated by the lungs ought however to have been taken into the account. If it amounts to 11 oz. in twenty-four, which I cannot believe it does, there will be but 4 oz. of pulmonary exhalation.

† Cruikshanks on *Insensible Perspiration*, and Ellis's *Further enquiry on the Changes produced in Atmospheric Air*, &c.

‡ *Medical Reports*, &c. § Rollo *On Diabetes*.

|| *La Médicine eclairée*, &c. T. 3.

the pulmonary and cutaneous exhalation; this therefore must have been counterbalanced by absorption somewhere, and no shadow of proof can be urged against its occurrence by the skin, as Dr. Kellie remarks in his excellent paper on the functions of the skin.* Seguin too found two grains of the mercurial salt disappear in an hour from the solution when of the temperature of 18° Reaumur.

There is every reason to believe the occurrence of cutaneous absorption independently of friction or abrasion of the cuticle. First, the existence of absorbents all over the surface cannot be intended for use merely when friction is employed or the cuticle abraded. Secondly, we have many facts which prove absorption without these circumstances, either by the skin or lungs or both, while no reason can be given why they should be attributed solely to the lungs. A boy at Newmarket who had been greatly reduced before a race, was found to have gained 30 oz. in weight during an hour, in which time he had half a glass only of wine.† Dr. Home after being fatigued and going to bed supperless, gained 2oz. in weight before seven in the morning.† In three diabetic patients of Dr. Bardsley's, the amount of the urine exceeded that of the ingesta, and the body even increased in weight, and in one of the instances as much as 17 lbs.‡ Dr. Currie allows that in his patient, "The egesta exceeded the ingesta in a proportion much greater than the waste of his body will explain." Similar facts are recorded by De Haen, Haller, &c. The same patients' urine too after the daily use of the bath, flowed more abundantly and became less pungent.

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* *Edinburgh Med. and Surg. Journal*, vol. i.

† Watson's *Chemical Essays*, iii. 101.

‡ *Medical Facts and Experiments.*

SECT. XII.

OF THE FUNCTIONS OF THE NERVOUS SYSTEM IN GENERAL.

197. We now come to the other class of functions termed *animal* (83 II.), by which the body and mind are connected. They have obtained their name from existing in animal systems only, and from enjoying a greater range of operation than those properly denominated vital.

198. The principal organs of these functions are the brain, medulla spinalis, and the nerves, the greater part of which originate from these sources.* They may be properly referred to two classes, *sensorial* and *nervous*: the former comprehending all excepting the nerves and their immediate origin,—all that serves more directly as the connection between the office of the nerves and the faculties of the mind.

199. Upon this division rests the beautiful observation of the illustrious Sömmerring,† respecting the correspondence between the relative size of each class with the faculties of the mind,—That the smaller the nerves are,

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* Eustachii, tab. xviii. fig. 2.

† *Diss. de basi encephali.* Gotting. 1778, 4to. p. 17. Also his work, already quoted, upon the anatomy of the negro, 59, sq.

J. Gotter. Ebel's *Observationes neurologicæ ex anatome comparata.* Traj. ad. Viadr. 1788, 8vo.

compared with the sensorial class, the greater is the developement of the mental faculties. In this sense, man has the largest brain of all animated beings,—if its bulk be compared with that of the nerves arising from it; but by no means, if its weight be compared with that of the whole body.

200. Besides the bony cranium, a threefold covering is afforded to the brain,* viz. the dura and pia mater, and between these two, the tunica arachnoidea.

201. The *dura mater*,† which lines the inside of the cranium, like a periosteum, forms various processes. By the falx it divides the hemispheres of the cerebrum and cerebellum; by the tentorium ‡ it supports the posterior lobes of the cerebrum, and prevents their pressure upon the subjacent cerebellum.

In its various duplicatures it contains and supports the venous sinuses,§ and prevents their pressure. These re-

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* Eustachii, tab. xvii. xviii.
Halleri *Icones anat.* fasc. vi. tab. i. ii. iii.
Santorini, tab. posth. ii. iii.

† J. Ladmiral's *Icones duræ matris in concava et convexa superficie visæ.* Amst. 1738, fasc. i. ii. 4to.

‡ In the skulls of some mammalia, a remarkable lamina of bone penetrates a duplicature of the tentorium, and supports it. Cheselden (*Anat. of the Bones*, c. 8.) supposes this bony tentorium to exist in *feræ* only; but it is found in the equine genus, the cercopithecus paniscus, the delphinus phocœna, &c. Its use is uncertain: that which is generally ascribed to it (for instance, by Laur. Nihell *de cerebro.* Edinb. 1780, p. 4) of supporting the cerebellum in those mammalia which leap considerably, is improbable, because we find it in animals also of slow motion, as the bear, and not in the ibex, which moves with the greatest velocity.

§ Vieussen's *Neurograph. universal.* tab. xvii. fig. 1.
Duverney's *Œuvres anatom.* vol. i. tab. iv.

ceive the blood returning from the brain to the heart, the proportion of which to the rest of the blood, Zinn long ago very truly remarked, has been over-rated by physiologists.

202. Next to the dura mater lies the *arachnoid*, so named from its thinness. Its use is not exactly known; it is destitute of blood-vessels (5), and extended like the dura mater merely over the substance of the brain, without following the course of its furrows and prominences. (A)

203. On the contrary, the membrane called *pia mater* by the ancients, closely follows the cortical substance of the brain,* and possesses innumerable blood-vessels, which penetrate into the latter. Hence, if a portion of this membrane is detached, we find the external surface very smooth, while the internal is villous, and resembles the roots of moss.†

204. The cerebrum and cerebellum are composed of various parts, differing in texture and figure, but unknown in their uses. The most remarkable are the four ventricles,‡ in the two anterior and fourth of which is found the choroid plexus, of whose function we are ignorant.§

Haller's *icones anat.* fasc. i. tab. vi.

Walter *De morbis peritonæi et apoplexia.* Berol. 1785, 4to. tab. iii. iv.

Vicq. d'Azyr's *Planches Anatomiques*, xxxii. et xxxv.

* Ruyschii *Respons. ad ep. problemat. nonam.* Amst. 1670, tab. x.

† B. S. Albini *Annot. acad.* L. 1. tab. ii. fig. 1. 5.

‡ S. Th. Sömmerring *über das Organ der Seele.* Regiom. 1796, 4to. tab. i. ii.

§ The importance of this plexus is shewn in the dissection of maniacs, in whom it alone is very frequently found diseased.

205. The substance of the brain is twofold: the one called cineritious or cortical, though not always situated exteriorly; the other white or medullary. Between the two, Sömmerring* has detected a third substance, most conspicuous in the arbor vitæ of the cerebellum, and the posterior lobes of the cerebrum.

206. The proportion of the cineritious † to the cortical substance, decreases as age advances; being greater in children, less in adults. It is almost wholly composed of very fine vessels, both sanguiferous ‡ and colourless (92), of which some few penetrate into the medullary substance:§ the latter is composed, in addition to these vessels and a fine cellular substance, of a pultaceous parenchyma, which, if examined with glasses, exhibits no regular structure,|| and, upon chemical analysis, affords a peculiar matter, in some measure resembling albumen.

207. The brain, after birth, undergoes a constant and gentle motion;** correspondent with respiration; so that,

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* *De basi encephali*, p. 13.

Compare Gennari *De peculiari structura cerebri.* Parmæ, 1782, 8vo. tab. ii. iii.

† Malpighi *De cerebri cortice* c. rel. *de viscerum structura Exercit.* Lond. 1699, 12mo.

Ruysch *De cerebri corticali substantia ep. problemat.* xii. Amst. 1699, 4to.

Chr. Frid. Ludwig *De cinerea cerebri substantia.* Lips. 1799, 4to.

‡ Sömmerring *De habitu vasorum cerebri* in *Denkschriften der Acad. der Wiss. zu München.* 1808, tab. i.

§ B. S. Albini *Annat. Acad.* L. 1. tab. ii. fig. 4. 5.

|| Consult Metzger's *Animadversiones ad doctrinam nervorum.* Regiomont. 1783, 4to.

** T. Dan. Schlichting first accurately described this phenomenon in the *Commerc. litter. Noric.* 1744, p. 409, sq. and more largely in the *Mém. presentés à l'Acad. des Sc. de Paris,* T. 1. p. 113.

when the lungs shrink in expiration, the brain rises a little, but when the chest expands, it again subsides.*

208. The *spinal* marrow is continuous with the brain,† and may be said either to spring from the brain, as from a root, or, on the contrary, to terminate in it, and grow into its substance.‡ Contained in the flexible canal of the vertebræ, it is enveloped by the same membranes as

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Haller discovered the cause of it by numerous dissections of living animals. See his pupil, J. Dit. Wolstorf's *Experimenta circa motum cerebri, cerebelli,* &c. Gotting. 1753.

Consult also after F. de la Mure, Larry's Dissertations on the same point in the *Mem. Presentés,* T. iii. p. 277, sq. 344, sq. Also Portal on a similar motion, observable in the spinal marrow. *Mém. de la Nature de plusieurs Maladies.* T. ii. p. 81.

* I once enjoyed an opportunity of very distinctly observing this motion and making some experiments with respect to it, in a young man eighteen years of age. When not five years old, he had fallen from an eminence and fractured the frontal bone on the left side of the coronal suture: since which time, there had been an immense hiatus, covered by merely a soft cicatrix and the common integuments. The hiatus formed a hollow, deeper during sleep, and varying according to the state of respiration: very deep if he retained his breath, much more shallow, and even converted into a swelling, by a long continued expiration. At the bottom of the hollow, I observed a pulsation synchronous with the pulsation of the arterial system, such as deceived Petriolus, Vandellus and other adversaries of Haller, confounding it with that which depends upon respiration.—I may add, that this wound on the *left* side of the head, had rendered the *right* arm and leg paralytic.

† J. J. Huber *De medulla spinali.* Gotting. 1741, 4to. The plate is to be found among Haller's fascic. i. tab. ii.

Haller's own plates of the same part are in the same fasciculus, vii. tab. iv. v.

Monro (filius) *On the Nervous System,* tab. x. fig. 1.

‡ Consult the *Anatomie et Physiologie du systeme Nerveux,* &c. par F. J. Gall et G. Spurzheim. T. 1. Paris, 1810, 4to.

the brain: its substance is also twofold, but the medullary is exterior to the cineritious.

209. From these two sources,—the brain and spinal marrow, arises the greater part of those chords, which are more or less white and soft, chiefly composed of cellular canals containing nervous medulla,* and distributed throughout nearly all the soft parts: some *nerves*,† however, may be more properly considered as uniting with the brain and spinal marrow, than springing from them.

210. After the numerous experiments‡ made by Haller and other very careful observers, we are certain, from minute anatomical examination, that many of the similar parts do not exhibit any true vestige of nerves; and from surgical observations,§ and dissections

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* Reil *De Structura Nervorum*, Hal. 1796, fol.

Osiander in the *Comm. Soc. Reg. sc. Gotting.* T. xvi.

† Rob. Martin's oration *De Proprietatibus Nervorum Generalioribus*, prefixed to his *Instit. Neuroligicæ.*

‡ Haller on the sensible parts of the body in the *Comment. Soc. sc.* Gotting. T. i. and his discourse upon them in the *Nov. Comment. Gotting.* T. iii.

Petre Castell's *Experim. quibus constitit varias h. c. partes sentiendi facultate carere.* Gotting. 1753, 4to. And three entire collections on the controversies excited by the Gottingen publications throughout Europe.

Sull' insensibilita e irritabilita, dissertazioni transportate da J.G. V. Petrini. Rom. 1755, 4to.

Sulla insensitiva ed irritabilita Halleriana opuscoli raccolti da G. B. Fabri. Bonon. 1757—59, iv. vol. 4to. And that which Haller himself published under the title of *Mémoires sur la Nature sensible et irritable des Parties du corps humain.* Lausanne, 1756—59 iv. vol. 12mo.

§ In the great variety and even contradiction of opinion, which, as we shall presently mention, exists in respect to the feeling of tendons and other parts when injured, I have always considered negative arguof living animals,* that they do not evince the least sign of feeling.

Such are the cellular substance, the epidermis, and reticulum mucosum, the hairs and nails.

The cartilages, bones, periosteum, and marrow.

The tendons, aponeuroses, and ligaments.

Most extended internal membranes, as the dura mater and arachnoid; the pleura, mediastinum, and pericardium; the peritonæum; also the cornea, &c.

The greater part of the absorbent system, especially the thoracic duct.

Lastly, the secundines and umbilical chord. (B)

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ments of more weight than positive, because nothing is more fallacious than the ideas of patients as to *the seat of internal pains*. To say nothing of cases where amputated parts appear to the patient as still in possession of feeling, it is well known that some have felt a fixed pain for a great length of time, in parts where after death nothing uncommon was observable; and that, on the other hand, in chronic diseases, pain is sometimes not felt in the diseased part, but in another which is healthy and perhaps very remote.

We may in this way much more easily explain syphilitic pains, for instance, referred to the bones, than so many contradictory experiments, in which I have seen the medulla roughly handled without causing the least uneasiness.

* I am every day more convinced that much caution and practice and repetition of the same experiment, in many different kinds of animals, are necessary in establishing the laws of physiology from dissections of living animals. To adduce the example of the supposed feeling of the medulla, I have found different results in many mammalia and birds. Many allowed the medulla to be destroyed without evincing any symptom of pain; others were convulsed, and cried out on the approach of the instrument. The latter might be agitated from the dread of fresh torment, on seeing the knife; and the former, having suffered great torture, might have been insensible to the less violent irritation of the medulla, although it were endowed with nerves.

211. The ultimate origin of most nerves from the brain cannot be detected. A question is agitated even at the present day, whether the nerves of each side arise from the corresponding or the opposite portion of the brain.* The latter opinion is countenanced by certain pathological phenomena,† and the decussation of fibres in the medulla oblongata‡ and conjunction of the optic nerves.§ (C)

212. A continuation of the pia mater follows the medulla of the nerves at their commencement,|| in such a way, as to unite very delicately with the vascular cortex.** But as soon as they have quitted the brain or medulla spinalis, their structure becomes peculiar, different from all the other similar parts. They form transverse folds more or less oblique and angular, long since described by P. P. Mollinelli,†† who not inaptly compared them to

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* Lassus has diligently collected the different opinions of writers on this point. *Sur les découvertes faites en Anatomie.* p. 299, sq.

† Compare Mein. Sim. De Pui *De homine dextro et sinistro.* L. B. 1780, 8vo. p. 107, sq.

‡ v. Gall and Spurzheim, and Osiander. ll. cc.

§ Sömmerring in the *Hessischen Beyträgen zur Gelehrsamkeit.* P. i. et iv.

F. N. Nöthig. (præs. Sömmerring) *De decussatione nervorum optic.* Mogunt. 1786, 8vo.

J. F. Ackermann in the *Biblioth. Medica,* which I published, vol. iii. p. 337. 706.

Hor. Caldani, *Opuscula Anat.* Patav. 1803, 4to. p. 111.

J. and C. Wenzel. *Prodromus eines Werkes über das Hirn,* p. 11.

|| Consult Pfeffinger *De structura Nervorum.* Argent. 1782, 4to.

** Wm. Battie *De Principiis Animalibus.* p. 126.

†† *Comment. Instituti Bonoinens.* T. iii. 1755, p. 282, sq. fig. 1, 2.

The observation of Mollinelli has been abundantly confirmed and further illustrated by Felix Fontana and Al. Monro: the latter in his work so often quoted, and the former in his treatise *Sur le Vénin de la Vipère.* Flor. 1781, 4to. vol. ii.

the rugæ of earth-worms, or the rings of the aspera arteria.

213. The nerves, especially those which are remarkable, for instance, the intercostals and par vagum, are every-whère distinguished by *ganglia*, or nodules of a compact structure and reddish ash colour, but with whose functions we are scarcely acquainted. I am most inclined to believe with Zinn,* that they unite more intimately the nervous filaments which meet in them from various directions; so that each fibre passing out, is composed of a portion of every fibre that has entered in.†

Nearly the same holds good with respect to the plexuses, which are produced by the union and reticulated anastomoses of different nerves, and by a similar contexture of filaments into which the nerves are split.

214. The ganglia and plexuses are most abundantly bestowed upon the spinal and intercostal or sympathetic nerve. The latter, united by a few delicate filaments only with the rest of the nervous system, constitutes a peculiar system, chiefly belonging to the involuntary functions. For this reason, Bichât, viewing it as presiding over *organic* life, distinguished it from the other nerves belonging to *animal* life, to use his own language.‡

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* *Mém. de l'Acad. des Sc. de Berlin.* Vol. ix. 1753.

† Consult among others who treat professedly of the ganglia, J. Johnstone in the *Med. Essays and Observ.* Evesham, 1795, 8vo.

J. Gottl. Haase's Dissertation. Leips. 1772, 4to.

T. Caverhill's *Treatise on Ganglions.* Lond. 1772, 8vo.

Ant. Scarpa's *Anatom. Annotat.* L. i. *De nervor. Gangliis et Plexubus.* Matin. 1799, 4to.

G. Prochaska *De structura nervorum.* Vindob. 1780, 8vo, Al. Monro l. c.

‡ See Reil in the *Archiv für Physiologie.* T. vii. p. 189.

215. The terminations of the nerves are no less concealed from us than their origins. Excepting a few, which spread out in the form of membranes, as the optic nerve, which becomes the retina; the portis mollis of the seventh pair, which forms a zone in the spiral lamina of the cochlea; the ultimate filaments of the rest penetrating into the viscera, muscles, corium, &c. are so intimately blended with the substance of these parts as to elude observation.

216. The parts just described, viz. the sensorium and the nerves originating in it and distributed throughout the body, constitute that system which, during life, is the bond of union between the body and the mind.

217. That the mind is closely connected with the brain, as the material condition of mental phenomena, is demonstrated, to omit such arguments as the immediate connection between the brain and the organs of sense, by our consciousness and by the mental disturbances which ensue upon affections of the brain. (D)

218. The singular situation and form before alluded to, of certain parts of the brain, and likewise some pathological phenomena, have induced physiologists to suppose certain parts, in particular, the seat of the soul. Some have fixed upon the pineal gland,* others the corpus

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† The Cartesian hypothesis appeared to receive some weight from the dissection of maniacs, in whom the pineal gland was found full of calcareous substances. But more careful observation shewed, that, after the twelfth year, it was generally filled with a pearly sand, in the healthiest persons, though very seldom in animals. Sömmerring *de lapillis vel prope vel infra gland. pin. sitis, s. de acervulo cerebri.* Mogunt. 1785, 8vo.

callosum,* the pons varolii, the medulla oblongata, the corpora striata, and the water of the ventricles, which washes against the origin of some nerves. Others not contented with one spot, have assigned particular parts of the brain for individual faculties and propensities. (E)

219. The energy of the whole nervous system does not depend solely upon the brain. The spinal marrow, and even the nerves, are possessed of their own powers, which are sufficient to produce contractions in the muscles. These powers are probably supported by the vascular cortex of these parts, (212). In man, the powers proper to the nerves are less, and those depending upon the brain greater, than in animals, especially the cold-blooded.

220. The office of the whole nervous system is twofold. To excite motion in other parts, especially in the voluntary muscles, of which we shall hereafter speak at large; and to convey impressions made upon the organs of sense to the brain, and there to excite perception; or by means of sympathies (56), to give occasion to reaction.

221. Experiment and observation put these functions of the nervous system beyond the reach of controversy. To unfold the nature of these functions is difficult indeed. (F)

222. Most opinions on this subject may be divided into two classes. The one class regards the action of the nervous system as consisting in an oscillatory motion. The other ascribes it to the motion of a certain fluid, whose nature is a matter of dispute; by some called animal spi-

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* The prerogative of this part was ably refuted by Zinn. *Exp. circa corpus callosum, cerebellum, duram meningem, in vivis animalibus instit.* Gott. 1749, 4to.

rits,* and supposed to run in vessels; by others a matter analogous to fire, to light, a peculiar ether, oxygen, electricity, or magnetism.

223. Although I would by no means assent to either of these opinions, I may be allowed to observe, that most arguments brought by one party against the hypothesis of the other, must necessarily be rude in proportion to the subtlety of the oscillations (if such exist) of the nerves or the nervous fluid.

224. These two hypotheses may, perhaps, be united, by supposing a nervous fluid thrown into oscillatory vibrations by the action of stimulants.

225. The analogy between the structure of the brain and some secreting organs, favours the belief of the existence of a nervous *fluid*. But tubes and canals are evidently no more requisite for its conveyance, than they are requisite in bibulous paper or any other matter employed for filtering.

The opinion receives much weight from the resemblance of the action of the nerves to the phenomena produced by the series of a galvanic apparatus and by the common electrical machine,† in a living animal, or in parts not quite deprived of vitality. These phenomena in fact long ago induced some physiologists to compare the nervous to the *electric* fluid. The singular and undeniable effects

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* See Michelitz's *Scrutinium Hypotheseos Spirituum Animalium.* Prag. 1782, 8vo.

† Fr. Al. Von Humboldt, *über die gereizte Muskel und Nerven fafer.* Posen. 1797, ii vol. 8vo.

J. W. Ritter, *Beweis dass ein beständiger Galvanismus den Lebensprocess im Thierreiche begleite.* Vinar. 1798, 8vo.

attributed to *animal magnetism*,* as well as other phenomena which have given rise to the belief of a kind of sentient atmosphere surrounding the nerves,† agree very well with the same hypothesis.

226. If we regard the *oscillation* of the nerves, not as similar to that which occurs in tense chords, but of such a description as may be conceived to occur in the soft pulp of the brain, we shall find many physiological phenomena exactly corresponding with the supposition.

It is demonstrated that hearing depends upon an oscillation.

In vision also it probably occurs, although not to the extent imagined by Euler.

The penetration of Hartley ‡ in following up the conjectures of the Great Newton,§ has rendered it so probable, that the action of the other senses is not very dissimilar from this oscillatory motion, that on the same supposition he very ingeniously explains, principally by means of the vapour of the ventricles (called by him the denser ether)‖ first, the association of ideas, and again by the assistance of this, most of the functions of the animal faculties. (G)

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* J. Heineken, *Ideen u. Beobachtungen den thierischen Magnetismus betressend.* Brem. 1800, 8vo.

† v. Humboldt and Heineken. ll. cc.

‡ Dav. Hartley's *Observat. on Man, his Frame, his Duty, and his Expectations.* Lond. 1749, 8vo. vol. i. p. 44.

§ *Queries* at the end of his *Optics*, Qu. 23, p. 355, Lond. 1789, 8vo.

‖ Er. Darwin has carried these opinions of Hartley still farther. *Zoonomia*, T. i.

NOTES.

(A) The *Pia Mater* and *Tunica Arachnoides* were considered as the same, till the Anatomical Society of Amsterdam confirmed, in 1665, the doubts which were arising on the subject, and Van Horne demonstrated both membranes distinctly to his pupils. The *Dura Mater* corresponds with the fibrous membranes, the *Pia Mater* with the cellular, and the *Tunica Arachnoides* with the serous. The latter is, in nature, office, and diseases, exactly like the serous; a close sac, affording as the peritonæum does to the abdominal viscera, a double covering to the brain and spinal marrow and the nerves before their departure through the foramina of the *Dura Mater*, and lining the ventricles; insulating the organs on which it lies, and affording them great facility of movement, and liable to all the morbid affections of serous membranes.*

(B) Although no nerves can be discovered in these parts, and although in common they have no feeling, yet that they have in a lower degree, what in a higher is called feeling, is shewn by the extreme sensibility which they acquire when inflamed, as they nearly all frequently are.

(C) Gall and Spurzheim have shewn that the nerves and spinal marrow do not arise from the brain, but only communicate with it: for where the brain is absent, the acephalous fœtus equally possesses them, and neither the cerebral nerves nor the spinal marrow are in proportion to each other, in the various species of the animal kingdom, nor the spinal nerves to the spinal marrow.

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* Bichat's *Traité des Membranes.*

They have also shewn that, besides the numerous communications of the whole nervous system, the two sides of the cerebrum, cerebellum, and spinal marrow, are united by commissures, and that the fibres of the anterior pyramidal eminences decussate each other, forming an exception to the rule observed in every other part of the brain, of the nervous fibres destined to each side of the body, running on the same side of the brain; and they hence explain why injuries of one side of the brain sometimes influence the same, sometimes the opposite side of the body. It is to be hoped, that morbid dissection will ascertain the correctness of their explanation.*

(D) See Sect. vi. Note A, near the end, and Sect. 44, Note E, near the beginning.

(E) Gall and Spurzheim maintain, that the fore part of the brain is subservient to intellect, the middle to sentiments, and the back part to propensities, and point out particular spots in each of their divisions for particular faculties, &c. and assert that the size of each spot, and of the corresponding part of the cranium, shew the strength of the faculty. I refer the English reader to Dr. Spurzheim's well known work for full information.

It must be allowed, that their enumeration of faculties and organs may and probably is very imperfect and incorrect, that infinitely more remains to be done, that many of Dr. Spurzheim's illustrations are objectionable, not to say ridiculous, and that his English work is a very hasty performance.

(F) While the brain is evidently the organ of mind, the nerves united with it, and the spinal marrow, together with its nerves, are as evidently the instruments by which

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* *Anatomie et Physiologie du Systeme nerveux*, par Gall et Spurzheim, and *Physiognomical System* by Spurzheim.

it affects, and is affected by the other parts of the body, to which these nerves are distributed. By their instrumentality, the brain contracts the voluntary muscles, influences the functions of every part when under the operation of the different passions, and receives impressions made upon the body. The consequences of divisions of the nerves or spinal marrow, fully substantiate these points.

In brainless fœtuses, the circulation, secretion, &c. proceed equally as in others which, besides spinal marrow, nerves and ganglia, possess a brain. Vegetables absorb, assimilate, circulate, secrete, and in many instances contract on the application of stimuli, and yet are not known to possess nerves. Muscles after the division of the nerves which connect them with the brain, contract equally as before, when irritated. In animals liable to torpor, the season of torpidity produces its effects equally upon those muscles whose nerves have been divided, or when the brain, &c. is destroyed.

After the removal or destruction of the brain and spinal marrow in animals, the heart still continues to act and the blood to circulate, provided respiration is artificially supported.* But the involuntary functions are closely connected with the brain and spinal marrow, for the sudden destruction of these parts or a certain portion of them, puts a stop to the circulation;† the application of stimuli to them excites the action of the heart and even of the capillaries after its removal;‡ to say nothing of the

* Experiments, &c. by A. P. Wilson Philip, M. D. and Wm. Clift, *Philos. Trans.* 1815.

† Le Gallois, *Sur le Principe de la Vie*, and Wilson Philip, l. c.

‡ Wilson Philip, l. c. Probably by excessive stimulus, as the voluntary muscles are afterwards insensible to stimuli, although after a mere division of their nerves, they retain their excitability.

influence of the passions upon them. Nay more, the involuntary functions seem as dependent upon the brain and spinal marrow, as they probably are upon the ganglia and gangliac nerves, for the division of the par vagum, or the destruction of that part of the brain with which it is connected, heavily impairs the functions of the lungs and of the stomach;* and although the division of the spinal marrow, or its nerves, prevents voluntary power over the corresponding muscles, without suspending the circulation, &c. in them, yet this, and what are dependent upon it,—nutrition and animal heat, are evidently impaired more, I think, than can be accounted for by the mere deficiency of muscular action.

(G) These oscillations are purely hypothetical and indeed improbable: were their existence proved, we should know nothing more of the real nature of the cerebral functions, for we should have to learn what were the peculiar properties of the nervous system, which enabled it alone of all substances to produce, when oscillating, the phenomena which it exhibits. We might as well attempt to explain the phenomena of motion, chemical affinity and galvanism by vitality and mind, as the phenomena of vitality and mind by mechanics, chemical affinity or galvanism. They are altogether distinct principles, although there can be no question, that the laws of mechanics, chemical affinity and galvanism, are important and indispensable in every living system, in subservience to life and mind. The mind, for ought we know, may stimulate the voluntary muscles by means of galvanism communicated along the nerves, but then the galvanism is not mind, it is merely an instrument employed by the mind.

* Le Gallois, l. c.

SECT. XIII.

OF THE EXTERNAL SENSES IN GENERAL, AND OF TOUCH IN PARTICULAR.

227. WE find the other function of the nerves to consist in communicating to the sensorium the impressions made by external objects. This is accomplished by the external senses, which are, as it were, the watchmen of the body, and the informers of the mind.

The latter alone belong to our present subject. For to regard, with Gorter, the stimulus which inclines us to relieve the intestines, the sensation of hunger, and other internal calls of nature, as so many distinct senses, is unnecessary minuteness, as Haller long since observed.*

228. *Touch* merits our first attention, because it is the first to manifest itself; its organ is most extensively spread over the whole surface, and it is affected by most properties of external objects.

229. For we perceive not only some qualities, as heat, hardness, weight, &c. by the touch alone; but our knowledge obtained by other senses, respecting some qualities, is rendered more accurate by the touch; such qualities are figure, distance, &c.

230. It is less fallacious than the other senses, and by culture capable of such perfection, as to supply the defects of the others, particularly of vision.†

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* J. De Gorter's *Exercitationes Medicæ*, iv. Amst. 1737, 4to.

† Consult Rol. Martin in the *Schwed Abhandl.* Vol. xxxix. 1777. G. Bew in the *Memoirs of a Society of Manchester*, Vol. i. p. 159. Ch. Hutton's *Mathematical Dictionary*, Vol. i. p. 214.

231. The skin, whose structure we formerly examined, is the general organ of touch.* The immediate seat is the papillæ of the corium, of various forms in different parts, commonly resembling warts,† in some places fungous,‡ in others filamentous.§ The extremities of all the cutaneous nerves terminate in these under the form of pulpy penicilli.

232. The *hands* are the principal seat of touch, properly so called, and regarded as the sense which examines solidity. The skin of the hands has many peculiarities. In the palms and on each side of the joints of the fingers, it is furrowed and free from hairs, to facilitate the closing of the hand. The extremities of both fingers and toes are furrowed internally by very beautiful lines more or less spiral;|| and are shielded externally by nails.

233. These scutiform *nails*¶ are bestowed upon man only and a few other genera of mammalia (I allude to the quadrumana which excel in the sense of touch),** for

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* F. de Riet, *De Organo Tactus.* L. B. 1743, 4to. reprinted in Haller's Anatomical Collection, T. iv.

† Dav. Corn. de Courcelles' *Icones Musculor. Capitis,* Tab. i. f. 2, 3.

‡ B. S. Albinus' *Annotat. Academ.* L. iii. tab. iv. fig. 1. 2.

§ Ruysch's *Thesaur. Anat.* iii. tab. iv. f. i. *Thes.* vii. tab. ii. fig. 5.

B. S. Albinus, l. c. L. vi. Tab. ii. fig. 3, 4.

|| Grew in the *Philos. Trans.* n. 159.

¶ B. S. Albinus. *Annotat. Acad.* L. ii. tab. vii. f. 4. 5. 6.

** Namely simiæ, papiones, cercopitheci and lemures, the apices of whose fingers in their four hands are very soft and marked, as in the human subject, with spiral lines.

Physiologists have disputed whether the sense of touch is bestowed on any besides man and the *quadrumana.* In determining this controversy we must recollect what was formerly said (81) concerning the difference of constitution according to the mode of living. On one the purpose of resisting pressure, and thus assisting the action of the fingers, while examining objects.

They are of a horny nature, but on the whole very similar to the epidermis. For under them lies the reticulum, which in negroes is black;* and under this is found the corium, adhering firmly to the periosteum of the last phalanx. These constituent parts of the nails are striated lengthwise. The posterior edge, which, in the hands, is remarkable for a little lunated appearance, is fixed in a furrow of the skin; and the nails are growing constantly from this, so as to be perfectly renewed every six months.

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hand, I would grant to both parties, that the snowy hands of a delicate girl must enjoy a much more exquisite sense of touch, than what I called the fingers of animals. But, on the other hand, I have frequently seen simiæ and papiones possessing much softer fingers, and using these fingers to explore surfaces much more dexterously, than many barbarous nations and innumerable persons among the lower orders of Europeans, whose hands have become hardened from labour.

* B. S. Albinus *De Habitu et Colore Æthiopum*, fig. 3.

SECT. XIV.

OF TASTE.

234. We perceive tastes by the tongue and in some degree by the other neighbouring internal cutaneous parts of the mouth; especially by the soft palate, the fauces, the interior of the cheeks and lips: by them, however, we taste only what is acrid and very bitter.*

235. The chief organ of taste is the *tongue*,† agile, obsequious, changeable in form, and, from its remarkable fleshy nature, not unlike the heart.

236. Its integuments resemble the skin. They are an epithelium, performing the office of cuticle; the reticulum Malpighianum;‡ and a papillary membrane, but little different from the corium.

237. The integuments of the tongue differ from the skin chiefly in these respects;—In the epithelium being moistened not by the oily fluid of the skin, but by a mucus

* Grew's *Anatomy of Plants*, p. 284, sq.

Petr. Luchtmans *De Saporibus et Gustu*. L. B. 1758. 4to. p. 58, sqq.

J. Gottl. Leidenfrost *De sensu qui in faucibus est, ob eo qui in lingua exercitur, diverso*. Duisb. 1771, 4to.

† Sömmerring's *Icones Organorum Humanorum Gustus*. Francof. 1808, fol.

‡ In dogs and sheep with variously coloured skin, I have commonly found the reticulum of the tongue and fauces also of various colours.

which proceeds from the foramen cæcum of Meibomius,* and the rest of the glandular expansion of Morgagni.†—And secondly, in the conformation of the papillæ, which are commonly divided into petiolated, obtuse, and conical.‡ The first are very few in number, and situated in a lunated series at the root of the tongue; the others, of various magnitudes, lie promiscuously upon the back of the tongue, and chiefly upon its edges and apex, where the taste is most acute.§

238. These papillæ are furnished with extreme filaments of the lingual branch of the fifth pair;|| and through them we probably acquire the power of tasting. The ninth pair** and the branch of the eighth, which also supplies the tongue,†† appear intended rather for the various movements of this organ, in manducation, deglutition, speaking, &c.

239. For the tongue to taste properly, it must be moist, and the substance to be tasted must be liquid, holding salts in solution.‡‡ (A) For if either is in a dry state, we may

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* Consult Just. Schrader's *Observat. et Histor.* from Harvey's book *De Generatione Animalium*, p. 186.

† Morgagni's *Adversar. Anat. Prima.* Tab. i.

‡ Ruysch's *Thesaur. Anat.* 1. tab. iv. fig. 6.

B. S. Albinus' *Annotat. Acad.* L. i. tab. i. f. 6—11.

§ Consult Haller's excellent description of the tongue of a *living man*, in the *Diction. Encyclopedique.* Yverdon edition. Vol. xxii. p. 28.

|| J. F. Meckel *De Quinto pare Nervorum Cerebri.* Gotting. 1748. 4to. p. 97. fig. 1. *n.* 80.

** J. F. W. Meckel *De Nono pare Nervorum Cerebri.* Gotting. 1777, 4to.

†† See Haller's *Icon. Anatom.* fasc. ii. tab. 1. letter g.

Monro *on the Nervous System.* Tab. xxvi.

‡‡ Bellini. *Gustus Organum novissime deprehensum.* Bonon. 1665. 12mo.

perceive the presence of the substances by the common sense of touch, which the tongue possesses in great acuteness, but cannot discover their sapid qualities. When the tongue tastes very acutely, the papillæ around its apex and margins are in some degree erected.

NOTE.

(A) Certainly an infinite number of bodies are sapid, which contain no kind of salt. Some gases and metals are sapid; they however may possibly be united with the fluids of the mouth, before they produce an impression.

SECT. XV.

OF SMELL.

240. WHILE taste and smell are closely related by the proximity of their organs, they are not less so by the analogy of their stimuli, and by some other circumstances. For this reason, they have been generally named chemical or subjective senses.

By smell we perceive odorous effluvia, taken in by inspiration, and principally applied to that part of the Schneiderian* membrane, which invests both sides of the septum narium and the convexities of the turbinated bones.

241. Although the same mucous membrane lines the nostrils† and their sinuses,‡ its nature appears different in different parts.

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* Conr. Vict. Schneider *De Osse Cribriformi et Sensu ac Organo Odoratus.* Witteb. 1655, 12mo.

This classical work forms an epoch in physiological history, not only because it is the first accurate treatise on the function of smell, but because it put an end to the visionary doctrine of the organ of smell being the emunctory of the brain.

† Sömmerring's *Icones Organorum Hnmanorum Olfactus.* Francof. 1810, fol.

‡ Haller's *Icones Anat.* fasc. iv. tab. ii.

Duverney's *Oeuvres Anatom.* Vol. i. tab. xiv.

Santorini's *Tab. Posthum.* iv.

Near the exterior openings it is more similar to the skin, and beset with sebaceous follicles, from which arise hairs, known by the name of vibrissæ.

On the septum and the turbinated bones it is fungous, and abounds in mucous cryptæ.

In the frontal, sphenoidal, ethmoidal, and maxillary sinuses, it is extremely delicate, and supplied with an infinite number of blood-vessels, which exhale an aqueous dew.

242. It appears the principal, not to say the sole use of the sinuses,* to supply this watery fluid, which is perhaps first conveyed to the three meatus of the nostrils, and afterwards to the other parts of the organ, preserving them in that constant state of moisture, which is indispensable to the perfection of smell.

The sinuses are so placed, that, in every position of the head, moisture can pass from one or other of them into the organ of smell.

243. The principal seat of smell,—the fungous portion of the nasal membrane, besides numerous blood-vessels, remarkable for being more liable to spontaneous hemorrhage than any others in the body, is supplied by nerves, chiefly the first pair,† which are distributed on both sides of the septum narium, and also by two branches of the

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* In my *Prolus. de Sinibus Frontal.* Gotting. 1779. 4to. I have brought forward many arguments from osteogony, comparative anatomy, and pathological phenomena, to prove that these sinuses contribute indeed to the smell, but little or nothing to voice and language, as was believed by many physiologists.

† Metzger. *Nervorum Primi Paris Historia.* Argent. 1766, 4to. reprinted in Sandifort's *Thesaurus*. Vol. iii.

Scarpa, *Anatomic. Annotat.* L. ii. tab. i. ii.

fifth pair. The former appear to be the seat of smell:* the latter to serve for the common feeling of the part, which excites sneezing, &c.

244. The extreme filaments of the first pair do not terminate in papillæ, like the nerves of touch and taste, but, as it were, deliquesce into the spongy and equal parenchyma of the nasal membrane.

245. The organ of smell is small and very imperfect at birth. The sinuses scarcely exist. Smell consequently takes place but late,—as the internal nostrils are gradually evolved, and is more acute in proportion to their size and perfection.†

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* This is shewn by pathological dissection and comparative anatomy. Thus in Loder's *Observ. Tumoris Scirrhosi in Basi Cranii Reperti.* Jen. 1779, 4to. is a case of anosmia, following a compression of the first pair by a scirrhus. We are taught, by comparative anatomy, that in the most sagacious mammalia, v. c. elephants, bears, dogs, bisulcous ruminants, hedgehogs, &c. the horizontal plate of the cribriform bone is very large, and perforated by an infinity of small canals, each of which contains a filament of the olfactory nerve.

† While animals of the most acute smell have the nasal organs most extensively evolved, precisely the same holds in regard to some barbarous nations. For instance, in the head of the North American Indian, (a leader of his nation, and executed at Philadelphia about 50 years since), which I have given in the *First Decade of my Collection of the Crania of different Nations,* illustrated by nine plates, the internal nares are of an extraordinary size, so that the middle conchæ, for instance, are inflated into immense bullæ; and the sinuses, first described by Santorini, which are contained in them, I never, in any other instance, found so large.

The nearest to these, in point of magnitude, are the internal nares of the Ethiopians, from among whom I have seven heads now before me, very different from each other, but each possessing a nasal organ, much larger than we find it described by Sömmerring to be in that nation, *über die körperl. Verschiedenh dos Negers,* &c. p. 22.

246. No external sense is so intimately connected with the sensorium and internal senses, nor possesses such influence over them, as the sense of smell.*

No other is so liable to idiosyncrasies, nor so powerful in exciting and removing syncope.

Nor is any other capable of receiving more delicate and delightful impressions; for which reason, Rousseau very aptly called smell, *the sense of imagination*.†

No sensations can be remembered in so lively a manner as those which are recalled by peculiar odors.‡

These anatomical observations accord with the accounts given by most respectable travellers concerning the wonderful acuteness of smell possessed by these savages.

Respecting the North American Indians, consult among others Urlsperger. *Nachr. von der Grossbritann. Colonie Salzburg. Emigranten in America.* Vol. i. p. 862.

Respecting the Ethiopians, the *Journal des Sçavans*, 1667, p. 60.

* See Alibert on the Medical power of odors, in the *Mem. de la Soc. Médicale*. T. i. p. 44.

† *Emile*. T. i. p. 367.

‡ Respecting the power of smell over the disposition and the propensities, consult Benj. Rush, in the *Medical Inquiries and Observations*. Vol. ii. p. 34.

SECT. XVI.

OF HEARING.

247. Sound, which is excited by the collision of elastic bodies and propagated by the air, is perceived by the sense of hearing,* and is first received by the conchiform cartilaginous external ear,† which few of our countrymen have the power of moving‡ By this it is collected; then conveyed into the meatus auditorius, which is anointed by a bitter cerumen;§ and strikes against the *membrana tympani,* which is placed obliquely in a circular furrow of the temporal bone, and separates the meatus from the internal ear.

248. Behind this membrane lies the middle portion of the ear,—*the cavity of the tympanum,* whose fundus is directed upwards and inwards.

It contains three‖ *ossicula auditus:* of which the exte-

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* Sömmerring. *Abildung des Menschlichen Hörorgans.* Francof. 1806, fol.

† B. S. Albinus. *Annotat. Academ.* L. vi. tab. iv.

‡ J. Rhodius ad Scribon. Largum. p. 44, sq.

J. Alb. Fabricius *De Hominibus ortu non differentibus.* Opuscul. p. 441.

Ch. Collignon's *Miscellaneous Works.* Camb. 1786, 4to. p. 25, sq.

§ Consult J. Haygarth in the *Med. Obs. and Inquiries,* vol. iv. p. 198, sq.

‖ The existence of a fourth bone (called *Lenticular*) commonly believed from the time of Franc. Sylvius, I have disproved at length in my Osteology, p. 155. et seq. edit. 2. It is wanting in the greater number of perfect examples from adults.

rior, or *malleus,* adheres by its manubrium to the membrana tympani, is generally united in the adult to the circular furrow abovementioned by its spinous process which is directed forwards, and it lodges its round head in the body of the *incus.*

The incus is united to the head of the *stapes* by the extremity of its long process which extends into the cavity of the tympanum.

The stapes resting its base upon the fenestra ovalis, runs towards the vestibule of the labyrinth, into which, sounds, struck against the membrana tympani, are propagated by the intervention of these three little bones.

249. The Eustachian *tube* * runs from the interior of the fauces into the cavity of the tympanum: and the inferior scala of the cochlea has the same direction; the opening of the latter, termed *fenestra rotunda,*† is closed by a peculiar membrane. The true and principal use of each is not sufficiently known.‡

250. In the deepest part of the petrous bone is placed *the internal ear,* consisting of three parts.

First, of the *vestibule,* placed between the other two, into which open not only the fenestra ovalis, but the five orifices of the *semi-circular canals* which lie posteriorly,

* Saunder's *Anatomy of the human ear.* Lond. 1801, fol. vol. i. ii.

† Scarpa *De Structura Fenestræ Rotundæ,* &c. Mutin. 1772, 8vo.

‡ Comparative anatomy renders it most probable that the Eustachian tube is subservient to the action of the membrana tympani. It is found in all red-blooded animals which possess a membrana tympani: but is wanting in fishes which are destitute of this membrane. The different opinions respecting its use may be found in Keil's *Archiv. für die Physiol.* T. ii. p. 18. iii. p. 165. iv. p. 105. viii. p. 67. ix. p. 320.

and the superior scala of the *cochlea,* which is placed anteriorly.

The vestibule and semi-circular canals loosely contain very delicate membranous bags, lately discovered by the celebrated Scarpa. Two of these lie in the vestibule, and three in the semicircular canals.*

251. They, as well as the cavity of the cochlea, contain a very limpid fluid, bearing the name of Cotunni, who shewed it to be absorbed by two canals, by him denominated *aqueducts,*† and by the no less illustrious Meckel, *diverticula*;‡ the one arises from the vestibule, the other from the inferior scala of the cochlea.

252. The portio mollis of the seventh pair, together with the portio dura, (which afterwards runs along the Fallopian *aqueduct*)§ having entered the internal acoustic opening, transmits its medullary filaments into the lower and cribriform part of it.|| These filaments run to the vestibule and semicircular canals, but especially to the base of the cochlea, where they form a medullary zonula, marked by beautiful plexiform striæ, which pass between the two laminæ of the septum cochleæ. ¶

253. The oscillatory tremor, which we formerly followed as far as the fenestra ovalis (248), is propagated to

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* Scarpa's *Disquisitiones Anatomicæ de Auditu et Olfactu.* Tab. iv. fig. 5. tab. vii. fig. 3.

† Cotunni *De Aqueductibus auris Humanæ.* Neap. 1760, 4to.

‡ Ph. Fr. Meckel *De Labyrinthi auris Contentis.* Argen. 1777, 4to.

§ Fallopius' *Observ. Anat.* p. 27, sq. Venet. 1561, 8vo.

|| Brendelii *Analecta de Concha auris Humanæ.* Gotting. 1747, 4to. The same, *De Auditu in Apice Conchæ ib. eod.* 4to.

¶ Consult Zinn's *Observ. Botan.* Gotting. 1753, 4to. p. 31, sq. Scarpa l. c. tab. viii. fig. 1. 2.

the vestibule, where, by means of the water of Cotunnius (251), it strikes the auditory nerves distributed among the windings of the labyrinth.

254. Besides the muscles of the malleus and stapes,* supposed to be voluntary,† the chorda tympani,‡ which is placed between the handle of the malleus and the longer leg of the incus, is believed to moderate the force of sound struck against the membrana tympani, and afterwards to be propagated along the cavity of the tympanum.§

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* B. S. Albini *Tabulæ Muscul.* tab. xi. fig. 29.

† Eustach. *De Auditus Organ.* p. 157,

Caldani. *Institut. Physiol.* 245, sq.

‡ T. Fr. Meckel *De Quinto pare Nervorum Cerebri.* fig. 1. x. 71.

Leop. M. A. Caldani on the Office of the chorda tympani, in the *Saggi dell' Acad. di Padova.* T. ii.

§ Cotunni. l. c. §. lxxxviii. Marherr's *Prælect. in Boerhaavii Inst.* Vol. iii. p. 342.

SECT. XVII.

OF SIGHT.

255. The instruments of vision,—the eyes,* are two moveable globes, fixed to the optic nerves whose decussation we formerly noticed (211), as it were to stalks, in such a manner, that their insertion is not exactly opposite the centre of the cornea and iris, but behind this imaginary axis, rather nearer to the nose.

256. They consist of various coats containing pellucid humours of different degrees of density, so placed that the rays of light can pass from the transparent anterior segment of the bulb to the opposite part of the fundus.

257. The external coat is called *sclerotic*. It is deficient in the centre, and that part is filled up by the *cornea*, which is transparent, lamellated, more or less convex, and projects like the segment of a small globe from one of larger size.†

258. The interior of the sclerotica is lined by the *chorioid*, which abounds in blood-vessels, especially verticose veins, and is dyed on each side by a black pigment, ad-

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* Sömmerring. *Abbildungen des Menschlichen Auges.* Francfort, 1801, fol.

† Ad. Jul. Rose *De Morbis Corneæ ex Fabrica ejus Declaratis.* Lips. 1767, 4to.

G. H. Gerson *De Forma Corneæ Deque Singulari Visus Phænomeno.* Gotting. 1810, 4to.

hering however but loosely to its concave surface in the form of mucus.*

259. The chorioid contains the internal coat—the *retina*†,—a medullary expansion of the optic nerve, which passes through the sclerotica and chorioid.‡ Its structure is very beautiful.§

In the imaginary axis of the eye, between the two principal branches of the central artery,|| it is perforated by the singular foramen of Sömmerring,¶ which is surrounded by a yellow edge.**

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* C. Mundini in the *Comm. Instit. Bononiens.* T. vii. p. 29. H. F. Elsaesser (præs. G. C. Ch. Storr) *De pigmento Oculi Nigro.* Tubing. 1800, 8vo.

† B. S. Albinus. *Annotat. Academ.* L. iii. p. 59, sq. L. iv. p. 75, sq. L. v. p. 66, sq.

‡ Walter *De Venis Oculi, &c.* Berol. 1778, 4to. tab. 1. fig. 2. tab. ii. fig. 2.

§ The extremely beautiful blood-vessels of the retina were first discovered by T. Mery to be visible in a living cat plunged into water. *Mem. de l'Acad. des Sc. de Paris, avant* 1699, T. x. p. 656; and 1704, p. 265.

The radiated surface of the retina in the hare is most beautifully displayed by Zinn, in an admirable plate. *Comm. Soc. Scient. Gotting.* T. iv. a. 1754, tab. viii. fig. 3.

By Fontana, in the rabbit. *Sur le venin de la vipere,* vol. ii. tab. v. fig. 12.

|| A plate accurately representing the courses of these branches will be found in the *Oeuvres de Mariotte.* p. 527, fig. 1.

¶ Sömmerring *De Foramine centrali limbo luteo cincto retinæ humanæ:* in the *Comment. Soc. Reg. Scient. Gottingens.* T. xiii. Ph. Michaelis in the *Journal der Erfindungen in der Natur und Arzneywiss.* p. xv.

** As I have discovered this central aperture in the eye of no animal besides man, except the *quadrumana,* the axes of whose eyes are, like

260. The anterior edge of the chorioid is terminated by a cellular belt, called *orbiculus ciliaris,* by which it adheres firmly to a corresponding groove in the sclerotic; and from which two other membranes, viz. the iris and ciliary processes, are expanded in a circular form.

261. The *iris,* (whose posterior surface is lined by a brown pigment, and termed *uvea*) lies anteriorly to the ciliary processes, is flat, and washed on all sides by the aqueous humour; narrower towards the nose, broader towards the temples. Its texture is dense and cellular, and contains no vestige of muscular fibre. We must regard it, with Zinn,* as a membrane sui generis, and not as a propagation from the chorioid. The anterior surface is differently coloured in different persons, and, during life, counterfeits a flocculent appearance.†

262. The blood-vessels of the iris run chiefly on its anterior surface, and are continued in the fœtus into the *membrana pupillaris,*‡ which begins to open in the cen-

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the human, parallel to each other, I think its *use* connected with this parallel direction of the eyes, and have endeavoured to explain the connection at large, in my *Handbuch der vergleichenden Anatomie,* p. 547. et seq.

As, on the one hand, this direction of the eyes renders one object visible to both at the same time, and therefore more clearly visible; so, on the other, this foramen prevents the inconvenience of too intense a light, if it is probable that it expands and dilates a little, and thus removes the principal focus from the very sensible centre of the retina.

* *Comment. Soc. Scient. Gotting.* tom. iv. p. 199.

† On the remarkable mutual relation of the arteries and nerves of the internal parts of the eye and especially of the iris, see Diet. G. Kieser *De Anamorphosi Oculi.* Gotting. 1804, 4to.

‡ This beautiful membrane was first discovered by Francis Sandys, a celebrated maker of anatomical preparations, and first described and

tre, at the seventh or eighth month of pregnancy, when the eyes have acquired some degree of size; and when, probably, the elliptic arches of its vessels begin to be gradually retracted into the *inner ring of the iris*, which ring I have never been able to perceive distinctly before that period.

263. The other circular membrane (260) bears the name of *ligamentum* or *corpus ciliare*; and inclining backwards, is distant from the iris. Its external edge is thick* and adheres to the ciliary circle (260): the internal is thin and adherent to the margin of the capsule of the lens. The brown pigment is copiously diffused over it.

Its anterior surface, lying opposite to the uvea, is striated. The posterior, lying upon the vitreous humour, is beautifully separated into about 70 flocculi, remarkable for an indescribably minute and elegant set of blood-vessels. These flocculi are named *ciliary processes*, and their use is still an object of enquiry.†

264. In the bulb of the eye, whose coats we have now described, are contained the humours, of three principal kinds.

The posterior, and by far the larger portion of the globe, is filled by the *vitreous* humour, proportionally larger in the human subject, especially after puberty, than in other animals, and so dispersed in innumerable drops

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exhibited in a plate by Ever. J. Wachendorf, *Commerc. Litter. Nor.* 1740. Hebd. 18.

* The ciliary canal, discovered by Fel. Fontana, (*sur le venin de la vipere*, vol. ii. tab. vii. fig. 8, 9, 10,) and afterwards described more accurately by Adolp. Murray, (*nov. actor. Upsaliens.* vol. iii.) runs, in bisulcous animals, along this thick edge.

† Consult among others Brandis in his *Pathologie*. p. 253.

throughout the cells of the delicate *hyaloid membrane*, that this membranaceo-lymphatic body has the singular appearance of a tremulous jelly.

265. Anteriorly it adheres to, and by means of the *zona ciliaris* surrounds, the capsule containing the *crystalline lens*, immediately around which lies the water of Morgagni.

The lens itself is very pellucid and cellular, but so much more dense than the vitreous humour, that it feels between the fingers like a very tenacious gluten, although amazingly clear. Its nucleus is more dense than the exterior lamellæ. These may, by management, be reduced into extremely delicate fibres, converging from the circumference to the centre. *

In the adult the lens is proportionally smaller than in quadruped mammalia; also less convex, especially on its posterior surface.

266. The remaining space of the eye is filled by the *aqueous humour*, which is very limpid, and divided by the iris into two *chambers*; the anterior and larger separating the cornea and iris; and the posterior, in which the uvea lies towards the corpus ciliare, so small, as scarcely believed by some to exist.

267. These most valuable parts are defended from injuries, both by the profundity of their situation in the orbits, and by the valvular coverings of the eye-lids.

In the duplicature of the *palpebræ*, lie the *sebaceous follicles* of Meibomius, † thickly distributed; and their

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* Th. Young in the *Philos. Trans.* 1793, fol. xx. fig. 2. 3.
Dav. Hosack, ib. 1794, tab. xvii. fig. 4.
J. C. Reil *De lentis crystallinæ structura fibrosa*. Hal. 1794, 8vo.

† H. Meibomius' *De vasis Palpebrarum novis ep*. Helmst. 1666, 4to.

edges are fringed by a treble or quadruple series of *cilia*:* the cartilaginous *tarsi* serve for their support and expansion, and also facilitate their motion upon the eyeball.

Above the eye-lids, to use the words of Cicero, the skin is covered by the *supercilia*, which preserve the eyes from the sweat flowing from the head and forehead, and in some measure screen them from too strong a light.

268. To lubricate the eyes, to preserve their brightness, and wash away foreign matters, is the office of the *tears*. Their chief source is a conglomerate gland placed in the upper and exterior part of the orbit. It has numerous but very fine excreting ducts, which are said to discharge about two ounces of tears upon each eye during twenty-four hours; the tears are afterwards absorbed by the puncta lachrymalia, the function of which may, in a certain sense, be compared to that of the lacteals in the villous coat of the small intestines: from the puncta they are conveyed through the snails horns, as they are called, into the lachrymal sac, and thence pass into the lower meatus of the nostrils.† (A)

269. Thus much it was necessary to premise upon the structure of the organ of vision. We now come to the function of the organ,—to the explanation of vision.

The rays of light falling upon the cornea at an angle more acute than forty-eight degrees, pass through it, and from both its density and figure, are considerably refracted towards the axis of the eye. On entering the aqueous

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* B. S. Albinus' *Annot. Academ.* L. iii. tab. iii. fig. 4.

† I. Chr. Rosenmüller. *Organa Lachrymalium Partiumque Externarum Oculi Humani Descriptio Anatomica.* Lips. 1797, 4to.

humour they experience rather a less degree of refraction.

Those rays which penetrate the pupil and are received by the lens, are still more refracted on account of the greater density of this medium.

The less density of the vitreous humour prevents the focus of rays from being too small, but allows it to fall elongated upon the retina, and exhibit the image of objects, inverse indeed necessarily from the laws of light.

270. The *focus* which, in this mode, falls upon the retina, is considered as acute, not absolutely but relatively, on account of the different refrangibility of colours; but the latitude arising from this aberration of the rays, is so small, that it not only does not obscure the clearness of vision, in any perceptible degree, but is the source of many advantages.*

271. The celebrated question, why we behold objects erect, while their image is painted inversely upon the retina,† may be easily answered, by considering that objects are called inverse in relation only to those which appear erect.

Now, since the images of all objects and of our own bodies are painted on the retina, all in their relative situation, their relative situation must correspond as exactly as if they were viewed erect, so that the mind (to which a sensation excited by the image and not the image itself is communicated) is preserved from all danger of error.

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* See Nev. Maskelyne's *Attempt to explain a Difficulty in the Theory of Vision, depending on the different Refrangibility of Light. Philos. Trans.* Vol. lxxix. p. 256.

† See J. H. Voight in the *Magazin für Physik und Naturgeschichte.* T. v. P. iii. p. 143.

272. Since many conditions are required for distinct vision, the Creator has wonderfully ordered the functions of these organs.

A sufficient, but, at the same time, a definite quantity of light, not too intense for distinct vision, is provided in two modes:—First, according to the greater or less intensity of the rays, a less or greater number of them passes to the lens;—Secondly, that portion which is superabundant and injurious to vision, is absorbed.

The first is effected by the motion of the iris; the second, by the pigmentum nigrum.

273. The iris is endowed with sufficient mobility to accommodate itself to the intensity and distance of light, that when exposed to a strong light or to near objects, it may expand itself and contract the pupil, but when to a weaker light or more remote objects, it may contract itself and dilate the pupil.* Physiologists have given different explanations of this motion. Some ascribe it to the impulse of blood into its vessels; others to contraction of its imaginary muscular fibres. I have shewn, in a particular treatise, that both these circumstances are impossible, and that it is by far more probable and natural to ascribe its proximate cause to the vita propria of the iris (42); the more remote cause, as we formerly hinted (56), is to be sought for solely in the reaction of the sensorium.†

274. The function of the dark pigment, so frequently

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* Zinn *De Motu Uveæ*, 1757, in the *Comment. Societ. Scient. Gotting.* T. i.

Fel. Fontana *Dei Moti dell'Iride.* Lucca. 1765, 8vo.

† For other explanations consult Troxler in Himly's *Ophthalmol. Biblioth.* T. i. P. ii. p. 21.

mentioned, (258, 261, 263,) viz. to absorb the superfluous rays, and its importance to the perfection of vision, are demonstrated, among other ways, by the dissection of different kinds of animals, and by the diseased condition of Albinos, whose eyes are very tender and impatient of light from the absence of this pigment.*

275. The focus of the refracted rays must fall exactly on the retina, so that the point of vision be neither produced beyond it, nor so shortened as to strike on the vitreous body.

The latter defect exists in short-sighted persons, from the too great convexity of the cornea, or gibbosity of the lens.

The former is the defect of long-sighted persons, in whom there is the opposite conformation of parts.

276. Since a perfect and sound eye beholds near and remote objects with equal distinctness, it must of necessity be supplied with appropriate powers of accommodation.† That these internal changes of the eye are chiefly accomplished by the pressure of the straight muscles of the ball, I am clearly convinced, from this among other arguments,—that in the Greenland whale,—an amphibious animal which must see in media of different densities, nature has most accurately provided for this, in the remarkable structure and obsequious flexibility of the sclerotica.‡ (B)

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* I have spoken of Albinos at large, in my work *De Generis Humani Varietate Nativa*, ed. 3. p. 274, and in my dissertation *De Oculis Leucœthiopum*.

† H. W. Math. Olbers *De Oculi Mutationibus Internis*. Gotting. 1780. 4to.

Ever. Home in the *Philos. Trans.* 1795, p. 1.

‡ *Comment. Societ. Scient. Gottingens.* T. vii. p. 62. fig. 11. f. g. h.

277. During the waking state, the eyes are perpetually, although insensibly, agitated, and directed towards the axes of objects, by these muscles.

For, although the whole of the retina is sensible, it is not all equally calculated to receive the images of objects.

In the first place, the true axis of the human* eye, where the optic nerve enters, is proved by the well-known experiment of Mariote,† to be nearly insensible to light. The *principal focus* of the other part of the retina, and which must be considered as the chief instrument of distinct vision, falls upon an imaginary axis of the globe, corresponding with the axis of the cornea and the whole eye. This, however, as Keinster observes in opposition to Boerhaave, is not to be understood as if only one point of an object could be seen distinctly at once, while the eye is fixed, and that, to behold another point, the axis of the eye must be changed; for the sensation of a complete object is simple and complete.‡

278. The habit of directing the axis of the eyes rapidly towards objects is acquired by practice. This is proved by the example of persons who were born blind, but have recovered their sight after puberty;§ and of children,

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* I say the human eye; for in some animals now before me, the seal and porcupine, for instance, the true and imaginary axis are the same, the optic nerve lying exactly opposite the centre of the cornea and pupil.

† Troxler speaks of this at large. l. c. T. ii. P. ii. p. i.

‡ *In Optica Quædam* Boerhaavii et Halleri *Commentatur* Abr. Gotth. Kaestner. Lips. 1785, 8vo. p. 7.

§ See Giov. Bartolozzi *sopra una cieca nata guarita.* Veron. 1781, 8vo. p. 99. sq.

who seldom acquire this facility of motion before the third month.

279. To habit we must ascribe also the circumstance of beholding an object singly, although we have two eyes.* For infants at first see double, and the double vision which occasionally remains after certain diseases of the eyes, may be removed by practice and experience.

280. The combined power of the two eyes does not exceed, according to Jurin, that of each, by more than one tenth part.

It is needless to add, what the celebrated painter, Leonardo da Vinci, long since remarked,—that in viewing distant objects, it is preferable to employ but one eye.†

281. Sight can never occur, unless the angle of vision is at least more than 34 *seconds*. This was proved by the very beautiful experiments of the acute Tob. Mayer who formerly was one of our number. And he demonstrated the great excellence of the human sight, by shewing that this still remained the limit of vision under any light, under the splendor of the meridian sun, and the gloom of a lantern; so that vision remains almost equally clear, although the light be considerably diminished.‡

282. We may hence infer the prodigious minuteness of the images of objects projected upon the retina,§ and

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* W. C. Wells's *Essay upon single vision with two eyes*. Lond. 1792, 8vo.

† Consult Lambert *sur la partie photometrique de l'art du peintre* in the *Mem. de l'Acad. des Sciences de Berlin*, 1768, p. 80, sq.

‡ Tob. Mayer's *Experimenta circa visus aciem*, in the *Commentar. Soc. Scient. Gottingen.* T. iv.

§ De la Hire. *accidens de la vue*, p. 375.

nevertheless impressed so forcibly upon it, that, under certain circumstances, their vestiges remain, after the removal of the objects from before the eye.*

NOTES.

(A) I am not satisfied with any account which I have hitherto seen, of the function of the eyelids with respect to the tears. If I am not mistaken, the tears pass over the ball of the eye as low as the edge of the superior tarsus, which is so applied to the ball as not ordinarily to allow of their ready escape under it.† As the lids cover the eye during sleep, and their fine inner edges meet, the whole of the ball is at this time readily preserved moist. But when the eyes are open, the front of the eye between the lids would not be moistened unless the upper tarsus occasionally descended with the fluid contained behind it. The fluid thus brought upon the front of the eye, trickles down by its gravity as far as the inferior tarsus, which also occasionally ascending, raises it somewhat.

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* Gassendi's *vita* Peireskii, p. 175, sq. Hague, 1655, 4to.

Franklin's *Letters on Philosophical Subjects*, at the end of his *Expts. on Electricity*. Lond. 1769, 4to. p. 469, sq.

Rob. War. Darwin's *Experimenta nova de spectris s. imaginibus ocularibus, quæ objectis lucidioribus antea visis, in oculo clauso vel averso percipiuntur*. Lugd. Bat. 1785, 4to.

Er. Darwin's *Zoonomia*, T. i.

C. Himly in the *Biblioth. Ophthalmolog.* T. i. P. ii. p. i.

† The object of this firm application of the tarsi to the eye must be the exclusion of foreign matters from the orbit.

Winking thus preserves the front of the eye constantly moist during the waking state.

It may be also observed that when the tarsi approximate, as they drive before them the moisture of the front of the eye-ball, they quite inundate the puncta lachrymalia, by which circumstance the puncta are of course enabled to carry off a large quantity of the secretion, and ordinarily to prevent its overflow, which would occur at the centre of the lower tarsus. During sleep the puncta are not so copiously supplied, as they have only the same share of tears as the eye in general; and there is less occasion for it, because the removal of the stimulus of the air and light by the closure of the eyelids, lessens the secretion.

M. Majendie has found the matter of the tarsal or Meibomian glands to be not sebaceous but albuminous, and soluble in the tears; hence we discover why, during sleep, it accumulates on the tarsi;—because its solvent, the tears, are not sufficiently abundant to remove it.

(B) In Albino animals, whether the rabbit, pigeon, or mouse, the sclerotic and chorioid are nearly transparent, the latter losing its blood after death, and the image formed upon the retina may be readily seen, without removing a portion of the sclerotic. From observations of this kind M. Majendie has found that whether the eye be presented to a neighbouring or distant object, the image upon the retina is equally distinct, and therefore all the explanations of this circumstance which have been hitherto given, founded on changes which can occur only during life, fall to the ground, whether founded on pressure of the ball by the recti muscles, motion of the crystalline, contraction of the crystalline or ciliary processes, &c. He also found that the escape of a little of the aqueous or vitreous humour, or the total removal of the former or of the cornea, impaired the distiuctness of the image; the total removal of the aqueous humour or of the crystalline also increased the size of the image; the removal of the humours prevented the formation of any image; an increase produced in the pupil by a circular incision of the iris produced an increase of the image.*

* *Précis Elementaire de Physiologie*, T. i. p. 61, sq.

SECT. XVIII.

OF THE VOLUNTARY MOTIONS.

283. We have seen that the nerves perform two offices: (220) the one of feeling, the other of moving. The former we have already considered; we shall now say something with respect to the latter.

284. All the motions of the body may be divided into voluntary and involuntary.

The pulsation of the heart, and the peristaltic motion of the intestines and other viscera, are commonly adduced as instances of involuntary motion.

The action of by far the greater number of the other muscles is voluntary.

Respiration, sneezing, the tension of the membrana tympani, the action of the cremaster, are regarded by some as belonging to the former class; by others, to the latter; and by others, as of a mixed nature.

285. If this division is narrowly examined, it will be found embarrassed by so many difficulties, that the limits of each class cannot well be determined.

For, on the one hand, few functions can be termed truly involuntary, especially if we consider the connection of the imagination and passions with the will.

Again, on the other hand, there are few voluntary motions that may not be rendered involuntary by the force of habit, whose influence upon our animal motions is immense.

286. Of the latter description are those muscular motions which, although generally voluntary, take place, under certain circumstances, without the knowledge of the mind, or even in opposition to its endeavours.

Thus we wink *involuntarily*, if a friend suddenly approaches his finger to one of our eyes, though it does not come in contact: the ring finger generally bends if we bend the little finger.

We often *unconsciously* move our limbs even while sleeping soundly.

On the contrary, some muscles which are almost always obedient to the will, occasionally cease to be so: an instance of this exists in the difficulty which we experience in attempting to move the hand and foot of the *same* side in *different* directions; and in all those motions, which, although voluntary and perfectly easy if produced separately, are found very difficult if attempted together.*

287. Among those motions which are supposed to be perfectly involuntary, no one is free from exception, as far as I know, excepting the spasms of the uterus during labour.†

With respect to the motion of the heart, we have the indubitable testimony of Baynard and Cheyne, that they saw the famous English officer, who could stop the motion of his heart and arteries at pleasure.‡

There is no question that the pulsation of the heart and

* Consult Winslow in the *Mém. de l'Ac. des Sciences de Paris*, 1739.

† These are partly voluntary in some warm-blooded animals, as is shewn in birds when setting, which, if deprived of their eggs, are well known to lay others in succession.

‡ Cheyne's *Treatise on Nervous Diseases*, p. 307, sq.

arteries can be accelerated or retarded by the varied state of respiration.*

The motion of the stomach is voluntary in all ruminating animals, and I myself once distinctly found it voluntary in the human subject, in an instance of rumination.

Although the motion of the iris is involuntary in most persons, I have been credibly informed that some have been able, by a considerable effort, to subject it to the will and contract the pupil in a faint light.

So numerous are the motions commonly called involuntary, which become voluntary in some particular individuals, especially if aided by attention and liveliness of imagination.†

Thus I have seen some able to produce at any time a spasmodic horripilation of the skin, by representing some unpleasant sensation to their imagination.

Others have had the power of exciting local sweat in the hands, &c.‡ (A)

288. This may perhaps be explained on the principle of sensorial reaction, (56) which may be produced by imagination,—a mental stimulus, as easily as by a corporeal stimulus acting upon the sensorium (52). Many phenomena accord admirably with this explanation; v. c.

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* See Sam. Lath. Mitchill *On the gaseous oxyd of azote*, &c. New York, 1795, 12mo. p. 26.

Also Leop Caldani in the *Memore della accademia di Mantova*. T. i. 1795, p. 118.

† See the *Rapport des Commissaires chargés par le Roy de l'examen du magnétisme animal*, written by J. Sylv. Bailly, a man worthy of a better fate. Paris, 1784, 4to. p. 16.

‡ See v. c. T. Bartholin in the *Act. Hafniens*, 1676, vol. iv. p. 191.

the various causes of the erection of the penis, and of the flow of saliva.

289. The voluntary motions are the distinguishing characteristics of the animal from the vegetable kingdom. For no plant has been discovered procuring for itself food by means of voluntary motion; nor any animal incapable of locomotion, or at least of procuring sustenance by the voluntary motion of individual members.

290. In ourselves, these motions afford a striking proof of the intimate harmony subsisting between the body and the mind; and which is demonstrated in the rapid and various motions of the fingers of a good performer on the harp, and of the vocal organs whenever we speak.*

NOTE.

(A) Those muscles I conceive, are called voluntary, which we ordinarily have the power of directly contracting: those involuntary, which we have not ordinarily the power of directly contracting. These two definitions appear to me unexceptionable. The latter does not contradict what is unquestionably true,—that we can indirectly affect involuntary muscles, as the heart or stomach, by thinking of certain objects, and thus exciting certain emotions; nor does the former contradict another truth,—that voluntary muscles often contract without or

* A person playing on the harp, dancing, and singing, at the same time, exercises about three hundred muscles at once. G. Ent's *animad.* in Thrustoni *diatribam*, p. 130.

against our will. And this leads me to remark that the respiratory muscles deserve the epithet voluntary as much as any in the body, for we directly contract them: we feel an uneasy sensation in the chest from the retardation which occurs to the blood, and we inspire to remove it; the uneasiness being removed, our effort ceases, and expiration spontaneously ensues. It is true that the uneasiness is so great that we are forced to inspire, and that respiration continues while we are asleep. But the same is true of all voluntary muscles. If you irritate any part of a person asleep, an effort of some kind is made to remove it; and if you cause strong pain or titillation in a person awake, he will be compelled, whatever restraint he may attempt upon himself, to make an effort to remove it by motion of some part, as forcibly as he is compelled to remove the uneasiness in the chest by inspiration.*

* See A. P. Wilson in the *Edinb. Med. and Surg. Journal*, 1809.

SECT. XIX.

OF MUSCULAR MOTION.

291. THE immediate organs of motion, by far the most numerous in the body, are the *muscles*, which form the greatest bulk among all the similar parts.

292. They abound in azote more than other animal parts; and the absence of this principle, from the combination of hydrogen and carbon, which exists during health, entirely converts them, under a particular morbid affection* and after death† into an an adipocerous substance, resembling soap or spermacete.

293. The muscles are distinguished from other similar parts by two characteristic features; the one derived from their structure, the other from their singular vital powers.

294. This fleshy structure is so constructed of moving fibres, *sui generis*, and of a very faint red colour, that every muscle may be resolved into fibrous bands, these into bundles of fibres, and these again into very fine fleshy fibrils.

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* For instance, in Elephantiasis. Consult Ph. Gabr. Hensler, *Vom Abendländischen Aussatze im Mittelalter*, p. 316. Accurately described examples of similar changes in other affections, may be found in *Hedendaagsche Letter-Œfeningen*, T. iv. P. ii. p. 45, and in the *Mémoires de Mathematique, &c. presentés à l'Academie des Sciences de Paris*, T. vii. p. 301.

† See Thouret in the *Journal de Physique*, T. xxxviii. p. 255. G. Sm. Gibbes in the *Philos. Trans.* 1794, p. 169.

295. Every muscle possesses a covering of cellular membrane,* which is so interwoven with its substance, as to surround the bands, the bundles, and even each particular fibril.

296. Every part of the muscles is amply supplied with blood-vessels and nervous threads. The latter appear to deliquesce into an invisible pulp, and unite intimately with the muscular fibres: the former are so interwoven with the fibres, that the whole muscle is red, and acquires its own paleness (294) only by being washed.

297. Most muscles terminate in tendons,† which are fibrous ‡ parts, but so different in colour, texture, elasticity, &c. as to be readily distinguished from muscles: thus disproving the opinion of some, that the tendinous fibres originate from the muscular. This error arose chiefly from the circumstance of the muscles of infants containing a greater number of fleshy fibres, in proportion to the tendinous, than those of the adult.

298. The other exclusive character of muscles (293) is the *irritability* of Haller,§ the notion of which, and its

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* See Ad. Murray, *De Fascia Lata.* Upsal. 1777, 4to.

† See Fourcroy in the *Mémoires de l'Academie des Sciences de Paris*, 1785, p. 392, and 1786, p. 38.

‡ Albinus, *Annotat. Academ.* L. iv. Tab. v. f. 2.

§ I thus distinguish it, not because the luminary of the Gottingen school first discovered it, for he repeatedly bestowed praises upon the opinions entertained with regard to it by his predecessors, from the time of Glisson; but because he first investigated it as it deserved, illustrated and enlarged upon it by numerous living dissections, and demonstrated the great power and influence of the doctrine thus remodelled, upon the animal economy. I have also another reason, viz. to distinguish it from the irritability of the truly meritorious Gaubius, who applied the same term to the morbid sensibility of the living solid.

difference from contractility, we formerly explained (41), but shall now prosecute farther.

299. This irritability, or muscular power, or *vis insita*, is bestowed upon all muscles, but in different degrees.*

300 The highest order are the hollow muscles which perform the vital and natural functions, and especially the heart, (124) whose internal surface enjoys a very lively and permanent irritability.

Next to the heart follows the intestinal canal, particularly the small intestines, which, in warm-blooded animals, contract after the heart has ceased to show signs of irritability.

Next the stomach.

Then the urinary bladder, &c.

Among the other muscles, the respiratory, v. c. the diaphragm, the intercostals, and triangularis sterni, are remarkable for their irritability.

Then follow the remaining muscles.

Less, but still however some, exists in the arteries (128).

Also in the venous trunks contained in the thorax (95).

Still less, if it deserve the name of irritability, in the other blood vessels. (132)

301. Haller, the great arbitrator in the doctrine of irri-

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* See Haller on the irritable parts in the *Commentar. Soc. Sc. Gotting.* T. ii. and in the *Nov. Commentar. Gctting.* T. iv.

Among innumerable other writers on the same point, suffice it to quote the following:

Zimmerman, *De irritabilitate.* Gott. 1751, 4to.

Oeder on the same. Hafn. 1752, 4to.

J. Eberh. Audreæ on the same. (Præs. Ph. Fr. Gmelin.) Tubing. 1758, 4to.

Some others have been already mentioned, as well as three entire Collections of Writers, (p. 182.)

tability, has ascribed it improperly (40, 5807) I think, to some parts possessed indeed of *contractility*, but in which I have never been able to detect genuine irritability.

Such are the lacteals, glands, gall bladder, uterus, the dartos, and the penis. (A)

And others, with no less impropriety, bestow it upon the iris, the external surface of the lungs, &c. in which it no more exists than in the cellular membrane and those parts which are composed of it,—the common integuments, membranes of the brain, pleura, peritonæum, periosteum, medullary membrane, tendons, aponeuroses, &c. or in the proper parenchyma of the viscera, (20) of the liver, spleen, kidnies, secundines, the brain, and the rest of the nervous system, every one of which parts is destitute alike of muscular fibre, and of what is peculiar to it,—irritability.

302. As we find muscular irritability sometimes confounded with the *contractility* of the mucous web; so on the other hand, some eminent men, particularly in modern times, have attributed it to the *nervous energy*.*

Now, although we cannot deny the influence of the nerves upon the muscles, most strikingly shewn of late (225) by the experiments of the celebrated Galvani and others, and although no muscular fibril, however minute, can be

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* To this point chiefly belong the celebrated disputes respecting the influence of nerves upon the motion of the heart, and the modus operandi of opium upon the heart and nerves.

Consult, besides other authors already quoted,

Rob. Whytt's *Essay on the vital and other involuntary motions of animals*. Edinb. 1751, 8vo. and more at large in his works, *ib.* 1768, 4to.

J. Aug. Unzer, *erste Gründe einer Physiologie der eigentlichen thierischen natur thierischer Korper*. Leipsig. 1771, 8vo.

found absolutely destitute of nervous pulp, we are not on this account to assert that irritability is not a power *sui generis*, as clearly different from the nervous energy as from contractility. For parts not muscular are not irritable, however abundantly they may be supplied with nerves, as the corium, the numerous nervous viscera; and the muscular texture alone exhibits the genuine phenomena of irritability. So that from the weight of these united arguments, to omit many others, it appears more just to assign these phenomena to the muscular fibre alone, than to ascribe them to the nerves, which are common to so many other parts, but do not in these excite the faintest sign of irritability. I say nothing of many weighty arguments derived, for instance, from the facts, that no proportion exists between the degree of irritability and the number of nerves in any part; that one description of vital powers is often very energetic, while the other is languid in the same individual, according to national, morbid, or more especially to sexual variety. (B)

303. The nerves exert their influence upon the muscles, as *remote* or *exciting* causes of their action, but by no means as the *proximate* or *efficient*, which is the inherent irritability of the muscles.

The passions, v. c. act upon the sensorium, this upon the nerves of the heart, so as to excite its irritability, which produces palpitation and other anomalous motions.

The will acts upon the sensorium, this reacts upon the nerves of the arm, which excite muscular motion, as remote causes; but the proximate cause is the irritability of the muscles themselves.

304. With this distinction of the two causes of muscular motion, the result of those experiments exactly cor-

respond, which have been so frequently made by dividing or tying the nerves.* Paralysis ensued, but irritability continued vigorous for a length of time afterwards.

There have been cases where one limb was motionless from paralysis, but retained its sensibility, while the other was insensible, but still capable of motion.† Others have had great pain in paralytic parts.‡

305. The true efficacy of the blood so copiously afforded to muscles, (296) in promoting their action, is not clearly ascertained.

In the Stenonian experiment,§ indeed, paralysis of the hind legs commonly follows the application of a ligature upon the abdominal aorta.‖ (C)

But after all, I am confirmed in the opinion formerly mentioned (125), that the action of what are commonly called voluntary muscles depends less than that of the heart, upon the afflux of blood to the moving fibres; and on the contrary, more than it, upon the influence of the nerves which excite their irritability.

306. Besides these inherent powers common to all muscles, there are some peculiar and adventitious, arising from figure, situation, &c. and answering their object with perfect accuracy.

307. From this circumstance, the muscles in general

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* J. H. v. Brunn's *Experimenta Circa Ligaturas Nervorum in vivis Animalibus Instituta.* Gotting. 1753, 4to.

† v. J. Stewart, *De Systematis Nervosi Officiis.* Edinb. 8vo.

‡ C. H. Pfaff, *über Thierische Elektricität und Reizbarkeit.* Leipsig, 1795, 8vo. p. 263.

§ Stenon's *Elementor. Myologiæ spec.* Florent, 1667, 4to. p. 86.

‖ See Courten in the *Philos. Trans.* No. 335, p. 500, and Haller in the *Comment. Soc. Sc. Gotting.* T. iv. p. 295.

are divided into hollow and solid. The former, as we have seen, not directly subject to the will, belong more to the vital and natural functions, and are consequently not to be considered at present, while we are speaking of the voluntary muscles, which belong to the order of animal functions.

308. Among the latter also, there is much variety. For, not to allude to difference of size, there is great variety in the disposition of their bands and fasciculi, and the direction of their fibres, in the proportion of the fleshy to the tendinous part, in their course, mode of insertion, &c.

309. The greatest number are long, and their fleshy bellies terminate at each extremity in tendinous chords, inert, and destitute of irritability, and fixed to the bones, which they move in the manner of levers.

310. While a very few muscles are destitute of tendons, such as the latissimus colli, an equally small number are not inserted into bones, such are the cremaster, as we generally find it, the azygos uvulæ, most of the muscles of the eye, &c.

311. The muscles endowed with those common (298 sq.) and peculiar (306 sq.) powers, are thus prepared to perform their actions, which also may be divided into common and peculiar.

312. A property common to all muscles, and the immediate consequence of their irritability, is to become shorter, more rigid, and generally unequal, and, as it were, angular, during contraction.

To attempt, with J. and D. Bernoulli and other mathematical physicians, to reduce this diminution to a general admeasurement, is rendered impossible, among other causes, by the great difference between the hollow and solid muscles in this respect, and between the solid muscles themselves, v. c. between straight muscles (such as the intercostals) and sphincters.

313. The peculiar actions of muscles (311) correspond with their peculiar powers, and consequently vary so much as to be referrible to no general laws.

To cite one instance out of many, that action of certain muscles is peculiar and anomalous, which seldom occurs alone, but nearly always *subsequently* to, or *simultaneously* with the action of some of a different order. Such is the action of the lumbricales, when, during rapid motions of the fingers, they follow the action of other muscles of the metacarpus and fore arm; and of the lateral recti muscles of the eyes, either adducens of which seldom acts, unless simultaneously with the abducens of the other eye.

The commonly received law,—that a muscle during its contraction draws the more moveable point of insertion to the more fixed, must be considered, as Winslow wisely remarks,* perfectly relative, and subject to different limitations. Thus, for example, sometimes the one point, and sometimes the other, may be the more moveable; accordingly, as the united action of many different muscles may render the opposite more fixed.

And, on the other hand, although the action of the flexors is generally so much stronger than that of their antagonists,—the extensors, that, when the body is at rest, the arms, fingers, &c. are a little bent, this does not so much depend upon the strength of the contraction of the flexors, as upon the voluntary relaxation of the extensors, for our own relief.

* *Mém. de l'Acad. des Scienc. de Paris*, 1720.

314. Every muscle has moreover a peculiar *mechanism*,* adapted to the individual motions for which it is intended. Besides the determinate figure of each, many other kinds of assistance are afforded to their peculiar motions. The *bursæ mucosæ*, chiefly found among the muscles of the extremities; the annular ligaments by which some are surrounded; the fat in which most are imbedded; the lymphatic vapour around each; and, above all, the conformation of the sceleton, chiefly in regard to apophyses, condyles, and the articulations; nay, even whole bones, v. c. the patella, the pisiform of the carpus, and the sesamoid bones;† are destined solely to facilitate the actions of certain muscles.

315. In this mode is compensated, or at least diminished, that inevitable loss of power, which necessarily takes place from the conformation and stature of the whole system, in which, from the acute angle at which some muscles are inserted, or the proximity of their insertion to the centre of motion, much of that power is lost, which would have existed, if their insertion had been more remote or at a more obtuse angle.‡

316. The human body, possessing 450 muscles, or even more, according to sexual or individual variety, is thus furnished with a double advantage,—with an extreme agility of motion in particular parts and throughout the

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* P. J. Barthez. *Nouvelle Mechanique des Mouvemens de l'Homme, et des Animaux.* Carcass. 1798, 4to.

† Hence, of all animals which I have dissected, the mole is supplied with the most remarkable apparatus of sesamoid bones; its anterior palmated feet, with which it digs, have many of these bones, which greatly facilitate the action of the brachial muscles.

‡ Gilb. Blane *on Muscular Motion*, p. 51.

whole; and with a surprising degree of strength and endurance of labour. Both these are accomplished partly by the perfection of the muscles, which, like the perfection of ossification, takes place at manhood; and partly by habit and practice, the former of which in affording strength and agility to the muscles, is demonstrated in rope-dancers, leapers, runners, wrestlers, porters, savages, and in the examples of ancient nations.‡

NOTES.

(A) Irritability is a power of contracting upon the application of a stimulus, ceasing with life. It comprehends animal and organic contractility, (See Note to Sect. vi.) and we must suppose the lacteals, vessels of glands, gall bladder and dartos to be possessed of it: the uterus will hereafter be shewn positively to have muscular fibres, and their existence will be rendered probable in the human penis.

(B) See Note F. Sect. xii.

(C) This paralysis does not show the irritability of the muscles to be impaired; they would doubtless contract immediately after this experiment, upon the application of a stimulus, as readily as they do after apoplexy. The ligatures act immediately by depriving the nerves of the

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* I have treated on this point at large, in the *Medic. Biblioth.* Vol. ii. p. 407.

power of stimulating them; for a supply of arterial blood is necessary to the function of the nervous system,* and the ligature of the abdominal aorta cuts this off from the lower part of the spinal marrow, and what originate from it,—the nerves of the hind legs. If venous blood is sent to the brain, death ensues, and the function of any part is destroyed by forcing venous blood into its arteries.†

Another source of paralysis must ultimately arise,—the loss of irritability from the want of circulation in the muscle.

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* Le Gallois, *Sur le Principe de la Vie.*
† Bichat, *Récherches Physiologiques.*

SECT. XX.

OF SLEEP.

317. The faculties both of feeling and motion, possessed by the nervous system whose history we have thus pursued, are so fatigued by their exertions in the day, that rest is necessary during the night to recruit them by means of *sleep*,*—the image of death.

318. Sleep is a periodical function, by which the intercourse of the mind and body is suspended, and whose phenomena now to be traced, correspond very aptly with the supposition of a nervous fluid.

319. Besides other precursors of sleep, may be enumerated a gradually increasing dulness of the external senses, and a relaxation of most, especially of the long, voluntary muscles; a congestion of venous blood about the heart, and relief afforded by yawning to the uneasy sensation thus produced: lastly, a curious kind of short delirium at the moment when sleep is all but present.†

320. The phenomena of sleep, therefore, amount to this,—that the animal functions are suspended, and all the rest proceed more slowly and inactively. For the pulse is slower, the animal heat, cæteris paribus, diminished, perspiration more sparing, digestion imperfect, and nearly

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* Consult, among authors hereafter to be recommended, Er. Darwin. *Zoonomia.* T. i. Sect. xviii.

† De Pauw has some singular observations upon it in his *Recherches sur les Egyptiens et les Chinois.* T. ii. p. 159.

all the excretions (except that of the semen, which is indeed rather unusual) suppressed. (A)

321. The remote causes of sleep are evident.* To say nothing of narcotics, it is induced by the expenditure of the animal powers from previous fatigue or watchfulness, also by habit, darkness, silence, rest, &c. which acquire their somniferous powers in some measure from habit; by mild, continued, and uniform impressions upon certain senses, v. c. the murmur of a rivulet, or the view of a field of standing corn agitated by the wind, a previous meal, intense cold applied to the surface, and other modes of deriving blood from the head, as pediluvia, clysters, profuse hemorrhages.

322. These remote causes may induce the *proximate* cause, which, upon mature consideration, I think probably consists in a diminished or impeded flow of oxygenated (arterial) blood to the brain, for that fluid is of the highest importance, during the waking state, to the reaction of the sensorium upon the senses and voluntary motions.†

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* Although the lethargic winter torpor of the Alpine marmot, the cricetum, and many other brute mammalia, differs importantly from the sleep now spoken of; modern observations respecting this torpor have shewn, that, in their phenomena and remote causes, both correspond and mutually elucidate each other. Consult, for instance, Sulzer. *Naturgeschichte des Hamsters*, p. 162.

Spallanzani, *Sur la Respiration*. Geneva. 1803, 8vo.

Mangili, and C. Ul. Von Salis in the latter's and Steinmüller's *Alpina*. T. iv. 1809.

Cuvier's *Analyse des Travaux de la Classe Physique de l'Institut*. 1807.

† Those who wish to know and compare other opinions upon the causes of sleep, may consult M. De Grimaud's *Mémoire sur la Nutrition*. Petersb. 1789. 4to. p. 194.

The influx of blood is diminished by its derivation from the brain and congestion in other parts; it is impeded by the pressure of foreign matter upon the brain, whether from serous or purulent collections, from depression of fractured bones, &c.

This diminution of, or impediment to, the flow of blood to the brain, causes a deficiency of water in the ventricles and a collapse of them, upon which that acute and deep physiologist, David Hartley, on whom we formerly bestowed praise, explains the various phenomena of dreams.* Besides other phenomena which accord with this explanation, one is very remarkable which I witnessed in a living person, and has been already noticed,—that of the brain sinking whenever he was asleep, and swelling again with blood the moment he awoke.

This opinion is likewise strengthened by the production of continued watchfulness from congestion of blood in the head.

523. The quantity of sleep depends much upon age, constitution, temperament, &c.; generally speaking, much

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Arn. Wienholt in the *Heilkraft des thierischen Magnetismus.* T. ii. p. 409.

H. Nudow. *Versuch einer Theorie des Schlafs. Ratisbon,* 1791, 8vo.

Steph. Gallini at the end of his *Saggio d'Osservazioni Sui Nuovi Progressi Della Fisica del Corpo Umano.* Padua, 1792, 8vo.

Manduit in Fourcroy in the *Médecine Eclairée,* &c. T. iv. p. 273.

T. Chr. Reil *Functiones Organo Animæ Peculiares.* Hal. 1794, 8vo. p. 108.

L. H. Chr. Niemeyer *Materialien zur Erregunstheorie.* Gotting. 1800, 8vo. p. 71.

Troxler. *Versuche in der Organischen Physik,* p. 435.

Brandis *Pathologie,* p. 534.

* *Observ. on Man.* Vol. i. p. 48.

sleep is the attendaut of weakness, (as we find it in infants born prematurely and in superannuated persons,) and the very frequent source of fatuity and torpor.

124. We awake refreshed with sleep; and this return to life is attended by the same phenomena as the approach of sleep,—by gaping, usually attended with stretching, by some degree of dulness of the senses, &c.

325. The causes of waking correspond with those of sleeping.

The proximate is the more free return of blood to the head.

The remote are (besides the power of custom, which is in this respect very great) various stimuli applied to the external or internal senses, either immediately affecting the nervous system, as the distension of the bladder, or mediately, by the intervention of the imagination, as in dreaming.

326. *Dreams* are a wandering of the imagination, which recalls the ideas of objects formerly perceived, especially of objects of sight, and appears to employ and interest itself with them.

It has been disputed whether dreams are natural during health. Some believe that they always occur during sleep, although they may escape our memory.* Others conceive them the consequence only of derangement in some of the abdominal viscera.† Very healthy adults have asserted that they never dreamt.‡

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* Consult Kant. *Critik der Urtheilskraft*, p. 298. and *Anthropologie*. p. 80.

† v. F. Xav. Mezler *von der Schwarzgallichten Constitution*, p. 80.

‡ v. Locke's *Essay concerning Human Understanding*. Vol, i. p. 74. Lond. 1726. 8vo.

They are generally confused and irregular, but occasionally discover extraordinary marks of reason.*

The power of corporeal stimulants is very great in producing dreams; v. c. of the semen in producing lascivious trains of ideas, of excessive repletion in causing frightful appearances. We have one instance of a man, in whom any kind of dreams could be induced, if his friends, by gently addressing him, afforded the subject matter.† This, however, appears to be a preternatural state, between sleeping and waking; as does also the truly diseased case of sleep-walkers, and that affection which seizes them with what is termed magnetic ecstasy, which is, however, of a very different nature.‡

Locke and others have regarded all dreams as a species of this mixed state. (C)

NOTES.

(A) Respiration also proceeds more slowly.

(B) It is certain that the supply of arterial blood to every part, and especially to the nervous system, is requisite to its functions and its life, and that in proportion to the activity of a part is the activity of its supply of arterial

* See for instance what Hollmann has related of himself in this particular. *Pneumatolog. Psycholog. et Theol. Natural.* Gotting. 1780, 8vo. p. 196.

† Beattie's *Dissertations Moral and Critical.* Lond. 1783, 4to. p. 217.

‡ G. Gottl. Richter *De Statu Mixto somni et Vigiliæ quo Dormientes multa Vigilantium munera obeunt.* Gotting. 1756, 4to.

Wienholt, l. c. Vol. iii. P. i. p. 10.

blood. Analogy, therefore, renders it more than probable, that, during the inactivity of sleep, the brain having less occasion for arterial blood, has a less vigorous circulation than during the waking state; and we know that whatever diminishes the ordinary determination of blood to the brain (321), or impairs the movement of the blood through it,* disposes to sleep.† But although this be granted, it must be viewed not as the ordinary cause, but as a circumstance, or in fact a consequence, of sleep. Increase the activity of an organ, you increase its circulation; diminish its activity, you diminish its circulation. The alteration of circulation is usually not the cause, but the consequence; necessary indeed to the continuance of the altered degree of activity in the organ, but not the cause. The degree of activity of any part, and the degree of its

* As arterial blood when at rest acquires the venous character, it is evident that in congestion of blood, by which is meant an unusual quantity of blood in a part, not moving with its usual freedom, the part affected has not its proper supply of arterial blood. Hence congestion in the head must, from this cause alone, produce drowsiness.

† The phenomena of torpid animals are precisely analogous to those of common sleep. The sensibility and all the functions are lessened, the temperature is low, the circulation slow, respiration almost or quite imperceptible, and digestion suspended. This torpidity is produced by a deficiency of external excitants, usually by cold and want of food, and in the language of Brown, is a state of direct debility, while our ordinary sleep is one of indirect debility. No structural peculiarity is discoverable, which enables certain animals to live through torpidity. See Dr. Reeve *On Torpidity*.

Some animals become torpid on being deprived of moisture. I put a garden snail into a dry closet without food a year and a half ago; it became torpid and has remained so ever since, except whenever I have chosen to moisten it:—a few drops of water revive it at any time. Moisture has revived some animalcules after a torpidity of twenty-seven years. Spallanzani. *Opuscules Physiques*.

circulation, are exactly and unalterably correspondent. If the circulation through a part be mechanically increased or diminished, the sensibility and activity of the part will, doubtless, be proportionally increased or diminished. This example occurs in hemorrhage; frequently both are caused simultaneously,—when diarrhea renders the surface pale and cold, both the blood is sent more sparingly to it, and the action of its vessels is diminished by the increased activity of those of the intestines; in ordinary sleep, the diminished circulation appears the consequence, for activity is always followed by inactivity. Stimulate a muscle, separated from the body, it contracts, but it soon refuses to do so; after a little rest, it again contracts upon the removal of the stimulus. The case of the brain is analogous; and when, after its daily activity, it falls asleep, the diminution of its circulation consequently ensues.

(C) In sleep the action of the mind is in a high degree suspended. But the degree of suspension is extremely various. In ordinary sleep the mind is sufficiently alert to feel unpleasant sensations and make an effort to remove their causes;—whether to remove the uneasiness of impeded circulation in the lungs by breathing, or to draw away the hand when tickled. Imagination is often active, and one idea associates with it another, constituting dreaming; but the activity of the mind is partial, and though we are able occasionally even to reason correctly in our dreams, we are not sufficiently ourselves to discover the incompatibility of many circumstances which we fancy. In a higher degree of activity, we answer questions put to us, although often ridiculously; as our deficiency of mental power prevents us from keeping our associations in a proper train; and we sometimes even perform a regular series of movements.

Between sound sleep and the waking state are innumerable degrees. The great feature of sleep is the deficiency of our active powers. If we have any external sensation, or if the imagination riots on, presenting trains of images to our internal senses, we reflect upon them but weakly, make great mistakes, and however well we may reason, or whatever corporeal movement we execute, the inferiority of our active powers is conspicuous. That active power is not suspended, as Mr. Dugald Stewart maintains in his theory of dreaming,* the simple fact of breathing during sleep, to say nothing of the other motions, and the acute, though circumscribed, reasoning which occasionally occurs in sleep, abundantly proves to the most superficial observer.

* *Elements of the Philosophy of the Human Mind.* Vol. 1.

SECT. XXI.

OF FOOD AND HUNGER.

327. As sleep repairs the loss of the animal powers, so food repairs that of the natural, and supplies fresh elementary particles in the room of those which are constantly wasting.

328. We are most effectually induced to procure and take food by various calls of nature, all tending to the same end; on one hand, by the intolerable torment of hunger and thirst; and on the other, by the equally powerful allurements of appetite.

329. Some ascribe *hunger* to an uneasiness arising in the stomach from being empty and unoccupied; others to the mutual friction of its rugæ; others not only to the stimulus of its fluids, now secreted in abundance,—of the saliva and gastric juice,—but to an acrimony which they acquire when food is not taken in proper time. (A).

330. *Thirst* appears referrible both to a very unpleasant dryness of the fauces, and to the particular stimulus of acrid matters, especially of salts, taken by the mouth. It may be, therefore, the consequence of excessive absorption in the cavity of the mouth, such as occurs when the mother again applies her infant to the breast immediately after it has sucked; or, as happens not uncommonly, when venesection or purging have been ordered. Violent passions frequently induce thirst. (B).

331. The necessity of obeying these stimuli, is more or less urgent according to age, constitution, and especially according to habit, and nothing can therefore be positively affirmed respecting its intensity; but thus much is certain, that an healthy adult, in whom all the calls of nature are felt in their usual force,* cannot abstain from food a whole day without great prostration of strength, nor scarcely beyond eight days without danger to his life. (C).

332. Although thirst is a violent desire, drink appears not very necessary to life and health; for many warm blooded animals,—mice, quails, parrots, &c. do not drink at all; and some individuals of the human species have lived in perfect health and strength without tasting liquids.†

333. It has been disputed whether our *food*, by which we satisfy these stimuli, is derived more advantageously and the more consistently with nature, from the animal or vegetable kingdom.‡

334. Some contend that man is herbivorous, from the shape of his teeth,§ the length of his intestines,‖ the dif-

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* Consult among innumerable writers on long fasting, James Barthol. Beccarius in the *Commentar. instituti Bononiens,* T. ii. p. i. and Flor. J. Voltelen's *memorab. apositiæ septennis hist.* L. B. 1777, 8vo.

† See G. Baker in the *Med. Transact. published by the Coll. of Physicians in London,* vol. ii. p. 265, sq.

‡ J. W. Neergaard's *vergleichende Anatomie und Physiologie der Verdauungswerkzenge der Saügethiere und Vögel.* Berlin, 1806, p. 244.

§ Gassendi's *Letter* to J. Bapt. v. Helmont. Opera. Florence, 1727, fol. T. vi. p. 17. Al. Monro, Senr. in his *Essay on Comparative Anatomy,* p. 17.

‖ J. Wallis in the *Philos. Trans.* No. 269.

ference between the structure of the small and large intestines, and from the cells of the colon. Rousseau ingeniously urges the circumstance that woman is naturally uniparous and provided with two breasts.* To these arguments it may be added, that some men have ruminated, —a power peculiar to herbivorous animals; that tame vegetable feeders are easily accustomed to animal food, whereas carnivorous animals, excepting the dog, can very seldom be brought to feed on vegetables.

The arguments of those who, with Helvetius,† regard man as carnivorous, are derived from the conformation of his stomach, the shortness of the cœcum, &c.

335. More careful observation, however, proves that man is not destined for either kind of food alone, but for both. His teeth, particularly the molares,‡ (D) and the peculiar structure of the intestines just alluded to, (E) hold a middle rank between the same parts in the feræ and in herbivorous animals. The mode in which the condyles of the lower jaw are articulated with the

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* *Sur l'origine de l'inegalité parmi les hommes.* p. 196, sq.

† *De l'homme.* T. ii. p. 17.

‡ The opinion of Broussonet is singular. He thinks the human molares closely resemble the teeth of herbivorous animals, and at the same time regards the incisores and canini as allied to those of the carnivorous tribes: and, after comparing the *number* of the molares with that of the other teeth, concludes that the quantity of vegetable food intended for man is to the quantity of animal food as 20 to 12.

But on this calculation it follows, that infants, who have four molares only in each jaw, are destined to consume a larger portion of animal food than adults, since the proportion of the molares to the other teeth is in them as 8 to 12.

temporal bones, demonstrates it in the most striking manner (F).

336. As the human race exists in more parts of the globe than any other kind of animal, we should have been but ill provided for, if we had been destined to subsist on either description of food alone; whereas man now inhabits some countries which afford either vegetable or animal food only.

337. Man is by far the most omnivorous of all animals, capable not only of feasting on luxurious combinations derived from each kingdom, but of subsisting with health and vigour on nearly one kind of the most simple food.

Thus, to mention a very few instances, many at present live on vegetables only, on the tubera of night-shade, (potatoes) chesnuts, dates, &c. The first families of mankind most probably subsisted for a long period merely on fruits, roots, corn, and pulses.*

The nomade Moors have scarcely any other food than gum seneka.†

The inhabitants of Kamtschatka and many other shores scarcely any other than fish.

The shepherds in the province of Caraccas in South America, on the banks of the Oronoko,‡ and even the Morlachs § in Europe, live almost entirely on flesh.

Some barbarous nations devour raw animals. This cannot be denied to have been formerly the case with the

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* Consult my very attached friend Heyne's *Opuscula Academ.* vol. i. p. 366, sq.

† Adanson in the *Mém. de l'acad. des Sc. de Paris,* 1778, p. 26.

‡ Fil. Salv. Gily's *Suggio di storia Americana,* vol. iv. p. 120.

§ Gius. Ant. Pujati's *Reflessioni sul vitto Pitagorico.* Feltri. 1751 4to.

Samojedes,* the Esquimaux,† and some tribes of South America.‡

Other nations are no less remarkable in their drink.

The inhabitants of many intertropical islands, especially in the Pacific Ocean, can procure no sweet water, and instead of it drink the juice of cocoa-nuts.

Others take only sea-water.

Innumerable other facts of this kind clearly prove man to be omnivorous.

NOTES.

(A.) If hunger arise from a sense of vacuity in the stomach, why should it be increased by the application of cold to the surface, the deglutition of cold liquids, &c ?

The explanation by friction of the rugæ is equally unsatisfactory; because the friction of these, if this does really occur, cannot be greater than the friction of the stomach against its contents after a meal, at which time hunger does not exist.

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* (De Klingstaedt) *Mém. sur les Samojeds et les Lappons.* 1762, 8vo.

† Curtis in the *Philos. Transact.* vol. lxiv. P. ii. p. 381, 383.

‡ T. Winter in Hakluyt's *Principal Navigations of the English nation,* vol. iii. p. 751.

Nor can the presence of the gastric juice explain the matter; because, as every one knows, no mental sensation arises in any other organ which is not excrementory from the stimulus of its natural fluid; and I presume that this is the stimulus alluded to, because the mechanical stimulus from the bulk of the gastric juice, occurs equally from the presence of food, which does not excite hunger.

The supposition of an acrimony generated in the gastric fluid, &c. is, as a cause of hunger, absurd; it would be unfit for its purposes, and would be most likely to destroy rather than produce appetite.

Hunger has been attributed by some to a sympathy of the stomach with a general feeling of want in the system. But hunger is removed immediately that a due quantity of food is swallowed, long before the general system can have derived benefit from the meal. The circumstance giving rise to this opinion is the continuance of hunger, although food be taken in abundance, in cases of scirrhus pylorus and enlarged mesenteric glands. Here, it is urged, the hunger continues, because the body receives no nourishment. But, in scirrhus of the pylorus, vomiting soon follows the reception of food into the stomach, and therefore this organ is reduced to the condition in which it was previously, and the return of hunger is easily explicable. In diseases of the mesenteric glands, there is in fact no obstruction to the course of the chyle. Blumenbach always found them permeable (427), and the continued hunger appears rather a part of the diseased state of the chylopoietic viscera. Besides, many cases of imperfect nutrition, from various causes, occur without any increase of appetite.

If hunger arose from fatigue of the stomach, it should be greatest immediately after the laborious action of digestion, and gradually decrease; but it on the contrary increases.

Were irritation the cause, hunger should be greatest when the stomach is filled with food.

On the whole, hunger may perhaps be regarded as a sensation arising from the corrugation of the interior coat of the stomach.

It is increased by cold drink, by cold air applied to the surface, by acids, bitters, and astringents;—all which may be presumed to induce contraction of the muscular fibres of the stomach, and thus corrugate its inner coat. It is diminished by heat and every thing which relaxes. Again, hunger ceases immediately that the stomach is filled, and thus all corrugation removed.

Being, on this explanation, a sensation arising from a local state of the stomach, it will be affected not only by whatever affects this state, but by whatever affects also the sensibility to this state, and therefore be subject to the common laws of sensation. Thus, the state of the stomach remaining the same, hunger may diminish from the occurrence of other sensations which attract our attention more forcibly, by passions of the mind, &c.; as is exactly the case with all other sensations, even with those that are morbid. Under strong attention of the mind either to pursuits of intellect or passion, to delightful or painful sensation, all other sensations cease to be felt, although really violent; and frequently, from being unattended to, do not recur. Passions, however, may affect hunger, not only by increasing or diminishing the sensibility to the corrugation, but by increasing or decreasing the corrugation,—the cause of the sensation.

(B.) As hunger appears to depend upon the local condition of the stomach, &c. so does thirst more evidently upon that of the fauces. Every consideration renders it probable that thirst is the sensation of the dryness of the parts in which it is seated. Whatever produces this dryness, either by diminishing the secretion of the mouth, &c. or by carrying off the fluid when secreted, produces thirst, and vice versâ. Being a sensation, the same may be repeated in regard to it as was observed respecting hunger.

(C.) Instances of fasting for a much greater length of time may be found in authors, but these are extraordinary cases.

(D.) In carnivorous animals, the incisors are very large; and the molares generally of an irregular wedge form, those of the lower jaw closing in those of the upper like scissars, and being adapted for lacerating. In the herbivorous, the surface of the molares is horizontal or oblique, adapted for grinding.

(E.) As the food of herbivorous animals requires more preparation before it becomes the substance of the animal, the stomach is adapted to retain it for a length of time. The œsophagus opens nearer the right extremity of the stomach, and the pylorus nearer the left, so that a blind pouch is left on either side. In the carnivorous, the reverse is the case, and the stomach cylindrical, to favour the quick passage of the food. For the same reason, the intestines in the latter have generally shorter and fewer valvulæ conniventes; and, in some instances, no cœcum.

(F.) In animals which subsist on animal food, the condyles of the lower jaw are locked in an elongated glenoid cavity, and all rotatory motion is thus prevented, as motion upwards and downwards is sufficient for the laceration of the food. In vegetable feeders the joint is shallow, so that a horizontal motion is allowed for grinding the food.

SECT. XXII.

OF MASTICATION AND DEGLUTITION.

338. THE lower jaw is the chief organ of mastication, and is supplied as well as the upper with three orders of teeth.

With incisores, generally * scalpriform for the purpose of biting off small pieces, and not placed in the lower jaw, as in other mammalia, more or less horizontally, but erect—one of the distinctive characters of the human race.

With strong conical canine teeth, by which we divide hard substances, and which in man neither project beyond the rest, nor are placed alone, but lie closely and in regular order with the others.

With molares of various sizes, adapted for grinding,

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* I say generally: for, omitting particular examples of their obtuseness, I may remark that, in the skulls of most mummies, I have found the crown of the incisores thick and obtuse. And since the more remarkable for this variety have resembled in their general figure and appearance, the singular and never-to-be-mistaken physiognomy of the ancient Egyptians, observable in the idols, sarcophagi, and images of ancient Egypt, it is probable that this peculiar form of the teeth, whether owing to diet or whatever else, was peculiar to the ancient Egyptians, so that it may be regarded as a natural mark or even characteristic by which true ancient mummies may be distinguished from those of late formation.

I have written at large on this subject in the *Philos. Trans.* 1794, P. II. p. 184.

and differing conspicuously from those of other mammalia, by possessing gibbous apices singularly obtuse.

339. The lower jaw is connected with the skull by a singular articulation, which holds a middle rank between arthrodia and ginglymus; and being supplied with two cartilaginous menisci of considerable strength, affords an easy motion in every direction.

The digaster, assisted by the geniohyoidei and mylohyodei muscles, draws the lower jaw down, when we open the mouth.

The masseters and temporal chiefly raise it again when we bite off any thing, and are most powerfully contracted when we break hard substances.

Its lateral motions are accomplished by the internal and external pterygoid.

The latter can also draw it forwards.

340. Substances are retained in the mouth and moved and brought under the action of the teeth by the buccinator and the tongue, which is very flexible and changeable in form. (235)

341. During manducation, there occurs a flow of *saliva*,* which is a spumous fluid, consisting of a large portion of water united with some albumen, and holding in solution a small quantity of phosphate of lime,—the source of the tartar of the teeth and salivary calculi. From being constantly applied to the tongue, it is insipid, although it contains some microcosmic salt (phosphate of ammonia), as well as muriatic and, invariably, a small portion of oxalic acid. It is antiseptic† and very resolvent. (A)

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* J. Barth. Siebold's *Historia Systematis Salivalis*. Jen. 1797, 4to. with plates.

† Pringle, *on the Diseases of the Army*. Append. p. XLVIII. L. LXI. sq. Lond. 1765, 4to.

342. The saliva flows from three orders of conglomerate glands, placed laterally and interiorally with respect to the lower jaw.

The principal are the *parotids,** which pour forth the saliva behind the middle molares of the upper jaw, through the Stenonian ducts.†

The *submaxillary,*‡ through the Whartonian.§

The *sublingual,*‖—the smallest, through the numerous Rivinian.**

343. The excretion of saliva, amounting, according to the arbitrary statement of Nuck,†† to a pound in twelve hours, is augmented by stimnli and mechanical pressure, or, if the expression may be allowed, emulsion.

The latter cause, greatly favoured by the situation of the parotids at the articulation of the jaws, occurs when we chew hard substances, which thus become softened.

The former occurs when acrid substances are taken into the mouth, which are thus properly diluted; or arises from imagination, (288) as when the mouth waters during the desire for food.

344. The mucus of the labial and buccal glands‡‡ and of the tongue, as well as the moisture which transudes from the soft parts of the mouth, is mixed with tbe saliva.

345. This mixture of fluids poured upon a substance

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* See De Courcelle's *Icones Musculorum Capitis,* Tab. I. *g. h.*

† Stenon's *Observationes Anatomicæ,* p. 20.

‡ De Courcelles, l. c. Tab. II. *t. t.*

§ Wharton's *Adenographia,* p. 120.

‖ De Courcelle's tab. V. *g. g. g.*

** Rivinus *De Dyspepsia.* Lips. 1678, 4to.

Aug. Fr. Walther, *De Lingua Humana,* ib. 1724, 4to.

†† Nuck's *Sialographia,* p. 29, sq.

‡‡ De Courcelles, l. c. Tab. IV. *e. e. e.*

which we are chewing, renders it not only a pultaceous and easily swallowed bolus, but likewise prepares it for further digestion and for assimilation.

346. The mechanism* of deglutition, although very complicated and performed by the united powers of many very different parts, amounts to this. The tongue being drawn towards its root, swelling and growing rigid, receives the bolus of food upon its dorsum, which is drawn into a hollow form. The bolus is then rolled into the isthmus of the fauces, and caught with a curious and rather violent effort by the infundibulum of the pharynx, which is enlarged and in some measure drawn forward to receive it. The three constrictores † muscles of the pharynx drive it into the œsophagus. These motions are all performed in very rapid succession and require but a short space of time.

347. Nature has provided various contrivances for opening and securing this passage.‡

The important motion of the tongue is regulated by the os hyoides.

The smallest particle of food is prevented from entering the nostrils or eustachian tubes, by means of the soft palate,§ which, as well as the uvula suspended from its

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* Fr. Bern. Albinus, *De Deglutitione.* L. B. 1740, 4to.

P. J. Sandifort's *Deglutitionis Mechanismus.* L. B. 1805, 4to.

† Eustachius. Tab. XLII. fig. 4, 6.

Santorini, *Tab. Posthum.* VI. fig. 1.

B. S. Albinus, *Tab. Musculor.* XII. fig. 23, 24.

‡ J. C. Rosenmüller's *Icones Chirurgico-Anatomicæ.* Fasc. I. Vinar. 1805, fol.

§ Littre in the *Mém. de l'Acad. des Sc. de Paris,* 1718, tab. XV.

arch, and whose use is not clearly understood, is extended by muscles of its own, and closes those openings.*

The tongue protects the glottis, for the larynx at the moment of deglutition is drawn upwards and forwards, and in a manner concealed under the retracted root of the tongue and applied to the latter in such a way, that the glottis being also constricted and protected by the epiglottis, is most securely defended from the entrance of foreign substances.

348. Deglutition is facilitated by the abundance of mucus which lubricates these parts, and which is afforded not only by the tongue (237), but by the numerous sinuses † of the tonsils and cryptæ of the pharynx.

349. The *œsophàgus,* through which the food must pass previously to entering the stomach, is a fleshy canal, narrow and strong, mobile, dilatable, very sensible, and consisting of coats resembling, except in thickness, the coats of the other parts of the alimentary canal.‡

The external coat is muscular, and possesses longitudinal and transverse fibres.

The middle is tendinous, lax, more and more cellular towards each of its surfaces, by which means it is connected with the two other coats.

The interior is lined, like all the alimentary tube, with an epithelium analogous to cuticle, (176) and is lubricated by a very smooth mucus.

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* Santorini's *Tab Posthum.* IV.—VI. fig. 2.—and VII.

B. S. Albinus' *Tab. Musculor.* XII. fig. 11, 27, 28.

† B. S. Albinus' *Annotat. Acad.* L. III. Tab. III. fig. 1, *n.*

‡ See Matth. Van. Geuns in the *Verhandelingen van de Maatschappye te Haarlem.* T. XII. p. 9, sq.

Jan. Bleuland's *Observ. de structura œsophagi.* L. B. 1785, 4to.

350. This canal receives the approaching draught or bolus of food, contracts upon it, propels it downwards, and, in the case of the bolus, stuffs it down, as it were, till it passes the diaphragm and enters the stomach.

NOTE.

(A) Saliva is composed of

Water - - - - - -	992 . 9
A peculiar animal matter - -	2 . 9
Mucus - - - - - -	1 . 4
Alkaline muriates - - -	1 . 7
Lactate of Soda and animal matter	0 . 9
Pure soda - - - - - -	0 . 2
	1000 . 0

General view of the composition of Animal Fluids, by J. Berzelius, M. D. *Medico-Chirurgical Transactions.* Vol. III. p. 242.

SECT. XXIII.

OF DIGESTION.

351. THE *stomach* is the organ of digestion. It exists, what cannot be affirmed of any other viscus, in perhaps all animals without exception; and, if tke importance of parts may be estimated in this way, evidently holds the first rank among our organs.

352. The human stomach* resembles a very large leathern bottle, is capable in the adult of containing three pints and upwards of water, and has two openings.

The superior, called *cardia*, at which the œsophagus, folded and opening obliquely, expands into the stomach, is placed at the left side of its fundus.

The inferior, placed at the right and narrower part of the stomach, and called *pylorus*, descends somewhat into the cavity of the duodenum.

353. The situation of the stomach varies accordingly as it is in a state of repletion or depletion. When empty, it is flaccid and hangs into the cavity of the abdomen, its greater curvature inclining downwards, while the pylorus, being directed upwards, forms by doubling, an angle with the duodenum.†

When full, the anterior curvature is rolled forwards,‡

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* Eustachius, tab. x. fig. 1, 2, 3. Ruysch's *Thes. Anat.* II. Tab. v. fig. 1. Santorini's *Tab. Posth.* XI.

† Vesalius, *De c. h. Fabrica.* L. v. fig. 14, 15.

‡ Id. l. c. fig. 2.

so that the pylorus lies more in a line with the duodenum, while the cardia, on the contrary, is folded, as it were, into an angle and closed.

354. The stomach is composed of four principal coats, separated by the intervention of three others, which are merely cellular.

The *external* is common to nearly all the alimentary canal, and continuous with the omentum, as we shall presently mention.

Within this, and united to it by cellular membrane, lies the *muscular* coat, very remarkable, and the seat of the extraordinary irritability (300) of the stomach. It consists of strata of muscular fibres,* commonly divided into three orders, one longitudinal and two circular, (straight and oblique) but running in so many directions that no exact account can be given of their course.

The third is the chief membrane. It is usually termed *nervous*, but improperly, as it consists of condensed mucous tela, more lax on its surfaces, which are united on the one hand with the muscular and on the other with the internal villous coat. It is firm and strong, and may be regarded as the basis of the stomach.

The *interior*, (besides the epithelium investing the whole alimentary canal) improperly called villous, is extremely soft and in a manner spongy, porous, and folded into innumerable rugæ,† so that its surface is more extensive than that of the other coats ; it exhibits very small cells,‡ somewhat similar to those larger cells which are so beautiful in the reticulum of ruminants.

* Besides Haller, consult Bertinus in the *Mém. de l'Acad. des Sc. de Paris*, 1761;

† Ruysch, *Thes. Anat.* II. Tab. v. fig. 2, 3. 4.

‡ See G. Fordyce, *on the Digestion of Food*, p. 12, 59, 191.

Its internal surface is covered with mucus, probably secreted in the muciparous crypts which are very distinct about the pylorus.

355. The stomach is amply furnished with nerves* from each nervous system (214), whence arises its great sensibility, from which it is so readily affected by all kinds of stimuli, whether external, as cold, or internal, as food and its own fluids, or mental; whence also the great and surprising sympathy between it and most functions of the system; to which are referrible the influence of all passions upon the stomach, and of the healthy condition of the stomach upon the tranquillity of the mind.†

356. The abundance and utility of the blood-vessels of the stomach are no less remarkable. Its arteries ramifying infinitely upon the cellular membrane and glands, secrete the *gastric juice*, which would appear to stream continually from the inner surface of the stomach.

357. The general composition of this fluid is analogous to that of the saliva, equally antiseptic, very resolvent,‡ and capable of again dissolving the milk which it has coagulated.§

358. Digestion is performed principally by it. The

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* Walter's *Tab. Nervor. Thorac. et Abdom.* tab. IV.

† J. H. Rahn. *Mirum inter Caput et Viscera Abdominis Commercium.* Gotting. 1771, 4to.

Dit. Vegens, *De Sympathia inter Ventriculum et Caput.* L. B. 1784, 4to.

Wrisberg, in the *Commentat. Societ. Scientiar. Gotting.* T. XVI.

‡ Ed. Stevens, *De Alimentarum Concoctione.* Edinb. 1777, 8vo.

Laz. Spallanzani, *Dissertazioni di Fisica Animale e Vegetabile.* Modena, 1780, 8vo. Vol. 1.

§ See Veratti, in the *Comment. Instituti Bononiens.* Tom. VI.

food, when properly chewed and subacted by the saliva, is dissolved * by the gastric fluid, and converted into the pultaceous chyme, so that most kinds of ingesta lose their specific qualities and are defended from the usual chemical changes to which they are liable, such as putridity, rancidity, &c. and acquire fresh properties preparatory to chylification.†

359. This important function is probaby assisted by various accessory circumstances. Among them, some particularly mention the *peristaltic motion*, which, being constant and undulatory, agitates and subdues the pultaceous mass of food.‡

The existence of a true peristaltic motion in the stomach during health, is, however, not quite certain; the undulatory agitation of the stomach which occurs, appears intended for the purpose of driving the thoroughly dissolved portions downwards, while those portions which are not completely subacted are repelled from the pylorus by the antiperistaltic motion.

360. The other assistants commonly enumerated, are the pressure on the stomach from the alternate motion of the abdomen, and the high temperature maintained in the stomach by the quantity of blood in the neighbouring viscera and blood-vessels, which at one time was supposed to be of such importance, that the word coction was synonymous with digestion.

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* Even the stomach itself when deprived of vitality has been found acted upon, and as it were, digested by it. See John Hunter, *on digestion of the stomach after death. Philos. Trans.* Vol. LXII.

† Ign. Doellinger. *Grundiss der Naturlehre des menschlichen Organismus.* p. 88.

‡ Wepfer. *Cicutæ Aquaticæ Historia et Noxæ*; in innumerable places.

361. To determine the time requisite for digestion, is evidently impossible, if we consider how it must vary according to the quality and quantity of the ingesta, the strength of the digestive powers, and the more or less complete previous mastication.

During health, the stomach does not transmit the digestible parts of the food before they are converted into a pulp. The difference of food must therefore evidently cause a difference in the period necessary for digestion.* It may, however, be stated generally, that the chyme gradually passes the pylorus between three and six hours after our meals. (A)

362. The *pylorus* † is an annular limbus, consisting not, like the other rugæ of the stomach, of merely the villous, but also of fibres derived from the nervous and muscular coats. All these united, form a conoidal opening at the termination of the stomach, projecting into the duodenum, as the uterus does into the vagina, and, as it were, embraced by it.

NOTE.

(A) The digestive process does not go on equally through the whole mass of food, but takes place chiefly when it is in contact with the stomach, and proceeds gradually from the superfices to the centre of the mass.

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* J. Walaeus, *De Motu Chyli*, p. 534. L. B. 1651, 8vo.

† H. Palm. Levelling. *Disserst. sistens Pylorum. &c.* Argent, 1764, 4to. Reprinted in Sandifort's *Thes.* Vol. III.

unless they afforded a salutary admonition, how fatal the practice of medicine may become, if not founded on sound physiology.

366. The source of this fluid is similar to that of the saliva. It is the *pancreas*,* by much the largest conglomerate gland in the system, excepting the breasts, and greatly analogous to the salivary glands in every part of its structure, even in the circumstance of its excretory ducts, arising by extremely small radicles, and uniting and forming one common duct, denominated, from its discoverer, Wirsüngian.

This duct penetrates the tunics of the duodenum, and supplies the cavity of this intestine with a constant stillicidium of pancreatic juice.

367. The excretion of this fluid is augmented by the same causes which affect that of the saliva; viz. by pressure and stimulus.

By the former it is emulged, whenever the stomach, being in a state of repletion, is incumbent upon the pancreas.

By the latter, when fresh and crude chyme enters the duodenum and the bile flows through the opening common to it and the pancreatic fluid.

368. Its use is to dissolve the chyme, especially if imperfectly digested in the stomach; and at all times, by its great abundance, to assimilate the chyme more to the nature of the fluids, and render it fitter for chylification.

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* Santorini's *Tab. Posth.* XIII. fig. 1.

SECT. XXV.

OF THE BILE.

369. THE bile is secreted by the *liver*,*—the most ponderous and large of all the viscera, especially in the fœtus,† in which its size is inversely as the age. The high importance of this organ is manifested, both by its immense supply of blood-vessels, and their extraordinary distribution, as well as by its general existence. It is not less common to all red-blooded animals than the heart itself.

370. The substance of the liver is peculiar, easily distinguished at first sight from that of other viscera; consisting of a parenchyma well known in colour, and delicate in texture,‡ supplied with numerous nerves§ and lymphatics (most remarkable on the surface);‖ with bili-

* Eustachii. tab. XI. fig. 3. 4. Ruysch. *Thes. Anat.* IX. tab. IV. Santorini. *Tab. Posth.* XI.

† J. Bleuland's *Icon hepatis fœtus octimestris.* Traj. ad Rhen. 1789. 4to.

F. L. B. Ebeling *De Pulmonum cum hepate Antagonismo.* Goett. 1806, 8vo.

‡ In which, however, Autenreith discovers two substances; the one medullary and the other cortical. *Archiv. für die Physiol.* T. VII. p. 299.

§ Walter. tab. IV.

‖ Maur. v. Reverhorst. *De motu bilis circulari ejusque morbis,* tab. I. fig. 1. 2.

ferous ducts; and blood-vessels* from which the latter originate, both very numerous and in some instances very large, but of different descriptions, as we shall state particularly.

371. The first blood-vessel to be noticed is the *vena portarum,* whose dissimilarity from other veins, both in its nature and course, was formerly hinted at. (97) Its trunk is formed from the combination of most of the visceral veins belonging to the abdomen, is supported by a cellular sheath, called the capsule of Glisson,† and on entering the liver, is divided into branches which are subdivided more and more as they penetrate into the substance of the organ, till they become extremely minute and spread over every part. On this account, Galen compared this system to a tree whose roots were dispersed in the abdomen and its branches fixed in the liver.‡

372. The other kind of blood-vessels belonging to the liver, are branches of the *hepatic artery,* which arises from the cœliac, is much inferior to the vena portæ in size and the number of its divisions, but spreads by very minute ramifications throughout the substance of the liver.

373. The extreme divisions of these two vessels termi-

Ruysch's *Ep. problemat.* v. tab. vi.

Werner and Feller's *Descriptio vasor. lacteor. atque lymphaticor.* Fascic. i. tab. iii. et iv. although Fr. Aug. Walter finds fault with these plates. *Annot. Academic.* p. 191, sq.

Mascagni, tab. xvii. xviii.

* Haller's *Icones Anat.* Fascic. ii. tab. iii.

† Glisson's *Anatomia Hepatis.* p. 305. sq. 1659.

‡ *De Venarum Arteriarumque dissectione.* p. 109. Opera. Basil. 1562. cl. i.

nate in true veins, which unite into large venous trunks running to the *vena cava inferior*.

374. These extreme divisions are inconceivably minute, and collected into very small glomerules,* which deceived Malpighi into the belief that they were glandular acini, hexagonal, hollow, and secretory.†

375. From these glomerules arise the *pori biliarii*, very delicate ducts, secreting the bile from the blood, and discharging it from the liver through the common hepatic duct, which is formed from their union.

376. It has been disputed whether the bile is produced from arterial or venous blood.

Although the former opinion ‡ is countenanced by the analogy of the other secretions which depend upon arterial blood, nevertheless more accurate investigation proves that the greater part, if not the whole, of the biliary secretion, is venous.

With respect to arguments derived from analogy, the vena portæ, resembling arteries in its distribution, may likewise bear a resemblance to them in function. Besides, the liver is but analogous to the lungs, in which the great pulmonary vessels are destined for the function of the lungs, while the bronchial arteries are intended for their nourishment; and if we are not greatly mistaken, the use of the hepatic artery is similar. We would, however, by no means completely deny its importance in the secre-

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* Nest. Maximeow. Ambodick *De Hepate*. Argent. 1775, 4to.

† *De viscerum structura*. p. ii. Lond. 1669.

‡ This has lately found an advocate in Rich. Powel. *On the Bile and its Diseases*. Lond. 1801, 8vo.

tion of bile, but we must regard it as inconsiderable, adventitious, and not well established (A).

377. The *bile* flows slowly and regularly along the hepatic duct. The greater portion runs constantly through the ductus communis choledochus into the duodenum, but some passes from the hepatic duct into the *cystic duct*, and is received by the gall-bladder, where it remains for a short period, and acquires the name of *cystic bile.* *

378. The *gall-bladder* is an oblong sac, nearly pyriform, adhering to the concave surface of the liver, and consisting of three coats.

The *exterior*, completely covering it, derived from the peritonæum.

The *middle*, called nervous, as in the stomach, intestines, and urinary bladder, the source of its firmness and tone.

The *interior*,† somewhat like the inner coat of the stomach, (359) containing a net-work of innumerable blood-vessels, abundant in mucous glands,‡ and marked by

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* In cows and other brutes there are peculiar *hepato-cystic* ducts, which convey the bile directly from the liver to the gall-bladder. *Observ. anat. coll. privati Amstel.* P. 1. Ams. 1667, 12mo. p. 16, fig. 7. Also, Perrault's *Essays de Physique.* T. i. p. 339, tab. ii.

Some have inconsiderately allowed them also in the human subject: v. c. De Haen in his *Ratio med. cont.* P. 11. p. 46, et seq. tab. x. fig. 1.

Also Pitschell in his *Anat. und chirurg. Anmerk.* Dresd. 1784. 8vo. tab. i.

Consult among many, R. Forsten's *Quæst. select. physiolog.* Lugd. Batav. 1774. 4. to p. 22.

† Ruysch's *Epist. problem. quinta* Tab. v. fig. 3.

‡ Vicq-d'Azyr, in his *Œuvres.* T. v. p. 343.

rugæ,* which occasionally exhibit a beautifully cancellated reticulum.

379. Its cervix is conical, terminates in the cystic duct, is tortuous, and contains a few falciform valves.†

380. The bile which has passed into the gall-bladder is retained until, from the reclined or supine posture of the body, it flows down from it spontaneously, or is squeezed‡ out by the pressure of the neighbouring jejunum or ileum, or of the colon when distended by fæces.

The presence of stimuli in the duodenum may derive the bile in that direction.

The great contractility of the gall-bladder, proved by opening living animals and by pathological phenomena, (although it has not true irritability (301) probably assists the discharge of bile, especially when this fluid has, by retention, become very stimulating.

381. For the cystic bile, although very analogous to the hepatic, (377) becomes more concentrated, viscid, and bitter, by stagnation in the gall-bladder; the cause of which is, in all probability, the absorption of its more watery parts by the lymphatic vessels.§

382. Our attention must now be turned to the bile itself,—a very important fluid, respecting the nature and

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* Casp. Fr. Wolff in the *Act. Acad. Scient. Petropol.* 1779. l. ii.

† Caldani's *Osservaz. intorno alle Tartarughe.* Tab. ii. fig. 10; but especially Wolff, lately recommended, l. c. P. i. tab. vi. Also, Fr. Aug. Walter, l. c. tab. i.

‡ Caldani's *Institut. Physiolog.* p. 364, sq. Patav. 1778, 8vo.

§ Reverhorst, l. c. tab. ii. fig. 4.

Ruysch. l. c. tab. v. fig. 4

Werner and Feller, l. c. tab. ii. fig. 5.

Mascagni. tab. xviii.

use of which there has been for these thirty years more controversy than respecting any other fluid.

The cystic bile being more perfect and better calculated for examination, will supply our observations.

383. Bile taken from a fresh adult subject, is rather viscid, of a brownish green colour,* inodorous, and if compared with that of brutes, scarcely bitter.

384. Its constituent parts obtained by chemical analysis, are, besides a large proportion of water, albumen, resin, soda,† united partly with phosphoric, sulphurous, and muriatic acid, a small portion of phosphate of lime and iron, and a variable quantity of a remarkable and peculiar yellow matter.‡

385. The composition of the bile varies greatly both from the proportion of its parts, particularly of the albuminous and resinous, differing under different circumstances, and also from the addition, during morbid states, to the biliary secretion, of other constituents, especially of adipocerous substances, which give origin to most biliary calculi; for these consist either of it alone, or of it combined with the yellow substance just mentioned (B).

386. The nature of the bile is not saponaceous and capable of effecting a combination between water and oils, as Boerhaave supposed, but which opinion the excellent experiments of Schröder,§ who was formerly of this

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* On the variety of colour in the bile, consult Bordenave's *Analyse de la Bile*, in the *Mém. Présentés*, &c. T. vii. p. 611. 617.

† Joachim Ramm *De alcalina bilis natura.* Jen. 1786, 4to.

J. Fr. Straehl *De bilis natura.* Gotting. 1787, 8vo.

W. M. Richter's *Experimenta circa bilis naturam.* Erlang. 1788, 4to.

‡ Thenard in the *Mémoires de la Societé d'Arcueil.* T. i.

§ *Experimenta ad veriorem cysticæ bilis indolem explorandam capta.* Sect i. Gotting. 1764, 4to.

university, both confirmed and extended by other physiologists,* have disproved. It even decomposes a combination of those substances.†

387. The important and various use of the bile in chylification is self-evident.

In the first place, it gradually precipitates the fæces, and separates the milky chyle from the mixed and equable pultaceous chyme, while this is passing through the tract of the small intestines, after being propelled from the stomach into the duodenum and diluted by the pancreatic juice.‡

It separates itself into two portions, the one serous, the other resinous. The latter combines with the fæces, tinges them, and is discharged with them; the former is probably mixed with the chyle and carried back to the blood. (C)

The bile seems to act as a stimulus to the peristaltic motion§ of the intestines.

We shall omit other less probable uses assigned to the bile, viz. of exciting hunger by regurgitating into the stomach,--a circumstance which I think can scarcely happen during health.

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* It will be sufficient to quote a few of a large number.

Spielman *De natura bilis.* Argent. 1767, 4to.

Ger. Gysb. ten. Haaf *De bile cystica.* L. B. 1772, 4to.

G. Chr. Utendörfer's *Experim. de bile.* Argent. 1774, 4to.

Dav. Willink's *Consideratio bilis.* L. B. 1770, 8vo.

Seb. Goldwitz *Neue Vers. zu einer wahren Physiol. der Galle.* Bamberg. 1785, 8vo.

† Marherr's *Prelect. in Boerhavii institut.* Vol. i. p. 463, 478, 1785.

‡ Chr. L. Werner's (Præs Autenrieth) *Experimenta circa modum. quo chymus in chylum mutatur.* Tubing. 1800, 8vo.

§ C. Fordyce *On the digestion of food,* p. 70.

NOTES.

(A) Two instances have occurred in London, of the vena portæ running not to the liver, but immediately to the vena cava inferior. The bile must have been secreted entirely from the blood of the hepatic artery. One of these is described by Mr. Abernethy,* and the other is mentioned by Mr. Lawrence.†

(B) Berzelius‡ states, that bile contains alkali and salts in the same proportion as the blood; that no resin exists in it, but "a peculiar matter, of a bitter and afterwards somewhat sweet taste, which possesses characters in common with the fibrin, the colouring matter, and the albumen of the blood." This forms with an excess of acid, a perfectly resinous precipitate. What has been considered as albumen in the bile, Berzelius regards as the mucus of the gall-bladder.

Bile contains of

Water - - - - - - - - -	907.4
Biliary matter - - - - - -	80.0
Mucus of the gall bladder dissolved in the bile - } -	3.0
Alkalies and salts common to all secreted fluids - } -	9.6
	1000.0§

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* *Philos. Trans.* Vol. 83.

† *Medico-Chirurgic. Trans.* Vol. 5, p. 174.

‡ *Animal Chemistry*, p. 65.

§ *Med. Chirurg. Trans.* Vol. 3. p. 241.

(C) During the precipitation of the chyle and the decomposition of the bile, a gaseous product is usually evolved, and the mass becomes neutral, and traces *of an albuminous principle* commence, strongest at a certain distance from the pylorus, and gradually fainter in each direction. On mixing bile with chyme out of the body, a precipitation takes place, and the mixture becomes neutral; but the formation of an albuminous principle is doubtful, probably from the want of the pancreatic fluid.*

It is wonderful that in jaundice, when no bile is seen in the fæces, and Fordyce says even in artificial obstruction of the choledochus by ligature, nutrition continues. Life and health are said to continue after the removal of the organ next to be considered,—the spleen. We know little of the compensating resources of nature.

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* Dr Prout. *Annals of Med. & Surg.* Vol. 1. p. 143.

SECT. XXVI.

OF THE FUNCTION OF THE SPLEEN.

388. THE *Spleen** lies to the left side of the liver, and with it has considerable vascular communications; its figure is oblong;† it applies itself to the contiguous viscera, and is liable to great varieties in point of form, number, &c.‡

389. Its colour is livid, its texture singular, soft, easily lacerated, and therefore surrounded by two membranes, the interior of which is proper to the spleen, and the exterior derived from the omentum.

390. The situation and size of the spleen are no less various than its figure, and depend upon the degree of repletion of the stomach: for when the stomach is empty and lax, the spleen is turgid; when the stomach is full, the spleen being compressed is emptied.

It undergoes a continual but gentle and equable motion, dependent upon respiration, under the chief instrument of which—the diaphragm, it is immediately situated.

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* Ch. Drelincourt, the younger, has carefully collected and concisely related whatever was known up to his time, respecting the spleen, *De lienosis*, at the end of his father's Opuscula. Boerhaave's edition. p. 710. sq.

Also Chr. Lud. Roloff *De fabrica et functione lienis.* Frf. ad Viadr. 1750, 4to.

† Walter, tab. iii. G.

Mascagni, tab. xiv. P.

‡ See Sandifort in the *Natuur en genees-kundige Bibl.* Vol. ii, p. 345. sq.

391. Its texture was formerly supposed to be cellular, and compared to the corpora cavernosa of the penis. This opinion was proved to be erroneous by more careful examination of the human spleen,* which consists entirely of blood vessels, of enormous size in comparison with the bulk of the organ. They are in fact proportionably more considerable than in any other part of the body.

392. The experiments of Wintringham demonstrate the great tenuity and strength of the coats of the splenic artery. It is divided into an infinite number of twigs, the terminations of which resemble pulpy penicilli and give rise to the splenic veins, which gradually unite into large, loose, and easily dilatable trunks.

393. This immense congeries of blood vessels is connected and supported by a sparing cellular parenchyma, from which the absorbents arise. The trunks of these run along the lower surface of the spleen between the two coats just described.†

394. This loose structure of the spleen, easily becoming distended with blood, admirably confirms what we formerly remarked respecting the turgor of this organ,(390). The congestion and slow return of the splenic blood, if the nature of the neighbouring organs is also taken into consideralion, illustrates its peculiar properties, which may throw some light upon the function of this enigmatical viscus,—the source of so much controversy.

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* Lobstein's Dissertation, *nonnulla de Liene sistens*. Argent. 1774. 4to.

† The singular and rather paradoxical opinions of Hewson, without doubt, a very superior man, respecting the functions of the spleen, whose lymphatic vessels he regards as excretory ducts, may be found in his posthumous work entitled *Experimental Inquiries*. Third edition. London, 1777. 8vo. C. ii. S. xlv. sq. xcv. sq.

395. The splenic blood is very fluid, coagulates with great difficulty, separates the serum from the crassamentum imperfectly, and is of a livid dark colour, like the blood of the fœtus. These circumstances clearly demonstrate the abundance in it of carbonaceous matter; which is likewise proved indisputably by an easy experiment. Whenever we have exposed sections of a recent spleen to oxygen gas, they became of a very bright red, while the air losing its oxygen, became impregnated with carbon.

396. But since the spleen is the only organ of that description quite destitute of an excretory duct, excepting its veins which run ultimately to the liver, its function is probably subservient to that of the liver. This opinion has appeared strengthened by the observation, that in animals deprived of their spleen,—an experiment frequently made from the most remote period,* the cystic bile is sometimes found pale and inert.

397. At least twenty hypotheses have been framed respecting the use of the spleen. Two more have been lately advanced, both supposing a connection between the spleen and *stomach*, but the one† regarding the spleen as a diverticulum to the blood destined to form the *gastric juice*; (A) the other,‡ supported by excellent arguments and experiments, making the spleen receive a great portion of our *drink* from the *cardiac* extremity of the stomach, so that these can pass through a short way, hitherto unknown, from the stomach to the spleen, and thus into

* J. H. Schulze *De splene canibus exciso.* Hol. 1735, 4to.

† Vinc. Malacarne in the *Memorie della soc. italiana.* T. viii. P. 1. p. 233.

A. Moreschi *Del vero e primario uso della milza.* Milan. 1803, 8vo.

‡ Ever. Home in the *Philos. Trans.* 1808.

the mass of blood. The latter hypothesis, if a few objections were removed,* would be much the most plausible of any hitherto constructed. (B)

NOTES.

(A) This opinion was proposed a century ago, by Dr. Stukely, Fellow of the Royal College of Physicians London.†

(B) Mr. Home, having passed a ligature around the pyloric extremity of the stomach of a dog, injected into it a solution of rhubarb; and, on killing the animal some hours afterwards, none of the absorbents of the stomach were found distended, nor could any trace of rhubarb be detected in the liver, but evident traces existed in the spleen and the urine.

* For instance, the size of the spleen in those warm blooded animals which never drink, or in bisulcous animals whose spleen adheres to the ruminant stomach receiving the crude food only, but never the drink, which is prevented from entering it by the well-known mechanism of a semicanal running from the œsophagus to the omasum.

† *Of the Spleen, its description and history, uses and diseases, particularly the vapors with their remedy. Being a lecture read at the Royal College of Physicians*, London, 1722. By Wm. Stukely, M. D. C. M. L. and S. R. S. folio. Considering the spleen to consist "entirely of complications and inoculations of arteries, veins, nerves, and a muscular net-work of fibrillæ, he supposed it propelled the blood from its own vessels into those of the stomach, when this organ required a larger supply during digestion, p. 37.

Dr. Haighton *(Lectures at Guy's Hospital)*, and Mr. Saumarez' *(New System of Physiology)* explain its operation in a very different manner. When the stomach is full, the compression experienced by the spleen impedes its circulation, and the blood makes its way the more copiously into the arteries of the stomach and liver.

SECT. XXVII.

OF THE FUNCTION OF THE OMENTUM.

398. THE omentum gastrocolicum or magnum,* (to distinguish it from the parvum or hepato-gastricum),† is a peculiar process of peritonæum, arising immediately from the peritonæum of the stomach.

399. Although there are innumerable continuations of the peritonæum in the abdomen, and every abdominal viscus is so covered by it, that, on opening the abdomen, nothing is found destitute of that membrane; this covering, nevertheless, is afforded in different ways, which may be reduced to classes.

Over some the peritonæum is merely extended, or it affords to them only a partial covering, as with respect to the kidneys, rectum, urinary bladder, and in some measure to the pancreas and gall-bladder.

To some which project into the cavity of the abdomen, although adhering to its parietes, it affords a covering for the greater part of their surface; v. c. to the liver, spleen, stomach, uterus, and the testes of the very young fœtus.

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* Eustachius, tab. ix.

Haller's *Icones. anat.* fasc. i. tab. iv. K. M. and the Appendix Colica, which he himself investigated in 1740. ib. R.

Rob. Steph. Henry's *Descript. omenti c. icone nova.* Hafn. 1748, 4to.

† Eustachius, tab. x. fig. 1. G. H.

Haller. l. c. Q.

The intestinal tube, with the exception of the rectum, projects so much into the cavity of the abdomen, that it is, as it were, suspended in loose processes of the peritonæum, called mesentery and mesocolon : the broad ligaments of the uterus are similar to these.

400. The longest and most remarkable process of peritonæum, is the *omentum*,—a large, empty, delicate, sac, hanging from the large curvature of the stomach, extended over the greater part of the small intestines, applying itself closely to their convolutions, and in some measure insinuating itself into their interstices.

401. Besides the blood vessels seen upon the omentum, it is marked by fatty striæ or bands, every where reticulated (whence the common appellation of this membrane), which in corpulent persons increase occasionally to a large and even dangerous size, and by means of which the whole omentum is lubricated by an adipose halitus.

402. On the latter circumstance depends the use commonly ascribed to the omentum,—of lubricating the intestines and assisting their continual movements: this also appears the use of those analogous small bursæ which are found* in such numbers about the rectum† and colon.‡ The omentum also prevents the adhesion of the intestines to the peritonæum, and the consequent impediment to the functions of the primæ viæ.

403. There is another two-fold office attributed with

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* I have lately seen similar appendices on the peritonæal covering of an uterus unimpregnated, but which had formerly been pregnant.

† Walter, tab. ii. *m. m. m.*

‡ Bidloo. *Anatomia hum. corporis.* tab. xxxix. fig. 6. C. C. C. D. D. D.

great probability to the omentum;* viz. that of facilitating the dilatation of the viscera to which it is contiguous, and of acting as a diverticulum to their blood during their state of vacuity.

404. If we reflect on the singular structure of the omentum parvum or hepato-gastricum especially, we may be inclined to believe that there is another and principal office attaching to it, unknown at present, and discoverable by comparative anatomy.

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* v. Chaussier in the *Mémoires de l'Acad. de Dijon*, 1784, Semestr. ii. p. 95.

SECT. XXVIII.

OF THE FUNCTION OF THE INTESTINES.

405. THE intestinal tube, over which the omentum is extended, and which receives the chyme to elaborate it farther (362, 363) and separate the chyle from the fæces, is divided into two principal portions,—the small and large intestines, of whose functions we shall speak separately.

406. The small* intestines are again divided into three: the duodenum, jejunum, and ileum.

The first is named from its usual length.

The second from generally appearing collapsed and empty.

The third from its convolutions: it is the longest of the three, fuller, and, as it were, inflated, and sometimes resembling the large intestines by the appearance of bullæ.

407. The coats of the small intestines correspond with those of the stomach (354).

The *external* is derived from the mesentery.

The *muscular* consists of two orders of fibres: the one longitudinal, interrupted, external, and found especially

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* Chr. Bernh. Albinus. *Specimen anat. exhibens novam tenuium hominis intestinor descriptionem.* L. B. 1724. 8vo.

about the part opposite the mesentery; the other, annular and falciform, possessing the power of narrowing the canal, while the former shortens it. Upon both depends the very great and permanent irritability of the intestines, formerly mentioned (300).

The *nervous* coat is condensed cellular membrane, easily reduced by handling, or more particularly by inflation, into a spumous tela;* in it the intestinal blood-vessels run to the mesenteric † in a beautifully arborescent form;‡ the intestines, no less than the stomach, are indebted to it for their tenacity and strength.

The interior, lined by its delicate epithelium, and deserving the name of *villous* in the small intestines more than in any other part of the canal, forms, in conjunction with the inner surface of the former coat, here and there, undulated ridges and rugous plicæ, which, in dried and inflated intestines, resemble the edge of a scythe, and are termed the valvulæ conniventes, or Kerkringhianæ.§

408. The *villi*, which are innumerable ‖ upon the inner surface of the intestines, and whose beautiful and minute vascular structure was first carefully investigated, though described with exaggeration, by Lieberkühm,** may be,

* B. S. Albinus *Annotat. Acad.* L. ii. tab. iv. fig. 1, 2.

† Eustachius, tab. xxvii. fig. 2. 4.

‡ B. S. Albinus *Dissert. de arteriis et venis intestin. hominis*, with coloured plates. L. B. 1736, 4to. Also his *Annotat. acad.* L. iii. tab. i. ii.

§ Kerkring's *Spicilegium anatomicum*, tab. xiv. fig. 1, 2.

‖ He estimated their number, in the small intestines of an adult, to be about 500,000.

** *De fabrica et actione villorum intestinor. tenuium hominis*, L. B. 1745, 4to.

perhaps, compared, while destitute of chyle, to little loose pendulous bags, internally soft and spongy; but when distended with chyle, they have the appearance of a morel.

409. The base of these villi is surrounded by innumerable *glandular follicles*, adhering chiefly to the nervous coat, and opening into the intestinal canal by a very small orifice, through which they discharge the mucus which lines the whole tract of the intestines.

These are distinguished into three orders. The Brunnerian, largest, distinct, found in most abundance in tha part of the duodenum which is contiguous to the pylorus.* The Peyerian, smaller, aggregated, found chiefly at the termination of the small intestines, about the valve of the colon.† Lastly, the Lieberkühnian, the smallest, said to be distributed in the proportion of about eight to each villus.‡ The two former orders are so inconstant, that I am inclined to consider the view given of them in the plates alluded to, as morbid; § for I have more than once been unable to discover the slightest trace of fungous papillæ with a single pore, in the small intestines

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J. Bleuland's *Descriptio vasculorum intestinorum tenuium hominis* Ultraj. 1797. 4to.

R. A. Hedwig's *Disquisitio ampullarum Lieburkühnii*, Lips. 4to.

C. A. Rudolph's *Anatomisch-physiologische Abhandlungen*. Berlin. 1802. 8vo. p. 39.

* J. Conr. a Brunn's *Glandulæ duodeni pancreas secundarium*, Frf. 1715. 4to. fig. 1.

† J. Conr. Peyer *De Glandulis intestinorum*. Scafhuf. 1677. 8vo. especially fig. 3.

‡ Lieberkühn. l. c. p 17, tab. iii.

§ The celebrated Rudolph thinks differently, l. c. p. 212.

of healthy adults; while, on the contrary, in *aphthous* subjects, I have found nearly the whole intestinal tube beset with them in infinite numbers, both solitary and aggregated.*

410. As the gastric juice is poured into the stomach, so an *enteric* or *intestinal fluid* is poured into the small intestines, demonstrated, among other ways, by the common experiment, first, I believe, instituted by Pechlin.† It is probably of a nature similar to the gastric liquor, but an accurate investigation of it is a physiological desideratum. I can say nothing respecting its quantity, but the estimation of Haller is certainly exaggerated,—at eight pounds in the twenty-four hours.

411. The intestines agree with the stomach in this particular, that they have a similar, and indeed a more unquestionable, or, at least, a more lively, *peristaltic action*,‡ which occurs principally when the chymous pulp enters them. This it agitates by an undulatory constriction of different parts of the canal, and propels from the duodenum towards the large intestines. Although the existence of an antiperistaltic motion, causing a retrograde course to their contents, cannot be disproved, it is in health much weaker, and less common and important than the former.

412. By these moving powers and by these solvents which are afforded by means of secretion, the chyme

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* These intestinal *aphthæ* exactly resemble those tubercles, which Sheldon (whom we shall presently quote) exhibits as small ampullæ full of chyle. Tab. i.

† *De purgantium medicamentor. facultat.* p. 509, tab. iv.

‡ Benj. Schwartz *De vomitu et motu intestinorum.* L. B. 1745, 4to. J. Foelix *De motu peristaltico intestinorum.* Trevir. 1750, 4to.

undergoes remarkable changes.* In the jejunum it becomes a more liquid pulp, equally mixed, of a grey colour, and acidulous odour: in the ileum, it begins to separate into two parts,—into the fæces, of a pale yellowish, brown colour,† and nauseous smell; and the genuine chyle, swimming upon the former, extracted from the chyme, separated by the bile from the fæces, and des-

* Consult the excellent observations and experiments of A. E. Ferd. Emmert, in the *Archiv für die Physiologie*. T. viii. p. 145.

† We have formerly (387) remarked, that the bilious colour of the fæces arose from the excrementitious part of the bile. In the jejunum, the bile being undecomposed and mixed with the equable pulp in the intestines, and consequently diffused and diluted, cannot exhibit its true colour. But after its separation into two parts, the excrementitious portion, mixed with the precipitated fæces, and, as it were, again concentrated, now discovers its original colour, and imparts it to the fæces.

C. F. Wolff (in the *Act. Petropolit.* 1779 P. ii. p. 245,), entertains a different opinion in regard to the cause of the bilious colour of the fæces contained in the ileum. He conceives that an addition of bile occurs near the extremity of the jejunum, *by exhaling from the gall bladder and penetrating this part of the intestine and its contents.* This bile differing, perhaps, in its nature, from the bile of the choledochus, and not being mixed with the fæces as the latter is with the chyme, retains its colour through all the remaining tract of the intestines and continues pure bile.

But, besides our being able easily to explain why this colour is not observable before the decomposition of the chyme and bile, it is extremely doubtful whether, during life and health, any exhalation can occur from the gall bladder and penetrate the intestine. For in subjects recent and scarcely cold, the intestines are but slightly tinctured with bile, although they are dyed with it very deeply and extensively after a lapse of some hours or days, i. e. after the coats of the gall bladder have lost their tone and become incapable of preventing the transudation of their contents.

tined for absorption by the lacteal vessels, as we shall find in the next section (A). At present, we shall enquire what course is taken by the fæces.

413. These, after becoming more and more inspissated in their long course through the ileum, have to overcome the valve of the colon and pass into the large intestines. To facilitate this, the extremity of the ileum is lubricated very abundantly by mucus.

414. The *valve of the colon,** or, as it may deservedly be termed after its discoverer, the valve of Fallopius,† is a short process or continuation of the part of the ileum penetrating into the cavity of the large intestine, which

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* Haller *De valvula coli.* Gotting. 1742. 4to. reprinted in his *Oper. minor.* T. i. p. 580, sq.

T. Mich. Röderer *De valvula coli.* Argent. 1768. 4to.

† The various opinions respecting the discoverer of this remarkable valve are well known. Haller's *Elementa,* t. vii. P. 1. page 142, may be consulted on this point.

In the mean time, I am certain that long before the period at which its discovery is in general dated, it was accurately known to that immortal anatomist Gabr. Fallopius. In our university library there is a manuscript of Fallopius, containing, among other things, his *anatomy of the monkey,* in which is an account of the structure and use of the valve of the colon, delivered in a public demonstration at Padua, Feb. 2, 1553, in the following words: "*The use of the cæcum in the monkey, is to prevent the regurgitation of the food during progression on all fours. This is proved by the circumstance of water or air thrown into the rectum, reaching the cæcum, but not passing beyond the large intestines. But, if thrown in from above, it passes into them. The reason is this,—at the insertion of the ileum are two folds, which are compressed by inflation and repletion, as occurs in the heart, and prevent retrogression; wherefore, in man, clysters cannot pass and be rejected through the mouth, unless in a weak and diseased state of the intestines.*"

surrounds the former. Its external lips, while a neighbouring fold of the large intestine at the same time projects considerably, are constituted* not like other similar folds, merely of the interior and nervous coats, but of fibres from the muscular coat. Hence it performs the double office of preventing too great a quantity of fæces from passing from the small into the large intestines, and of preventing regurgitation from the latter.

415. The large intestines, divided like the small into three parts, commence by the *cæcum* (which has a *vermiform process*, whose use in man is unknown)† and afford a very ample receptacle, in which the fæces may be collected and retained till the period of their discharge arrives.

416. They exceed the small intestines in thickness and strength, as well as in capacity. The muscular coat has this peculiarity,—that its longitudinal fibres, excepting at the extremity of the rectum, are collected into three bands, called ligaments of the colon;‡ and the intestines themselves are divided into a kind of prominent cells. The inner coat is not so beautifully flocculent as in the small intestines, but more similar to that of the stomach.

417. Their peristaltic motion is much fainter than that of the small intestines. On the other hand, they experi-

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* A view of a recent and entire valve is exhibited by B. S. Albinus in his *Annotat. Academ.* L. iii. tab. v. fig. 1. and overcharged by inflation and drying, in Santorini's Posthumous Tables, xiv. fig. 12.

† Lieberkühn. *De valvula coli et usu processus vermicularis.* L. B. 1739. 4to.

J. Vosse *De intestino cæco ejusque appendice vermiformi.* Gotting. 1749. 4to.

‡ Eustachius. tab. x. fig. 2. 4. 5.

ence to a greater degree the pressure of the abdominal parietes, to which the whole length of the *colon* is contiguous.

418. They gently propel the fæces into the *rectum*, which thus becomes internally stimulated to discharge its contents. This is facilitated by the absence of transverse rugæ, and especially by the great quantity of mucus at the extremity of the bowels.

419. The discharge of fæces is principally effected by the pressure of the abdomen downwards, overcoming the resistance of the os coccygis and of both sphincters, the inner of which is a remarkable bundle of circular fibres; and the outer, a truly cutaneous muscle. After the excretion, the effort of the abdomen having ceased, the levator ani retracts the intestine, which is again closed by its sphincter.*

NOTE.

(A.) A great part of the chyle is generally formed and absorbed before the digested mass reaches the ileum. See *Annals of Med. and Surgery*, Vol. i. p. 144. On arriving in the large intestines, the mass undergoes fresh changes, at present unexplained, and is converted into excrement. Here it is that the true *succus entericus* must be poured forth.

* All these parts may be seen as they exist in each sex, in Santorini's Posth. Tables, xvi. and xvii.

SECT. XXIX.

OF THE FUNCTION OF THE ABSORBENT VESSELS.*

420. THE chyle which we left in the ileum just separated from the fæces, must evidently be a mixture of different fluids. The proportion derived from the *secretions*, —the saliva, bile, the gastric, pancreatic, and enteric fluids, surpasses, without the least doubt, that which is derived from the aliment, although it cannot be accurately ascertained. Hence must be obtained the solution of the problem,—how injesta of such various kinds can be converted into the chyle—a fluid constantly of the same appearance, homogeneous, and of an animal nature.

421. The course of the chyle from the intestines to the blood, is through a part of the absorbent system, which we have hitherto only hinted at, but shall now speak of particularly. It is divided into four parts,—lacteal and lymphatic vessels, conglobate glands, and the thoracic duct. Each of these will now fall under consideration.

422. It is certain that the lacteals originate among the villi of the internal coat of the intestines; but whether they are an immediate continuation of these villi, or merely connected with them by a cellular medium, admits a question. I myself have never been able to trace them

* A very copious list of writers upon the absorbents will be found in Sömmering's work *De morbis vasorum absorbentium corporis humani.* Francof. 1795. 8vo.

so far as to discover their immediate connections with the villi, but they appear to arise here and there in the coats of the intestines, by a conspicuous trunk, and we may conjecture that they take up the chyle from the cellular structure into which it is first drawn by the villi. This I have in fact observed repeatedly in puppies, after making them swallow a solution of indigo, according to the celebrated experiment of Lister,* an hour or two before opening them alive.

423. The trunks just mentioned run some inches along the surface of the intestines, under the external coat, sometimes meandering in an angular course, before they reach the mesentery.

424. In their course through the mesentery they run into the mesenteric glands, of which there are two series. The one, nearer the intestines, dispersed, small, and resembling beans in shape; the other, nearer the receptaculum chyli, large, and aggregated.

425. Both appear nothing more than closely-compacted collections of lacteals, interwoven with innumerable blood-vessels,† and retarding the course of the chyle; to the end, perhaps, that it may be more intimately and perfectly assimilated to an animal nature, previously to its entrance into the thoracic duct and its mixture with the blood.

426. It has been inquired whether lacteals exist also in the large intestines, and their existence has been contended for from the effects of particular injections, nutrient, inebriating, &c. and also by the circumstance that the

* *Philos. Trans.* No. 143, compared with No. 275.

† Boerhaave and Ruysch's *De fabrica glandularum opusculum*. L.B. 1722. 4to. p. 81.

fæces, if retained for any length of time, become hard and dry. Although these arguments do not demonstrate the absorption of genuine chyle below the valve of Fallopius, nevertheless it is rendered probable by the visible existence of an abundance of lymphatics in the large intestines,* having the same structure and function with the lacteals; for these absorb lymph from the intestines,† during the absence of chyle.

But the very different structure of the internal coat of the large intestines from that of the villous coat of the small, strongly argues that they are not naturally intended to absorb chyle.

427. There is another question more important and difficult of solution, whether all the chyle absorbed from the small intestines, passes through the thoracic duct, or whether some enters the blood by other more secret passages?

The latter opinion rests upon very unstable arguments. Thus the assertion of Ruysch, that the mesenteric glands become, in advanced life, indurated and unfit for continuing their functions, was long since disproved; and affections of these glands, swellings, &c. are improperly called obstructions,‡ as the glands remain pervious, readily allowing a passage to quicksilver. The well-known phenomenon of tepid water injected after death into the mesenteric veins, passing into the cavity of the intestines, has little weight with me in regard to a function which occurs during life; and much less weight can be

* Mascagni, Tab. xvi.

† See Nuck's *De Inventis novis ep. Anatomica*, p. 146, sq.

‡ v. J. Rezia's *Specim. Observat. Anatomicar. et Pathologicar.* Ticini. 1784. 8vo. p. 18.

allowed to the bifurcated brass tube invented by Lieberkühn to prove the existence of these passages. The assertion, that chyle has been seen in the mesentric veins,* requires farther investigation and proof; so that I cannot believe that they carry any thing more than blood, very carbonized, and destined for the formation of bile.†

428. The ultimate trunks of the lacteals, arising, like the other lymphatics, from the combination of a great number of small twigs,‡ unite into the *receptaculum* or *cisterna chyli*,—the appellation by which the lower and larger part of the *thoracic* or PECQUETIAN *duct* is distinguished.

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* Werner and Feller, l. c. p. 12, sq.

† There is a beautiful experiment, which seems, at first sight, to favor the existence of these secret passages, and for which I am indebted to the eminent L. M. A. Caldani. In a lamb or kid, after hearty feeding, a ligature is placed upon the vein corresponding with our left subclavian, and another, particularly tight, upon the mesentery, at its origin near the lumbar vertebræ. The lacteals and lymphatics, between the ligatures, become very evident; and likewise the lymphatics ascending from the hind legs. At first, the lacteals between the intestines and constricted mesentary swell, but they soon subside and disappear.

But this singular phenomenon appears to me not owing so much to any clandestine passages for the chyle, as to a retrograde motion of the chyle into the intestines; the valves, under these circumstances, not offering sufficient opposition. Vide B. N. Gottl. Schreger's *Fragmenta Anatomica et Physiologica*. Fasc. 1. Lips. 1791, 4to. p. 26.

Flor. Caldani, in his *Riflessioni sopra alcuni punti di un nuovo sistema de' vasi assorbenti*, &c. Padua. 1792. 8vo. p. 58.

And his uncle, commended above, L. M. A. Caldani, in his Commentary to be found in the *Memorie lette nell' Acad. di Padova*. 1804. 4to.

‡ Sheldon, l. c. Tab. v.

429. This duct is* a membranous canal, slender, strong, more or less tortuous, subject to great varieties in its course and division,† destitute of muscular fibre and nerves, and possessing here and there valves. At about the lowest cervical vertebra, after passing the subclavian vein, it turns back again,‡ and is inserted into it, being furnished with a peculiar valve at the point of insertion.

430. The motion of the chyle throughout its course is to be ascribed to the contractility of its containing vessels, to their valves, and the vis-a-tergo.

431. The use of the valve placed at the opening of the thoracic duct, is probably not so much to prevent the influx of blood, as to modify the entrance of the chyle into the vein,—to cause it to enter by drops.

By this contrivance, such a portion of fresh chyle cannot have access to the blood as would stimulate the cavities of the heart too violently, and be imperfectly and difficultly assimilated; for fresh chyle consists of very heterogeneous elements, brought not only from the primæ viæ by the lacteals, but from every part of the body by the lymphatics.

432. These *lymphatics*,§ which constitute the third part

* See Haller's *Observationes de ductu thoracico in theatro Gottingensi factæ*. Gotting. 1741, 4to.

B. S. Albinus' *Tabula vasis chyliferi*, L. B. 1757, large folio. Mascagni. tab. xix.

† v. J. C. Bohl's *viæ lacteæ, c. h. historia naturalis*. Regiom. 1741, 4to.

Sömmering in the *Commentat. Soc. Scient. Gottingens*, T. xiii. p. iii.

‡ v. Haller's *Opera Minora*. Vol. 1, Tab. xii.

§ Consult among others already and hereafter quoted. J. F. Meckel, *De vasis lymphaticis glandulisque conglobatis*. Berol. 1757. 4to. And the celebrated Al. Monro, filius, *De venis lymphaticis valvulosis*, ib. at the same time. 8vo.

of the absorbent system, and resemble the lacteals in structure and function, are much more, and perhaps, indeed, universally, diffused.* They arise principally from the mucous web, which we therefore called the grand bond of connection between the sanguiferous and absorbing system (27); but in great numbers likewise from the external common integuments, from the fauces and œsophagus (330), the pleura and peritonæum, and from the thoracic and abdominal viscera.†

433. Their origin is similar to that of the lacteals in the intestines, so that the radicle of each lymphatic absorbs the fluid from the neighbouring cellular membrane, as from its territory, and propels it onwards.

434. The lymphatics have double valves, set more or less thickly in different parts; they all enter conglobate glands; those which are contiguous to each other, anastomose here and there; and those found on the surface of certain viscera, as the lungs, liver, &c. form a most beautiful network.

435. Besides other assistances to their functions, evident from what has already been said, no inconsiderable assistance is derived from the combination of great strength with thinness in their coats, by which they are enabled to support a heavy column of quicksilver. In the limbs, especially, the motion of the muscles pressing them on every side, is highly useful in increasing their power.

436. But their principal action, by which they take up fluids more or less rapidly, eagerly absorbing some, and

* W. Hunter's *Medical Commentaries*, P. i. p. 5. sq.

† Mascagni, Tab. i. ii. iii.

T. Gottl. Haase, *De vasis cutis et intestinorum absorbentibus*, &c. Lips. 1786, fol. tab. i.

absolutely rejecting others,* depends upon the peculiar modification of their vitality, and is ascribed by the very acute Brugmans to a certain *vita propria.* (42)†

437. The far greater part of these lymphatics terminate in the thoracic duct; except, however, those of the right arm, the right side of the neck, the right lung, and the right portion of the diaphragm and liver, which terminate in the subclavian vein of the same side.

438. From the universal existence of the lymphatics, and especially from the great numbers on the surface, capable of absorbing fluids from without, the heterogeneous nature of the lymph must be obvious; and this is further proved by accurately examining it in different parts of a subject; v. c. that contained in the hepatic or splenic lymphatics is perfectly different from that in the uterine.

439. We will enumerate the principal fluids which are continually absorbed during health, to say nothing of many different kinds of substances taken up during disease. There is, besides the chyle separated from the fæces in the small intestines, the halitus of the cavities properly so called, especially that of the fauces and the whole mucous web, the fat, the more watery part of those secreted fluids which are retained for some time in their

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* On this remarkable difference consult T. Fr. Lucr. Albrecht's *Commentatio* (honoured with the Royal Prize) *in qua proponitur recensus eorum alimentor. et medicaminum quibus sive tubo alimentario sint ingesta, sive communibus corporis integumentis applicata, ingressus in systema vasor. sanguifer. aut concessus a natura, aut negatus sit.* Gotting. 1806, 4to.

† Conr. Ger. Ontyd. (Præside Seb. Just. Brugmans) *De Causa absorptionis per vasa lymphatica*, Lug. Bat. 1795. 8vo. p. 45.

ducts, v. c. of the milk, semen, bile, &c. and not a small portion of the fluids in contact with the surface.*

440. The solids, after performing their purpose in the economy, insensibly melt away and are absorbed, as is proved by the absorption of the greater part of the thymus gland during infancy, of the roots of the first teeth, and of the alveoli after the second teeth have fallen out. The constant change of the whole osseous system, arising from the insensible renovation of the bony matter, of which we have treated elsewhere professedly,† may also be adduced.

441. It is therefore evident, since so great a variety of matter is absorbed, and at the same time nothing crude or improper allowed to enter the blood, that there is a necessity for some peculiar medium for previously sub-acting and assimilating the various substances.

442. It appears to be the chief office of the *conglobate glands*, which constitute the last part of the absorbent system, to prevent the ill effects, upon the heart, of the improper admixture of crude fluid ‡ with the blood, by

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* Consult among others, Valer. Lud. Brera's *Anatripsologia*, fourth edition. Par. 1799. 11 vols. 8vo. A. J. Chrestien, *De la methode iatraliptice.* Montpell. 1803. 8vo.

† Decade 1. of my collection of the crania of different nations, p. 27.

‡ If we consider the winding course which nature has provided for the purpose of changing and assimilating the absorbed fluids previously to their admixture with the blood; and, on the other hand, the dreadful symptoms, such as palpitation, convulsions, &c. which ensue upon the *artificial infusion* of a minute portion of any mild fluid into the blood, we shall be thoroughly convinced that no absorption of heterogeneous fluid takes place by the *veins, excepting that of the blood itself* (v. e. in the erection of some parts, in the placenta, &c.), and that those absorptions which Haller endeavours to prove to be accomplished by the veins, do really take place by means of the lymphatic system. *De c. h. Funct.* V. i. p. 281 & seq.

assimilating the various fluids, particularly those absorbed by the skin, more and more to an animal nature, by retarding their motion, and perhaps also by superadding to them some fresh secreted fluid. (A)

443. As to the rest of those glands dispersed generally through the body, and aggregated here and there, as in the groin and axillæ, they are perfectly similar to those found in the mesentery, consisting, like them, in a great measure, of convoluted absorbent vessels, supplied with an immense number of blood vessels, and liable to the same diseases.*

NOTE.

(A) Although some albumen is discovered actually in the duodenum, and some fibrin in the first lacteals, the chyle is found to contain more and more of these substances, in proportion to its progress towards the left subclavian vein. The chyle contains a certain fatty matter, which is considered as *incipient albumen,* and in proportion as this decreases, does the quantity of fibrin and albumen increase. *Annals of Med. and Surgery.* Vol. i. p. 144.

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* Nuck's *Adenographia Curiosa.* L. B. 1696, 8vo.

SECT. XXX.

OF SANGUIFICATION.

444. There is scarcely occasion to remark that we employ the term Sanguification to denote the assimilation of the chyle to the blood, and the successive reparation, by means of the *former*, of the successive loss sustained by the *latter*.

445. The division of all our fluids into three classes (45), *crude*, *sanguineous* and *secreted*, turns upon this; that the middle class contains the stream of the vital fluid itself, from which the numerous secreted fluids are perpetually withdrawn, and to which, on the other hand, there is a constant afflux of chyle and lymph from the absorbent system.

446. But since the blood is a peculiar fluid, *sui generis*, without its fellow in nature, various assistances and media are evidently requisite to subact and assimilate the heterogeneous and foreign fluids which pass to it from the thoracic duct.

447. This is, in the first place, especially in the mesenteric and other conglobate glands, favoured by those windings, mentioned formerly, of the lacteals and lymphatics, which are, at the same time, gradually more impregnated, as it were, with an animal nature.

448. We must also take into consideration, that a great part of the lymph which enters the left subclavian after its

admixture with the intestinal chyle in the thoracic duct, has been derived from the substance of the viscera and other soft parts, formerly secreted from the blood, and, therefore, already imbued with an animal nature, and easily, without doubt, again miscible with the mass of blood, to which it does but return.

449. Something is contributed by the slow and almost stillatitious manner in which the chyle drops into the blood through the last valve of the thoracic duct, these very minute portions becoming the more intimately combined with the blood.

450. The heart, too, by means of the remarkable papillary muscles of the ventricles, agitates and mingles the blood just impregnated with fresh chyle.

451. The great importance of the lungs which receive the blood immediately after its addition of fresh chyle, and also of respiration, in the business of assimilation,* will be evident on considering the extraordinary vascularity of those organs (14), and their constant and regular motion.

452. The remaining part of sanguification is accom plished by the general circulation and the powers which assist it, particularly by muscular motion, &c.

453. Although so many means are provided for the combination of the chyle with the blood, and although the constituents of the chyle somewhat resemble those of this fluid; nevertheless, it is commonly asserted, that many hours are required for the complete change of the colour

* Especially, according to the opinion of Cuvier, in the conversion of the chyle into the lymphatic or fibrous part of the blood. *Leçons d'Anatomie Comparée.* T. i. p. 91. T. iv. p. 304. Thomson's *System of Chemistry.* V. iv. p. 497. Bostock's work, recommended above, in the chapter on *Respiration.*

of the chyle and its assimilation. Besides other arguments in favour of this assertion, the pathological fact is urged, that chyle is frequently seen in blood drawn many hours after digestion. I myself have witnessed this appearance in cases where the blood too evidently bore an inflammatory disposition, to use a common phrase; but I am persuaded that no inference can be hence drawn, in regard to the healthy state, which alone is the object of physiology.

SECT. XXXI.

OF NUTRITION.

454. Besides the function of the blood formerly investigated—of distributing oxygen through the system and removing carbon, its principal use is to afford nourishment to the body in general, and to the secreting organs the peculiar fluids which they possess the power of deriving from it. Nutrition shall be first examined.

455. *Nutrition* is the grandest gift of nature, and the common and highest prerogative of the animal and vegetable kingdoms, by which these, beyond all measure, surpass, even at first sight, all human machines and automats. Upon these no artist can bestow the faculty, not to say of increasing and of coming to perfection, but even of existing independently and repairing the incessant losses incurred from friction.*

456. By the nutritive faculty of the body, its greatest and most admirable functions are performed; by it we grow from the first of our formation and arrive at manhood; and by it are remedied the destruction and con-

* "Nutrition, in fact, appears to be a continued generation," according to the old observation of the very ingenious Ent. See his work, already recommended, (290 note.)

sumption which incessantly occur in our system during life.*

457. Respecting the nature of this consumption, it has been greatly disputed, whether it affects the solids,† or whether, according to some very acute writers,‡ these, when once formed and perfected, remain invariably entire.

458. There can be no doubt that some of the similar solids, v. c. the epidermis and nails, are gradually destroyed and renewed; and the same is proved respecting even the bones, by the well known experiment of dying them with madder root; (A) and by the frequently remarkable attenuation of the flat bones, especially of the skull, from defective nutrition in old age.§

459. If I am not mistaken, those solid parts undergo this successive change, which possess the *reproductive power*,—an extraordinary faculty, by which not only the natural loss of particles, but even the accidental removal of considerable parts, from external injuries, is repaired

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* Th. Young *De corporis humani viribus conservatricibus.* Gotting. 1796, 8vo.

Fl. J. Van Maanen *sui ipsius humana sui ipsius Conservatrice ac medicatrice.* Harderv. 1801, 8vo.

† See the celebrated V. J. Bernouilli's *Diss. de nutrit.* Groning. 1669, 4to. He estimates the continual, though insensible, loss and reparation of the solids so high, that the whole body may be said to be destroyed and renewed every three years.

‡ See J. Chr. Kemme. *Beurtheilung eines Beweises vor die immaterialität. der seele aus der medicin.* Halle. 1776, 8vo.

And his *Zweifel und erinnerungen wider die lehre der aerzte von der Ernährung der festen theile.* Ibid. 1778, 8vo.

§ Respecting this mutability of the bones, I have spoken at length in my osteological work, ed. 2. p. 26, and elsewhere.

and perfectly supplied, as the bones* and a few other parts sufficiently demonstrate.

460. On the other hand, I have been led by many experiments to the conclusion, that this genuine *reproductive power* appears completely bestowed upon no similar parts *which possess any other vital power* besides CONTRACTILITY, i. e. *irritability*, *sensibility*, or a *vita propria*.†

461. In these parts, therefore, whose vital powers are of an higher order, the parenchyma constituting their base, appears permanent, and is liable to this change only,—that the interstices of the fibres and parenchyma, while nutrition is vigorous, are constantly full of nutrient animal gelatine; but, when nutrition languishes, are deprived of their gelatine, collapse, and consequently become thin.

462. For as the plastic lymph, the importance of which has been frequently mentioned, is readily converted into cellular membrane, so it appears to constitute the principal material of the body, and, as it were, the animal gluten, which is nourished by its means.

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* Consult among others G. L. Koeler's *Experimenta circa regenerationem ossium*. Gotting. 1786, 8vo.

Alex. Herm. Macdonald, *De necrosi et callo*. Edinb. 1799, 8vo.

† That the corium is not really reproduced, is probable, not only from its perpetual *cicatrices* (for some contend that the *matter* of those does not continue, but their *form* only, which is preserved by a perpetual apposition of fresh particles in the room of the decayed and absorbed), but much more by the lines and figures which are made upon the skin by the singular art of pricking it with a needle, (a process denominated in the barbarous language of the Otaheiteans *tatooing*) and imparting to the corium a blue or red colour, as permanent as the cicatriculæ, by means of charcoal powder, ashes, soot, the juices of plants, or galls; on the other hand, the red hue imparted to the bones, by means of madder, quickly disappears, as these parts undergo a continual renovation.

463. During the growth of the body, peculiar powers are exerted, by which the lymph deposited in the cellular membrane by the blood vessels is properly distributed and intimately assimilated to the substance of each organ, &c. This is referrible, both to the laws of affinity, by which particles attract, and, as it were, appropriate others which are similar and related to themselves; and to the nisus formativus, which we shall enlarge upon hereafter, and to which the proper application of shapeless elementary matter, and its modification to particular forms, must be ascribed.

464. To both these powers, we conceive, must be particularly attributed the nutrition of such similar parts as are not supplied with blood; but are, nevertheless, at first generated by a most powerful and infallible nisus, grow, are nourished, and, if destroyed by accident, are very easily reproduced;* such are the nails, hairs, &c.

465. As this appears to be the true account of nutrition in general, so, on the other hand, it evidently has great varieties of degree and kind, especially where, from the more or less lax apposition of the nutritious matter, the structure of the similar parts is more or less dense, and the specific weight of the whole body more or less considerable.† In this respect, not only individuals, but whole

* *Zwo abhandlungen über die nutritionskraft welche von der Acad. der Wiss. in St. Petersburg den preiss getheilt erhalten haben.* Petersburg, 1789, 4to.

De Grimaud. *Mém sur la nutrition qui a obtenu l'accessit.* ib. same year, 4to.

Steph. J. P. Housset, on the same subject (in the same school) in his *Mémoires physiologiques & d'hist. naturelle.* Auxer. 1787, 8vo. T. 1. p. 97.

† J. Robertson. *On the specific gravity of living men,* in the *Philos. Trans.* Vol. L. P. i. p. 30, sq.

nations differ from each other. The Jakats and Burats, who are remarkable for the lightness of their bodies, are a sufficient example of this.

NOTE.

(A) The redness imparted to the bones by feeding animals with madder, does not prove that the matter of the bones is constantly changing; because the opinion that the madder unites with the phosphate of lime in the blood, and thus reddens all the bony matter subsequently deposited, is erroneous. Mr. Gibson proved, by numerous experiments, that the serum has a stronger affinity than the phosphate of lime for madder. The serum being charged with madder, the phosphate of lime of the bones, already formed, seizes the superabundant madder and becomes red. If the madder is no longer given to the animal, as it is continually passing off with the excretions, the stronger attraction of the serum draws it from the bones, and they re-acquire their whiteness. *Manchester Memoirs*, vol. i.

SECT. XXXII.

OF THE SECRETIONS IN GENERAL.

466. Besides the nutritious fluids, others of various descriptions are produced from the blood by means of *secretion,* which Haller, no less than his predecessors, with truth and regret declared to be among the most obscure parts of physiology.*

467. The secreted fluids on the one hand differ so considerably among themselves, and on the other, have so many points of resemblance, that their classification cannot but be extremely arbitrary. If we arrange them according to the degree of difference between them and the blood from which they are formed, they will stand in the following order:

First, the *milk,* which may be in some degree considered as chyle reproduced, and appears formed by the most simple process from the blood newly supplied with chyle.

Next, the *aqueous* fluids, as they are commonly denominated from their limpid tenuity, although the greater part differ importantly from water in the nature of their

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* v. Fouquet on Secretion, in the Encyclopedical Lexicon of Paris. T. xiv.

Fr. L. Kreysig *De secretioribus.* Spec. i. ii. Lips. 1794, sq. 4to.

constituents, and especially in the proportion of albumen: such are the humours of the eye, the tears, in all probability the vapour contained in the cellular interstices and the cavities of the abdomen and thorax; nearly similar, also, is the fluid of the pericardium and of the ventricles of the brain.

The liquor amnii of pregnancy, and the *urine* remarkable for the peculiar nature and mixture of its proper constituents, are generally enumerated among these.

The *salivary fluids*, concerned in mastication, digestion, and chylification, appear more elaborated.

Next the *mucous*, which line the cavities of most of the organs performing the natural and genital functions, and likewise the tract of the nostrils, larynx, and trachea.

The mucus within the eye, and under the epidermis, is nearly similar.

In the same class may be included the cerumen of the ears, the unguent of the Meibomian glands, and of the joints, and, perhaps, the nameless fluid poured forth into the vagina during the venereal œstrum.

The *adipose* are, besides the common fat, the medulla of the bones and grease of the skin.

Related to these are the secretion of the corona glandis under the preputium, and of the external female genitals.

The truly *serous*, or albuminous, are the fluid of the ovarian vesicles of De Graaf; and the liquor of the prostate.

The *semen virile* and the *bile* are each sui generis.

468. It is obvious that so great a variety of secreted fluids cannot be secreted from the mass of blood in the same way, nor by similar organs. Their chief distinction is the simplicity or complexity of their preparation.

469. The most simple mode of secretion is diapedesis,

or transudation; which is the case with the fat and the bony fluid.*

470. Secretion by *glands*† is more complicated. Such is considered the secretion even by follicles and cryptæ found, v. c. in some parts of the corium, the fauces, and aspera arteria, and denominated the *most simple* glands.

Properly speaking, the *conglomerate* (as they are called to distinguish them from the lymphatic conglobate) are the only true secreting organs; such as the salivary and lachrymal glands, the pancreas and breasts. They are provided with an excretory duct coming immediately from the large lobes which are composed of others, smaller, and so intricate in their structure, as to have been the source of warm disputes in the schools of medicine.

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* Physiologists have given different explanations of this mode of secretion. Some assert that every fluid is formed by passing merely through inorganic pores from the blood: others altogether deny the existence of these pores. I think much of this is a verbal dispute. For, on the one hand, I cannot imagine how *inorganic* pores can be supposed to exist in an *organized* body, for we are not speaking of the common interstices of matter, in physics denominated pores; and I am persuaded that every opening in organized bodies is of an organic nature, and possesses vital powers exactly correspondent. On the other hand, these openings or pores in the coats of the vessels, are evidently little different in function from the cylindrical ducts, through which fluids are said to percolate in conglomerate glands and secreting viscera: for this percolation depends less on the *form* of the organ than on its *vital powers*.

Vid. Schreger's *Fragmenta*.

P. Lupi's *Nova per poros inorganicos secretionum theoria refutata*, &c. Romæ, 1793, ii. Vol. 8vo.

Kreysig's *Specimen secundum*, formerly mentioned.

† Sam. Hendy, *On Glandular Secretion*. Lond. 1775, 8vo.

Malpighi* considered the miliary globules, which are easily discoverable in most glands, as acini internally excavated. Ruysch, on the contrary, contended that these supposed hollow acini were nothing more than glomerules of blood vessels,—an opinion far more consistent with microscopical observation and the effects of minute injection.

471. The structure of some secreting organs, especially of the liver and kidnies, the latter of which strikingly exhibit the glomerules of Ruysch or the acini of Malpighi, are not, excepting in their peculiar parenchyma, very dissimilar from this structure, and indeed throw considerable light upon the question. On the outer part of these, small twigs arise from the sides of the capillary arteries and run into vascular glomerules, hanging like granules as from stalks; from these arterial glomerules spring very minute colourless secreting vessels, whose origin from the extremities of arteries, was formerly alluded to (92); and the radicles of veins into which the arteries are continued, and which convey back into the venous trunks the remaining blood deprived of the secreted fluid.†

472. The organization of some other secreting parts is evidently peculiar, v. c. of the testes, which are composed of very long and numerous vessels, closely compacted, &c.

473. That the different nature of the secreted fluids depends not so much on the size and external form of the

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* In works repeatedly quoted, and also in his *Diss. de glandulis conglobatis.* Lond. 1689, 4to.

But consult especially his *Opera Posthuma.* ib. 1697. fol. and published likewise elsewhere.

† Al. Schumlansky *De structa renum.* Argent. 1782, 4to. tab. ii.

secreting organs as upon their interior structure and corresponding vital powers, is rendered probable by the example of many of our fluids, which, although secreted by organs at first sight very different from each other, have considerable resemblance to each other in nature; v. c. the saliva and gastric juice. And comparative anatomy teaches us, that the same fluids are formed by organs very different in external appearance, in different animals.*

474. We shall now investigate the causes why particular fluids are found in particular organs,—the most difficult part of the doctrine of secretion, and still open to many doubts.

475. There can be no question that the absolute cause of the variety of secretions is referrible to the intimate nature of the secreting organ. This depends, in the conglomerate glands and secreting viscera especially, both upon the direction and distribution of the secreting blood vessels, and upon the peculiar *parenchyma* of each secreting organ, in some instances distinguishable at first sight from the substance of every other part (20).

476. It is likewise probable, and indisputable arguments in favour of the opinion have been continually afforded in the course of this work, that secreting organs have not only a peculiar parenchyma, but a *vita propria,* viz. a singular species of vitality distinct from the common vital powers of contractility, irritability, and sensibility.

* Compare, for instance, the form of the kidnies in mammalia with the true conglomerate glands which supply their place in birds; or the pancreas of warm-blooded animals with the pyloric appendices, which, although varying in appearance, in different fish secrete a fluid very similar to the pancreatic.

477. The absorbent system seems of much importance in the business of secretion. In every secreting organ, it absorbs and conveys to the blood a fluid which is, as it were, contaminated by the secretion of the part: v. c. a bilious fluid in the liver; a spermatic in the testes. A constant circle would, therefore, appear to exist in the secretory system, so that the elements of the secretions are incessantly carried to the blood from the secreting organs, and when they have returned to the organs are the more easily attracted by a species of affinity, and draw with them those parts of the blood whose nature is related to their own.

478. The blood from which some secretions are produced, is endowed with peculiar qualities. The bile, for example, is derived from blood which contains an abundance of carbonaceous element.

479. We omit other assistances afforded to certain secretions; v. c. congestion and derivation, so striking in the secretion of milk, &c.

480. There is this difference between the different fluids secreted by the organs and powers now described,—that some pass to the place of their destination immediately, while others are deposited in receptacles, and detained there for some length of time, becoming more perfect previously to their excretion. The milk in its ducts, the urine, bile, and semen in their respective bladders, and the serum contained in the vesicles of De Graaf, are examples of this. (A)

NOTES.

(A) "There are two classes of secreted fluids, viz. the *secretions*, properly so called, or the fluids intended to fulfil some ulterior purpose in the animal economy, and the *excretions*, which are directly discharged from the body. The fluids of the former class are all alkaline, and of the latter all acid. The excretions are the urine, the perspired fluid, and the milk. All the other fluids appear to belong to the former class.

"The alkaline secreted fluids may be divided into two very distinct species. The former of these contains the same quantity of water as the blood, so that the change induced by the nervous influence, seems to be confined to that of altering the chemical form of the albuminous materials,* without affecting their relative proportion to the water and other substances dissolved in the blood. The bile, spermatic fluid, &c. are of this kind. The latter species consists of fluids, in which the influence of the nervous system has separated a large portion of the albuminous matter, and left the remaining liquid proportionally watery. The saliva, the humours of the eye, and the effused serum of membranes, are of this species, and in these the quantity of salts, and in general also of alkali, is the same as in the blood.

"The influence of the chemical agent of secretion is, therefore, chiefly spent upon the albuminous materials of the blood, which seems to be the source of every substance that peculiarly characterises each secretion, each of which

* This appellation Berzelius gives to the fibrin, albumen, and colouring matter of the blood.

is *sui generis*, and is its principal constituent. All the other parts of the secretion seem to be rather accidental, and to be found there only because they were contained in the blood out of which the secretion was formed. Therefore, in examining the secreted fluids, the chief attention should be paid to the peculiar matter of the fluid, which varies in all. This matter sometimes retains some of the properties of albumen, at other times, none; and hence an accurate analysis, shewing the quantity and nature of this peculiar matter, is above all to be desired.

" If the several secretions be supposed to be deprived of their peculiar matter and the remainders analysed, the same residue would be found from them all, which also would be identical with the fluid separated from the serum after its coagulation. Thus we should find, first, a portion soluble in alcohol, consisting of the muriates of potash and soda, lactate of soda, and of an extractive animal substance, precipitable by tannin; and secondly, of a portion soluble only in water, containing soda (which acquires carbonic acid by evaporation, and is separable by acetic acid and alcohol) and another animal substance, not extract, precipitable from its solution in cold water, both by tannin and muriate of mercury. Sometimes a vestige of phosphate of soda will also be detected.

" The excretions are of a more compound nature. They all contain a free acid, which is termed lactic, and in the urine this is mixed with the uric acid. Urine seems to contain only a single peculiar characteristic matter; but milk has as many as three, viz. butter, curd, and sugar of milk, which, however, seem to be produced by different organs that mingle their fluids in the same receptacle. The perspired fluid appears to have no peculiar matter, but to be a very watery liquid, with hardly a vestige of the albumen of the blood, and, in short, is the same as the other excretory fluids would be when deprived of their peculiar matter. If we suppose this matter taken away from those excretions which possess it, the remaining fluid will be found to have properties very different from the fluid part of the secretions, when equally freed from their peculiar matter. That of the excretions is acid, contains earthy phosphates, and when evaporated, leaves a much larger residue than the fluid of the secretions. This residue is yellowish-brown, of the consistence of syrup, with an unpleasant sharp saline taste of the salts that it contains. It reddens litmus, is most soluble in alcohol, and this spirituous solution contains the muriates of the blood, together with free lactic acid, much lactate of soda (the soda being the free alkali of the blood, neutralized by this acid), and the extractive matter, which always accompanies this neutral salt. The part insoluble in alcohol contains a distinguishable quantity of phosphate of soda, a little of a similar animal matter to that found in the secretions, and also the earthy phosphates which were held in solution by the lactic acid, and were precipitated by the action of the alcohol. The urine possesses also a number of other substances, which will be specified when describing this excretion in particular."

* General Views of the Composition of Animal Fluids, by J. Berzelius, M. D. *Medico-chirurgic. Trans.* Vol. iii. p. 234.

SECT. XXXIII.

OF THE FAT.

481. Of most of the secreted fluids, a concise and connected view of which was given in the last section, distinct mention has been made in its proper place: the rest shall be described as opportunity may permit. Two remain, which cannot be discussed in a more proper place than the present,—at the close of our inquiry into the natural functions. The one,—the fat, is a part of the system (4); the other,—the urine, is excrementitious. Each shall be separately examined.

482. The *fat** is an oily fluid, very similar in its general character to vegetable oils,† bland, inodorous, lighter than water; containing, besides the two elements common to water, the oils just mentioned, and to wax, viz. carbon and hydrogen, sebacic acid,‡ which is pretty similar to the benzoic.

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* W. Xav. Jansen's *Pinguedinis Animalis Consideratio Physiologica et Pathologica.* Lugd. Bat. 1784, 8vo.

† J. D. Brandis' *Comm.* (rewarded with the Royal Prize) *de oleor. unguinosor. natura.* Gotting. 1785, 4to. p. 13.

‡ Joach. J. Rhades *De ferro sanguinis hum. aliisque liquidis animalium.* ibid. 1753, 4to. ch. 4.

Dav. H. Knape (Præside Segnero) *De acido pinguedinis animalis.* ibid. 1754, 4to.

Laur. Crell. *Chemisches Journal.* 1778 P. i. p. 102.

483. When secreted from the blood and deposited in the mucous tela, it exists in the form of drops, divided by the laminæ of the tela, in a manner not unlike that in which the vitreous humour of the eye is contained in very similar cells.

484. The relation of fat to different parts is various. In the first place, some parts, even those whose mucous tela is extremely soft and delicate, never contain fat. Such are the palpebræ and penis.

In very many parts, it is diffused indefinitely, especially in the *panniculus adiposus*, the interstices of the muscles, &c.

In some few, it is always found, and appears to be contained in certain definite spaces, and destined for particular purposes. Such I consider the fat around the basis of the heart:* and in the mons veneris, where it forms a peculiar and circumscribed lump.†

485. Its consistence varies in different parts. More fluid in the orbit, it is harder and more nearly resembling suet around the kidnies.

486. It is of late formation in the fœtus; scarcely any trace of its existence is discoverable before the fifth month after conception.

487. There have been controversies respecting the mode of its secretion. Some, as Hunter, contending that it is

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* Hence it is clear how many exceptions must be made to the assertion of the celebrated Fourcroy,—that fat is an oily matter, formed at the extremities of arteries, and at the greatest distance from the centre of motion and animal heat. See his *Philosophic Chimique*, p. 112.

† I found it more remarkable in the body of a female of the species *simia cynomolgus*, from which, by means of cold, I was able to remove it entire.

formed by peculiar glands; others, that it merely transudes from the arteries. Besides other arguments in favour of the latter opinion, we may urge the morbid existence of fat in parts naturally destitute of it; a fact more explicable on the supposition of diseased action of vessels, than of the preternatural formation of glands. Thus, it is occasionally formed in the orbits; a lump of hard fat generally fills up the place of an extirpated testicle; and steotoms have been found in almost every cavity of the body.

The glands which some celebrated characters have contended to secrete the fat, are at present imaginary. Whatever may be the truth of this matter, the deposition and absorption of the fat take place with great rapidity.

488. The use of the fat is multifarious.

It lubricates the solids and facilitates their movements; prevents excessive sensibility; and, by equally distending the skin, contributes to beauty.

We pass over the particular uses of fat in certain parts, v. c. of the marrow of the bones.

During health, it contributes little or nothing to nourishment.* The modern opinion has more probability,—that it affords a receptacle for the superfluous hydrogen, which could not otherwise be easily evacuated.† (A)

* P. Lyonet conjectures with probability, that insects destitute of blood derive their chief nourishment from the fat in which they abound. *Tr. anat. de la Chenille qui ronge le bois de Saule*, p. 428, 483, et seq. præf. p. xiii.

† See Fourcroy, l. c.

NOTE.

(A) The fattest person on record is, I believe, Lambert of Leicester. He weighed seven hundred and thirty-nine pounds. Excessive formation of fat may be strongly opposed by regularly taking great exercise, little sleep, and little, but dry food. See the instructive case of the Miller of Billericay, in the second volume of the *Transactions of the Royal College of Physicians, London*. A large collection of cases of obesity will be found in Mr. Wadd's *Cursory Remarks on Corpulence*.

SECT. XXXIV.

OF THE URINE.

489. BESIDES the nutritious (4) fluids and those which form a part of our system, others are superfluous and excrementitious, commonly termed the excrements of the second digestion, and are of two orders. The one exhaled by perspiration, of which we treated formerly; the other, —the *urine*, streaming from the kidnies.

490. The kidnies* are two viscera, situated at the upper part of the loins on each side, behind the peritonæum; rather flattened; more liable than any other organs to varieties of figure and number;† suspended by the emulgent vessels,‡ which are excessively large in proportion to the kidnies; and imbedded in sebaceous fat. (485.)

491. They are enveloped in a membrane of their own which is beautifully vascular; and each, especially during infancy, consists of eight, or rather more smaller kidnies, each of which again consists, as Ferrein asserts, of seventy or eighty fleshy radii, denominated by him pyramides albidæ.

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* See Al. Schumlansky, l. c.

† See Ger. Blase's *Renum monstrosorum exempla*, at the end of Bellini *de structura et usu renum*. Amstel. 1665, 12mo.

‡ Eustachius' *tabulæ*, 1—5, which belong to his classical work, *De renibus*; bound up in this eminent man's *Opusc. anatom.* Venet. 1564, 4to. same edition. tab xii.

492. A kidney, if divided horizontally, presents two substances; the exterior, called *cortex;* the interior, *medulla.*

Each abounds in blood vessels, but the cortical portion has likewise very minute colourless vessels, which *secrete* the urine;* the medullary part contains those which *carry it off.*

These secreting ducts arising from the arteries in the manner formerly described, (471) are united with glomerules, which adhere to the cortical part and constitute the greatest proportion of it. They may be readily distinguished by their angular course from the excreting or Bellinian tubes, in which they terminate. These, pursuing a straight course, run from the cortical to the medullary substance, of which they constitute the greatest part, and after having coalesced into fewer trunks, their mouths perforate, like a sieve, the *papillæ* of the pelvis of the organ.†

493. These papillæ usually correspond in number with the lobes which form the kidnies, and they convey the urine secreted in the colourless vessels of the cortex and carried through the Bellinian tubes of the medulla, into the *infundibula,* which finally unite into a common *pelvis.*

494. The pelvis is continued into the *ureters,* which are

* These secreting ducts appear to have imposed upon Ferrein as a new description of vessels, which he called neuro-lymphatic, or white tubes, and of which he imagined the whole parenchyma of the viscera to be composed. He affirmed that they were of such tenuity, that their length in each kidney of an adult man was equal to 1000 orgyæ, or 5 leucæ.

† Eustachius. tab. xi. fig. 10.

membranous canals, very sensible, lined with mucus, extremely dilatable, generally of unequal size in the human subject in different parts,* and inserted into the posterior and inferior surface of the bladder in such a way, that they do not immediately perforate its substance, but pass a short distance between the muscular and nervous coats, which at that part are rather thicker than elsewhere, and finally open into its cavity by an oblique mouth. This peculiarity of structure prevents the urine from regurgitating into the ureters from the bladder. (A)

495. The urinary *bladder*,† varying in shape according to age and sex, is generally capable, in the adult, of containing about two pounds of urine. Its fundus, which in the fœtus terminates in the urachus, is covered posteriorly by the peritonæum. The other coats correspond with those of the stomach.

The *muscular* consists of interrupted bands of fleshy fibres, variously decussated, and surrounding the bladder.‡ These are usually called the detrusor urinæ: the fibres which imperfectly surround the neck and are inconstant in origin and figure, have received the appellation of sphincter.

The *nervous* chiefly imparts tone to this membranous viscus.

The *interior*, abounding in cribriform follicles,§ is lined with mucus, principally about the cervix.

496. The urine conveyed to the bladder, gradually be-

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* See Nuck's *Adenographia*, fig. 32, 34, 35. Leop. M. Ant. Caldani, in the *Saggi dell' accad. di Padova*. T. ii. p. 2.

† Duverney's *Œuvres anatomiques*. Vol. ii. tab. i.—iv.

‡ Santorini's posthumous tables, xv.

§ Flor. Caldani's *Opus. anat.* Patav. 1805, 4to. p. 5.

comes unpleasant by its quantity, and, growing urgent, inclines us to discharge it. For this purpose the *urethra* is given, which varies with the sex, and will be farther considered in our account of the sexual functions.

497. The bladder is evacuated by the constriction of the sphincter being overcome both by the action of the detrusor (495) and by the pressure of the abdomen. To these in men is superadded the action of the acceleratores, which force out even the drops of urine remaining in the bulb of the urethra.

498. The nature of the *urine* varies infinitely * from age, season of the year, the length of the period since food or drink was taken, the quality of the ingesta,† &c. The urine of an adult, recently made after a tranquil repose, is generally a watery fluid of a nidorous odour and of a lemon colour, which qualities depend on a peculiar uric substance, besides a variety of other matters‡ held by the water in solution and differing in proportion in different persons. There is a remarkable quantity of phosphoric acid united with other constituents, forming phosphates of soda, ammonia, and lime. A peculiar acid,—the lithic or uric, is found in the urine alone.§ (B)

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* See Hallé in the *Mem. de la Soc. de Médec.* Vol. iii. p. 469, sq.

† The specific quality of some ingesta manifest themselves in the urine so suddenly, even while blood drawn from a vein discovers no sign of their presence, that physiologists have thought that, besides the common channels, there must be some private ways running directly from the alimentary canal to the kidnies. See v. c. Grimaud *Sur la nutrition,* p. 115. Darwin's *Zoonomia,* vol. i. § 29. and Home, in the *Philos. Transact.* 1808.

‡ See Fr. Stromeyer's *Theoret. chemie.* p. 609.

§ Consult on the analysis of the urine, among others, **Berthollet,** in the *Mem. de l'Acad. des Sc. de Paris,* 1780, p. 10.

NOTES.

(A) Mr. Charles Bell has lately described two long muscles, running from the back of the prostate gland to the orifices of the ureters. Their action is not only to assist in emptying the bladder, but to pull down the orifices of the ureters, thus assisting to preserve that obliquity of insertion which the ureters lose in proportion as the bladder is depleted.—*Med. Chirurg. Trans.* Vol. III.

(B) The following is Berzelius' analysis of urine, in the *Med. Chirurg. Trans.* Vol. III.

Water - - - - - - - - - - - - - -	933.00
Urea - - - - - - - - - - - - - - -	30.10
Sulphate of potass - - - - - - - - - -	3.71
Sulphate of soda - - - - - - - - - -	3.16
Phosphate of soda - - - - - - - -	2.94
Muriate of soda - - - - - - - - - -	4.45
Phosphate of ammonia - - - - - - -	1.65
Muriate of ammonia - - - - - - - -	1.50

Th. Lauth (præs. Spielmann) *De analysi urinæ et acido phosphoreo.* Argent. 1781, 4to.

H. Fr. Link's *Commentatio* (honoured with the Royal Prize) *de analysi urinæ et origine calculi.* Gotting. 1788, 4to.

Fourcroy, in the *Annales de chimie.* T. vii. p. 180. and T. xvi. p. 113.

C. Fr. Gaertner's *Observata quædam circa urinæ naturam.* Tubing. 1796, 4to.

Free lactic acid Lactate of ammonia Animal matter soluble in alcohol, and usually accompanying the lactates Animal matter insoluble in alcohol Urea, not separable from the preceding	17.14
Earthy phosphates with a trace of fluate of lime	1.00
Uric acid	1.00
Mucus of the bladder	0.32
Silex	0.03
	1000.00

SECT. XXXV.

OF THE GENERAL DIFFERENCES OF THE SEXES.

499. The functions hitherto examined are common to both sexes, but some are performed very differently in each. The most prominent differences shall be briefly reviewed previously to examining the sexual functions, properly so called.*

500. In general, each sex has its peculiar form; more or less striking after birth, but not very obvious in the young fœtus: for the genitals of the male and female, at this period, are not at first-sight different, on account of

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* Melch. Sebiz, *De differentiis corporis virilis et muliebris*, Argent, 1629, 4to.

F. Thierry E. *præter genitalia sexus inter se discrepant*, Paris, 1750, 4to.

Dictionn. Encycloped. (EbroJun edit.) vol. xviii. art. Femme, and Vol. xlii. art. Viril.

J. Fidel Ackermann *De discrimine sexuum præter genitalia*, Mogunt. 1788, 8vo.

The same Writer's *Historia ichnographia infantis androgyni*. Jen. 1805, fol. p. 61, seq.

P. Roussel. *Systeme physique et morale de la femme*, ed. 2, Paris, 1803, 8vo.

Ad. F. Nolt *Diss. sistens momenta quædam circa sexus differentiam*. Gotting. 1788, 8vo.

J. Lud. Moreau de la Sarthe, *Histoire naturelle de la femme*, Paris, 1802, 3 vols. 8vo.

Autenreith in the *Archiv. für die Physiol.* T. vii. page 3, sq.

the clitoris being remarkably large,* and the scrotum scarcely visible.† (A)

501. During infancy, the general form is but little different, but becomes more so as age advances; when the round and plump breasts, the general conformation, the delicacy, softness, and the proportionally low stature of the female, form a striking contrast with the sinewy and robust body of the male.‡

502 The relation of parts, in well-formed females, is somewhat different from that in the male. For instance, in the female the face is proportionally smaller; the abdominal and lumbar portion of the trunk longer; the hips broader, not however, if well formed, broader than the shoulders; the buttocks larger; the legs in their descent gradually approach the knees. (B)

503. A similar difference is remarkable in the osseous

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* Langguth, *Embryo, 3½ mensium qua faciem externam*, Viteb. 1751, 4to.

James Parsons, *Philos. Transact.* Vol. xlvii. p. 143.

Morgagni, *De sedibus et causis morborum.* xlviii. p. 10.

† This I lately found confirmed in twin abortions of different sexes and of about sixteen weeks formation, in which, although they were most beautifully and correctly formed, the difference of the genitals was not at first discoverable. In every other respect, in the general figure, physiognomy, the dimensions of the loins, &c. they were perfectly similar.

‡ Examine besides the *Vier Bücher von menschlicher Proportion.* Nurimb. 1528, fol. of our great countryman Alb. Dürer, the two celebrated male and female figures painted by Titian or one of his school, in Vesalius's *Epitome suor. libror. d. c. h. anatome.* Basil, 1542, fol.

The three delineated by that excellent Artist, Ger. Laidresse, in Bidloo, tab. i. ii. iii. and Girardet's drawings in the *Cours complet d'Anatomie gravé par* A. E. Gautier *et expliqué par* M. Jadelot. Nantz. 1773, fol. max.

system. In females, the bones are, cæteris paribus, smoother and rounder, the cylindrical more slender, and the flat thinner; to pass over individual differences, v. c. the very slight prominence of the frontal sinuses, the more elliptic edges of the alveoli, the greater narrowness of the chest, the greater capacity on the contrary of the pelvis, the difference of the clavicles, thigh bones, &c.* (C)

504. With respect to the soft parts, the female mucous tela is more lax and yielding, so as to dilate more easily during pregnancy; the skin is more delicate, and of a clearer white, from the quantity of fat below it. The hair of the head is commonly longer; but other parts, which are covered with hair in men, are either quite smooth in women, as the chest and chin; or less hairy, as the perinæum; or smaller in circumference, as the pudenda; or covered with merely a very delicate and soft down, as the arms and legs. (D)

505. Among the particular differences of function, must be mentioned the pulse, which is, in females, cæteris paribus, more frequent (116); the quantity of blood too passing to the abdomen is greater. The lungs, on the other hand, are smaller, from the greater narrowness of the chest, which is however more moveable above. The os hyoides is much smaller, the larynx scarcely prominent and more contracted, whence the voice is less grave.

506. As to the animal functions, besides the greater abundance of nerves in the organs of *generation*, the general nervous system of females is far more mobile, and the propensity to emotion stronger. On the other hand, the

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* I have described these differences more fully throughout the sceleton in my *Osteological work*, p. 87, sq. ed. 2.

Compare Soemmerring's *Tabula sceleti fœminei*. Francof. 1796, fol. with the male figure in B. S. Albinus's *Tabulæ sceleti*. tab. 1.

muscular system is weaker, and the muscles (with the exception of the glutei, psoæ, quadrati lumborum, and a few others) proportionally smaller. (E)

507. In regard to the natural functions, the stomach and the appetite for food, are less;* the growth of the body more rapid; and the periods of dentition, puberty, and full growth, earlier.

508. But by far the greatest difference exists in the genital functions, which are intended in man for impregnating, and in women for conceiving. The fuller investigation of these now remains to be prosecuted.

NOTES.

(A) Sir Everard Home has published a singular theory, which he supports by extremely ingenious arguments.† He contends that the sex is not determined at the first formation of the individual, but that the parts of generation are originally so situated, and of such a nature, that they are capable of becoming either male or female organs when the sex is subsequently fixed. His arguments are the following: 1. The Testes and Ovaria lie originally in the same situation. 2. The Clitoris is at first of great size. 3. When the female among Mammalia has inguinal Mammæ, so likewise has the male; men also possess breasts. 4. The Scrotum occupies in the male, the place occupied in the female by the Labia, and is of the same structure with them. 5. The Nymphæ

* Hence genuine and indubitable cases of long abstinence from food, have generally occurred in females. (F.)

See, among many others, Fl. James Voltelen, *Diatr. Memorabilem septennis apositiæ historiam exhibens.* Lugd. Bat. 1777, 8vo.

† *Philos. Trans.* Vol. 89.

of the female exactly correspond to the Preputium of the male. 6. Twins are usually of the same sex, as if the same cause had influenced the generative organs of each; when they are of different sexes, it is a common remark that they seldom breed, nature probably having been disturbed in her operations. 7. When among black cattle twins are produced of different sexes, that which appears the cow is really an hermaphrodite, incapable of breeding, and vulgarly termed a free martin;—a circumstance in every respect analogous to the preceding.* It may be added, that the round ligaments of the female descend, like the two spermatic chords of the male, to the abdominal ring, and that marsupial bones exist, without any function whatever, in the males of some marsupial animals; the bursa fabricii of the hen, and the bifid glans clitoridis of the opossum, are examples similar to these, and comparative anatomy furnishes many others. Perhaps Blumenbach's explanation is correct,—that they occur in conformity with a general law; teleologically in the sex, where they are useful, and physico-mechanically in the other.† And this explanation is confirmed by the existence in some kinds of animals, of parts which are of no use to them, but exist for useful purposes generally in animals of that description.‡

The sex of the offspring would appear determined by the female rather than by the male. Mr. Knight has observed that individual cows, &c. however various the

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* J. Hunter's *Observations on certain parts of the animal economy*, p. 55.

† *Comparative Anatomy*, Bones of the Mammalia.

‡ "The title of *vestiges* is given in comparative anatomy to parts without use in the animal in which they are seen, and which only shew the uniform plan followed by nature in the formation of animals."

An elementary summary of Physiology, by F. Majendie, *translated by a member of the Med. Chirurg. Society*, T. 1. p. 64.

males, produce one sex rather than the other, so that he has with tolerable certainty predicted the number of male and female young; while nothing similar was ever observable in regard to his bulls, rams, &c. Even the external appearance and the habits of animals and vegetables, he has found much more, and sometimes altogether, influenced by the female. The quantity of pollen employed in the fecundation of female plants, he found of no importance in this respect.*

(B) The form as well as the texture of the female is more delicate: her surface has no muscular protuberances, but is beautifully rounded; her legs therefore have no calves, but, like the arms and fingers, they gently taper; her feet and hands are small; her stature one sixth shorter than that of the male; her neck longer. From the smaller stature and the greater size of the abdominal and lumbar regions, it follows that the middle point which lies at the pubis in the male, is situated higher in the female. Her abdomen is more prominent and rounded, and her shoulders less forward and distant from the trunk. Her thighs are more voluminous and distant from each other.

(C) The greater capacity of the female pelvis, which contains the chief organs of generation and affords a passage for the child, arises from the greater expansion of the ossa ilei, the larger angle of the junction of the ossa pubis, and the greater concavity and breadth of the os sacrum: the os coccygis likewise is more slender and moveable. The clavicles are less bent; the thorax more projecting, whence deeper, although narrower and shorter; the sternum shorter and broader; the cartilago ensiformis shorter; the two superior ribs flatter. Camper remarks, that if the male and female forms are traced

* *Philos. Trans.* 1809.

within two ellipses of equal dimensions, the male shoulders will stand without and the pelvis within, while the female shoulders will remain within and the pelvis without.* The face and brain are absolutely smaller than in men, the face likewise proportionally so; yet such is the relative size of the cranium, that while in the male, the head, including the teeth, is as 1 to 8 or 10, in the female it is as 1 to 6, of the weight of the rest of the sceleton.

(D) An instance is related by Professor Roux of a woman forty years of age who had one child and whose breasts were well developed, having a strong and long beard: the lobes of her ears were also covered with hair.† Hen birds have a far less beautiful and copious plumage than cocks.

(E) Inferior to man in reasoning powers and corporeal strength, woman possesses more sensibility of both body and mind, more tenderness, affection, and compassion, more of all that is endearing and capable of soothing human woes, but less firmness of character, except indeed where affection subsists;—although *Varium et mutabile semper fœmina*, is a true character, yet nothing is too irksome, too painful, or too perilous, for a mother, a wife, or a mistress, to endure or attempt for the object of her love.

(F) And beastly gluttons for the same reason are generally men. A collection of cases of voraciousness will be found in Professor Percy's *Memoire sur la Poliphagie*.‡

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* *Mémoire sur le beau Physique.*

† *Anatomie descriptive*, par Xav. Bichat. T. V.

‡ *Journal de Medecine.* Brumaire. An. xiii.

SECT. XXXVI.

OF THE GENITAL FUNCTION IN MAN.

509. THE genital fluid is produced in the two testicles, which hang in the scrotum, by their *spermatic chords*, through a ring called abdominal, or through, more properly, a fissure in the tendon of the external oblique muscle of the abdomen. Besides abundant lymphatics, three orders of vessels are found in the testes. (A)

The *spermatic artery*, which is, in proportion to the fineness of its caliber, the longest artery, by far, in the system, and usually conveys blood to the testicle immediately from the aorta.

The *ductus deferens*, which carries to the vesiculæ seminales the semen separated from the arterial blood.

The *pampiniform plexus* of veins, which return to the cava or renal vein the blood remaining after secretion (B).

510. The testes are not always suspended in the scrotum. In the very young male fœtus, they are placed in a far different situation, the nature and successive changes of which were first accurately investigated by Haller,* but have since been variously explained; and the causes of this change of situation have given rise to numerous controversies. I shall derive my account of

* Haller's Progr. *de herniis congenitis*, reprinted in his *opusc patholog*. p. 311, sq. vol. iii. *Opera minora*.

this subject from the natural appearances which I have preserved in a great number of small embryos, dissected by me with this view.

511. On opening the lower part of the abdomen of a young fœtus, there appears in each groin, at the ring of the oblique muscles, a very narrow opening in the peritonæum, leading downwards to a narrow passage which perforates the ring and runs to a peculiar sac, extended beyond the abdominal cavity towards the scrotum, interwoven with cellular fibres, and destined for the future reception of the testicle.

512. At the posterior margin of this abdominal opening, there is sent off another process of peritonæum, running upwards, and appearing, in the young fœtus, as little more than a longitudinal fold; from the base of which arises a small cylinder, or rather an inverted cone, which terminates above in a globular sac, containing the testis and epididymis, so that the testis, at first sight, resembles a small berry resting on its stalk, and appears hanging, like the liver or spleen, into the abdomen (399).

513. The vessels which afterwards constitute the spermatic chord, are seen running behind the very delicate and pellucid peritonæum; the spermatic artery and vein, descending along the sides of the spine, and the vas deferens passing inwards in the loose cellular substance behind the peritonæum towards the neck of the bladder. They enter the testis in the fold of peritonæum just mentioned.

514. After about the middle period of pregnancy, the testes gradually descend and approach the narrow passage before spoken of (511), (the fold of peritonæum becoming at the same time doubled together with the cylinder) until they lie directly over the opening of the passage.

515. The testis being now ready for its descent, the opening which was hitherto small, becomes dilated, so as to allow the organ to pass the abdominal ring and passage and descend into the bulbous sac (511); after this occurrence, the opening soon becomes strongly closed and even unites together, leaving scarcely any vestige of itself in infancy.

516. In proportion to the slowness with which the testis proceeded towards the opening, does its transit through the abdominal passage appear rapid, and, as it were, instantaneous. It is common to find the testis in mature fœtuses either lying over the peritonæal opening, or, having passed this, resting in the groin; but I once only met with the right testis, in a twin fœtus, at the very time when it was adhering, and in a manner strangled, in the middle of the passage, being just about to enter the sac; in this instance, the left testis had passed the abdominal canal and was already in the sac, and the abdominal opening was perfectly closed.

517. This remarkable passage of the testis from the abdomen through the groin, is limited to no period, but would seem to occur generally about the last month of pregnancy; not very rarely, however, the testicles are found in the abdomen or the upper portion of the groin at birth. For they have always another part of their course to finish, after leaving the abdomen, viz. to descend, together with their sac, from the groin into the scrotum.

518. Repeated observation demonstrates this to be the true course of the testicles. To assign the *powers* and *causes* of its accomplishment is no easy matter. For I am every day more convinced, that neither of the powers to which it is usually ascribed, viz. the action of the

cremaster or diaphragm, or the mere contractility of the cellular membrane interwoven with tendinous fibres, which adheres to the cylindrical process of peritonæum (512) and is called the Hunterian *gubernaculum,* is sufficient to explain so singular a movement, and least of all to explain the transit of the testis through the passage so often mentioned: but that the whole affords, if any thing does, a striking illustration of a vita propria, without the peculiar influence of which, so remarkable and unique a course, similar to no other function of the system, cannot even be scarcely imagined (C).

519. The coats of the testes, after their descent, are conveniently divided into *common* and *proper.*

The common is the *scrotum,* consisting of the skin having a very moderate substratum of fat and differing from the rest of the integuments in this,—that it is continually changing its appearance, being sometimes lax and pendulous, sometimes (especially during the venereal orgasm and the application of cold) constricted and rigid, and in the latter case, singularly marked by rugæ and furrows.

520. With respect to the coats proper to each testis, the *dartos* lies immediately under the scrotum, and is endowed with a peculiar and strong contractile power, which deceived the celebrated Winslow, Haller, &c. into the belief of the presence of muscularity (D).

521. Next to this, with the intervention however of much soft cellular substance, are found three orders of *tunicæ vaginales*;* viz. an exterior *common* to the testis

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* J. E. Neubauer *De tunicis vaginalibus testis et funiculi spermatici.* Giess. 1767, 4to.

F. L. Eichhorn *De hydrocele.* Gotting. 1809, 4to.

and spermatic chord, and to which the *cremaster* muscle adheres by disjoined bundles of fibres; and two interior, one *proper* to the chord, and one to the testis; the fundus of the latter of which usually adheres to the common coat, but is internally moistened, like the pericardium, by a lubricating fluid (E).

522. The origin of these coats,—the subject of so much controversy, may, I think, be readily explained, from the circumstances already mentioned attending the descent of the testis.

The *common* coat arises from the descending bulbous sac or peritoneal process (511).

The *proper* coat of the *testis*, from that production of the peritonæum which, ascending from the cylinder (512) originally invests the testis.

The coat *proper* to the *chord* from that fold and short cylinder of the peritonæum in which the fold terminates before it surrounds the testicle (F).

523. To the body of the testis* there adheres very firmly, like the bark of a tree, a coat called *albuginea*, through the combination of which with the internal part of the vaginal coat, blood-vessels penetrate into the pulpy substance of the testis.† This pulpy substance is entirely composed of innumerable vessels, about a span in length‡ and convoluted into lobules, both conveying blood and secreting semen,§ the latter of which is carried through

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* Alex. Monro fil. *De testibus et de semine in variis animalibus.* Edinb. 1755, 8vo.

† B. S. Albinus. *Annotat. Acad.* L. ii. tab. vii. fig. 1, 2, 3.

‡ Vide Grew. *Museum of the Royal Society,* page 7.

§ The celebrated Sömmerring was so successful as to inject all the vessels composing the testis, and the entire head of the epididymis with mercury. See his *Uber die körperl. Versch. des negers vom Europäer,* p. 38.

the rete vasculosum of Haller* and the vasa efferentia of de Graaf, to the apices of the cones of the epididymis.†

524. The *Epididymis*, lying on the side of the testicle and consisting of one vessel about thirty feet in length, is less, and divided into about twenty glomerules or cones at the part called its head,‡ and is continued into the vas deferens, at its lower part, which gradually becomes thicker § and is denominated its tail.

525. Each vas deferens, ascending towards the neck of the urinary bladder and converging towards the other under the prostate gland, is then directed backwards and dilated into the vesiculæ seminales, in such a manner, that the common mouth both of the vesicles and vasa deferentia, opens into the urethra, behind the caput gallinaginis.‖

526. The *vesiculæ seminales*, which adhere to the posterior and inferior surface of the bladder, surrounded by an abundance of fat, resemble two little intestines, variously reflected, and branching into numerous blind appendices.

They consist of two coats, nearly similar to those of the gall bladder; the one strong, and of the description usually termed nervous; the other interior, delicate, abounding in cells, and divided into compartments by pro-

* Haller *De viis seminis* in the *Philos. Trans.* No. 494, fig. 1, g. g.

† De Graaf *De Viror. organis generationi inservientibus.* Tab. iv. fig. 1, 2.

‡ Vide Alex. Monro fil. *Observations anatomical and physiological.* Edinb. 1758, 8vo. tab. i. E. E. E. F. G. H.

§ B. S. Albinus. *Annotat. Acad.* L. ii. tab. iii. fig. 1.

‖ B. S. Albinus. l. c. L. iv. tab. iii. fig. 1. 2. 3.

minent ridges, like those found in the cervix of the gall bladder.*

527. In these passages is slowly and sparingly secreted and contained from the time of puberty, the *semen*, a very remarkable and important fluid, of a milky yellowish colour,† of a peculiar odour, of the same viscidity as mucus, and of great specific gravity, of greater indeed than any other fluid of the body.‡

528. Semen has also this peculiarity, first observed by Lewis Ham of Dantzic, in the year 1677,§ of being animated by an infinite number of small worms visible by the microscope, of the kind denominated infusoria, and of different figures in different kinds of animals. In man,|| these *spermatic animalcules* are oval and have very fine tails: they are said to be found in prolific semen only, so that they are in some degree an adventitious criterion of its prolific maturity; I say adventitious, because I hope there is no necessity, after so many weighty arguments and observations,** at present to remark, that they have no fecunda-

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* See besides the figures by Graaf, Haller, Albinus and Monro, especially the beautiful one by Fl. Caldani in his *Opusc. Anat.* p. 17.

† The opinion of Herodotus respecting the black semen of Ethiopians, refuted in ancient times by Aristotle, has, to my surprise, been taken up in modern times by Le Cat, de Pauw, Wagler, &c.

‡ F. B. Ossiander asserts, "that fresh semen emitted under certain circumstances, is occasionally phosphorescent." *De causa insertionis placentæ in uteri orificium.* Gotting. 1792, 4to. p. 16.

§ Vide Fr. Schrader, *De microscopior. usu in nat. sc. et anatome.* Gotting. 1681, 8vo. p. 34.

|| W. Fr. v. Gleichen, *Ubër die Saamen und Infusionsthierchen,* Nurimb. 1778, 4to. tab. i. fig. 1.

** Consult especially Laz. Spallanzani, both in his *Opuscoli di fisica animale e vegetabile.* Milan. 1776, 8vo. vol. ii. and in his *Dissertazioni,* &c. ibid. 1780, 8vo. vol. ii.

ting principle, nor much less are the germs of future offspring (G).

529. The genital fluid gradually collected in the vesicles is retained for subsequent excretion, and by its stay experiences changes nearly similar to those of the bile in the gall bladder;—becoming more inspissated and concentrated by the removal of its watery portion.*

530. As the whole of the testis and spermatic chord abounds in lymphatic vessels which carry back to the blood a fluid with a seminal impregnation and thus facilitate the secretion of semen in the manner before described (477); so the vesiculæ seminales are likewise furnished with a similar set of vessels, which, by absorbing the inert watery part, render the remaining semen more powerful.

531. But I very much doubt whether the semen is ever absorbed during health; still more that it ever passes into the neighbouring veins; and most of all, that by this absorption, if it does occur, unseasonable venereal appetites are prevented; since, if we compare the phenomena of animals procreating at particular periods, with the constitution of those which are castrated, we must conclude, that this absorption is rather the cause of ungovernable and almost rabid lust.

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* A parodoxical opinion was formerly entertained by some, that the semen is not discharged from the vesiculæ seminales but from the vasa deferentia, and that the fluid of the vesicles is not truly spermatic and derived from the testis, but of quite another kind, secreted in peculiar glands belonging to the vesicles. This has gained some advocates among the moderns. J. Hunter, *On certain parts of the Animal Economy*, p. 27. J. A. Chaptal, in the *Journal de Physique*. Febr. 1787, p. 101. It has been refuted by Söemmerring, in the third volume of the *Bibliotheca Medica*, which I edited, vol. iii. p. 87. (H.)

532. I conceive that this end is accomplished in a very different mode, by a circumstance which occurs, as far as I have been able to discover, in no animal but man,—by *nocturnal pollutions*, which I regard among the natural* excretions, intended to liberate the system from the otherwise urgent superfluous semen, more or less frequently, according to the variety of temperament and constitution.†

533. The semen is never discharged pure but mixed with the *prostate fluid*, which is very much of the appearance of the white of egg, and has acquired its name from the organ by which it is produced, an organ of some size, of a singular and very compact texture, lying between the vesiculæ seminales and bulb of the urethra, and commonly denominated *prostate gland*. The passages for the course of this fluid are not well known, unless perhaps they communicate with the sinus of the seminal caruncle, the middle of the orifice of which opens into the urethra ‡ between the two mouths (525) of the seminal vesicles.

534. The male *urethra* is the common emissary of three different fluids, the urine, semen, and prostate fluid. It is lined with mucus which proceeds from numerous sinuses dispersed along the canal.§ We find it surrounded

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* Chr. R. Jaenisch, *De pollutione nocturna*. Gotting. 1795, 4to.

† I willingly grant that barbarous nations, of a phlegmatic temperament and copulating promiscuously, do not require this excretion; but I must contend, that it is a perfectly natural relief, in a young man, single, sanguineous, full of juices, with a strong imagination, and living high, although enjoying the completest health.

‡ Morgagni's *Adversar. Anat.* iv. fig. 1. 2.

§ J. Ladmiral, *Effigies penis humani*. L. B. 1741, 4to.

by a spongy texture, upon which lie two other *spongy bodies** of much greater thickness, constituting the greater part of the penis. The penis is terminated anteriorly by the *glans*, a continuation of the spongy texture, usually covered by a delicate and very moveable skin which is destitute of fat, and, at the corona of the gland, forms the preputium which moves over the gland as the eyelids do over the eyeball. The internal duplicature of the preputium, changing its appearance, is reflected over the gland, like the albuginea of the eye, and is beset at the corona with many Littrian† glands, similar to the Meibomian of the eyelids, and secreting a peculiar smegma.‡

585. The virile organ thus constructed, enjoys the power of *erection*; i. e. of becoming swollen and stiff, and changing its situation, from the impetuous conges-

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* Ruysch. *Observat. anat. chirurg. Centur.* page 99, fig. 76—82. and *Ep. problemat.* xv. fig. 2.-4. 6. 7.

T. H. Thaut. *De virgæ virilis statu sano et morboso.* Wirceb. 1808, 4to. fig. 1.

† Morgagni. *Adversar. anat.* 1. tab. iv. fig. 4. 1. k.

‡ This smegma in young men, especially when heated, is well known to accumulate readily and form an acrimonious caseous coagulum. The inhabitants of warm climates are particularly subject to this inconvenience, and the chief use of *circumcision* appears to be the prevention of this accumulation. We know that for this reason Christians in the scorching climate of Senegambia occasionally cut off the preputium, and that uncircumcised Europeans residing in the East, frequently suffer great inconvenience. Guido de Cauliaco, the celebrated restorer of surgery in his day, who flourished in the middle of the fourteenth century, said that circumcision was useful to many besides Jews and Saracens, "Because there is no accumulation of sordes at the root of the gland, nor irritation of it." *Chirurg.* Tr. vi. doctr. ii. p. m. 111.

tion and effusion* of blood into its corpora cavernosa either by corporeal or mental stimulus, and of detumifying and collapsing after the return of the blood† (I).

536. When in a flaccid state, it is remarkably bent at its origin from the neck of the bladder,‡ and thus perfectly adapted for the discharge of urine, but quite unfit for the emission of semen,§ because the origin of the urethra then forms an acute angle with the openings of the seminal vesicles.

537. When the penis swells from desire, the prostate fluid generally flows first, and indeed is often discharged pure, rarely together with the urine: its principal use is to be emitted with the semen, either by its albuminous lubricity correcting the viscidity of the former and promoting its emission, or contributing something peculiar to generation.

538. The emission of semen is *excited* by its abundance in the vesicles and by sexual instinct: it is *effected* by the violent tentigo which prevents the course of the urine, and, as it were, throws the way open for the semen; by a kind of spasmodic contraction of the vesiculæ seminales, a convulsion of the levatores ani** and of the acceleratores

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* Vide Theod. G. Aug. Rooze, *Physiologische Untersuchungem.* Brunsw. 1796, 8vo. page 17.

† A phenomenon worthy of remark, from the light which it throws on this function in general, is the erection so frequently observed in those who are being executed, and especially in those who are being strangled. Consult after Garmann's farrago (*de Miraculis Mortuorum*, i. xi. 7. sq.) Morgagni, *De sed. et caus. morb.* xix. 19, et sq.

‡ See Camper. *Demonstration. anat. pathologic.* L. ii. tab. iii. fig. 1.

§ Gysb. Beudt, *De fabrica et usu viscerum uropoieticorum.* L. B. 1774, 4to. reprinted in Haller's *Collect. disput. anat.* T. iii. tab. iii.

** Carpus in Mundinum, page 190, b. et 310.

urinæ, and by a short and less violent succussion of the whole system, almost of an epileptic nature, and followed by great depression of the strength * (K).

NOTES.

(A) Instances of more than two testes are extremely rare. Three, four, and even five are said to have existed, and Dionis in his Anatomy informs us, that he himself once saw three in a person of rank, who assured him that the greater part of his family were equally well provided.† Haller quotes several authors for similar instances. Unless such cases are related by an experienced medical man from his own observation, they deserve no credit, and even then must be regarded with suspicion, if anatomical examination does not prove the additional bodies to be analogous to testes no less in structure than in form and situation. The late eccentric Dr. Mounsey, who ordered that his body should either be dissected by one of his friends or thrown into the Thames, was found to have in his scrotum a small steatom, which during life must have given the appearance of three testicles.

Writers who relate these wonderful cases completely disagree in their account of the powers of the individuals,

* For which reason Zeno, the father of the Stoic philosophy, called the loss of semen the loss of part of the animating principle. (M.)

† *L'Anatomie des corps humains.* Demonstration quatrième. Sect. 1.

some asserting them to be prodigious, others greatly below those of ordinary men.

One testis is commonly larger than the other, and the right spermatic chord being for the most part shorter than the left, the right testis is generally the higher.

(B) The original situation of the testes accounts for the circumstance of their blood vessels arising from the loins, as Mr. Hunter remarked, for parts generally derive their vessels from the nearest source. The same applies to their nerves. Hence too the right spermatic artery frequently springs from the right renal as being nearer than the aorta, and the left spermatic vein frequently pours its blood into the left renal as being nearer than the inferior vena cava.

The original situation of the testes accounts also for the circumstance of the vas deferens arising from the lower part of the epididymis and bending upwards; in the fœtus this is not the case, but it is the necessary consequence of the subsequent change in the situation of the testis.*

C. The descent of the testes into the scrotum must, I apprehend, arise from the growth of their nerves and vessels, and the direction afforded by the contraction of the gubernaculum; the growth of the former, and therefore the whole process, is accounted for in the minds of some by the contraction of the latter.† Mr. Hunter's original account of the gubernaculum may not be unacceptable. "At this time of life, the testis is connected in a very particular manner with the parietes of the abdomen, at that place where in adult bodies, the

* Hunter, *A description of the situation of the testis in the fœtus, with its descent into the scrotum.* Obs. 13.

† Bichat's *Anatomie descriptive.* T. ii. p. 234.

spermatic vessels pass out, and likewise with the scrotum. This connection is by means of a substance which runs down from the lower end of the testis to the scrotum, and which at present I shall call the ligament or gubernaculum testis, because it connects the testis with the scrotum, and seems to direct its course through the rings of the abdominal muscles. It is of a pyramidal form; its large bulbous head is upwards, and fixed to the lower end of the testis and epididymis, and its lower and slender extremity is lost in the cellular membrane of the scrotum. The upper part of this ligament is within the abdomen, before the psoas, reaching from the testis to the groin, or to where the testicle is to pass out of the abdomen; whence the ligament runs down into the scrotum, precisely in the same manner as the spermatic vessels pass down in adult bodies, and is there lost. That part of the ligamentum testis, which is within the abdomen, is covered by the peritonæum all round, except at its posterior part, which is contiguous to the psoas, and connected with it by the reflected peritonæum and by the cellular membrane. It is hard to say what is the structure or composition of this ligament: it is certainly vascular and fibrous, and the fibres run in the direction of the ligament itself, which is covered by the fibres of the cremaster or musculus testis, placed immediately behind the peritonæum. This circumstance is not easily ascertained in the human subject; but is very evident in others, more especially in those whose testicles remain in the cavity of the abdomen after the animal is full grown."*

(D) We know that the skin of every part relaxes by heat and contracts by cold, although it is not muscular:

* *A Description of the situation of the testis in the fœtus, with its descent into the scrotum. Obs. 6.*

in the cold fit of an ague, it is constricted throughout so forcibly as to have acquired, during this state, the appellation of *Cutis Anserina.* The scrotum being much more lax than any other portion of the skin, experiences these effects to the greatest extent. What is termed dartos is merely thick cellular membrane.

(E) Another coat exterior to the rest, is described by M. Roux, and termed *Enveloppe fibreuse.* It is an elongated sac, large below to contain the testis and epididymis, and narrow above, afförding a sheath to the chord. It vanishes among the cellular membrane of the ring.* M. Roux considers this coat as having been known to Haller, from the following passage in Haller's account of the testicle. "Ita fit ut interiores cavæ duæ sunt; superior vasculis spermaticis circumjecta; inferior testi propria." But Haller continues thus, "Ita sæpe se habet, ut etiam aquæ vis aut in partem testi propriam solam intacta parte vasculosi funiculi, aut in istam solam, intacta testis vagina, effundatur, neque flatus impulsus de ea vaginali ad istam commeet.† He appears therefore to describe merely the tunica vaginalis of the chord and testis.

(F) The cremaster deserves a little attention. This muscle arises from the superior anterior spinous process of the ileum, from the transversalis abdominis, the internal surface of the Fallopian ligament and neighbouring parts, and, passing through the ring, spreads upon the chord, vanishing upon the beginning of the testicle. Its office is evidently to support the testicle and draw it upwards against the groin, during procrea-

* Bichat's *Anat. Descrip.* T. ij. p. 176.

† *Elementa Physiologiæ.* T. vij. p. 420.

tion. In those animals whose testes, instead of hanging in the scrotum, lie in the perinæum, the groin or the abdomen, this muscle is, as might be expected, much less considerable.

It may here be mentioned, that the human testes do not always descend into the scrotum, but occasionally remain, one or both, in the groin or abdomen. Individuals so circumstanced were called testicondi by the ancients. A ridgil is a bull in which one only has descended. In these instances the generative powers are not impaired; a testicle which has not descended is prevented by the pressure of the neighbouring parts from fully evolving itself, but such persons, it is certain, "*militant non sine gloria.*" The generative powers indeed are not impaired by the removal of one testis: the Hottentots are said always to cut away one from their sons on arriving at eight years of age to render them lighter for running. And we read in Varro, that if a bull is admitted to a cow immediately after both testes are removed, impregnation takes place, "Exemptis testiculis, si statim admiseris, concipere (vaccas.)"* This at least is certain, that some men have perfectly performed the act of copulation after castration.† In a case mentioned by Mr. Astley Cooper in his surgical lectures, the complete power remained some time after the removal of both organs, but gradually diminished.

(G) According to Haller, Lewis Hamme, a young German, discovered the seminal animalcules, and shewed them to Leuwenhoeck; and the sagacious Dutchman

* *De Re Rustica.* ii. 5.

† See Cabrol, Philostrate, Scaliger *De subtilitate*, aud Martin Schurig's *Spermatol.* Quoted in Very's *Histoire naturelle de l'Homme.*

catching eagerly at the discovery, published an account of them illustrated by plates. Hartzoeker, ambitious of the honor of the discovery, wrote upon the subject the following year, and asserted that he had seen the animalcules three years before they were observed by Hamme. The subject being the very summit of filthiness, excited the earnest attention of all Europe. Physiologists, Naturalists, Popish Priests, Painters, Opticians and Booksellers, all eagerly joined in the pursuit of the seminal animalcules, and the lascivious Charles the Second of England, commanded them to be presented to him swimming and frisking in their native fluid. Some of the curious could not find them. Others not only found them, but ascertained their length to be the $\frac{3}{100000}$ part of an inch, their bulk such as to admit the existence of 216,000 in a sphere whose diameter was the breadth of a hair, and their rate of travelling to be nine inches in an hour. They saw them too in the semen of all animals, and what is remarkable, of nearly the same size and shape in the semen of the largest and of the smallest, in the semen of the sprat and of the whale; they could distinguish the male from the female; in the semen of a ram, they beheld them moving forwards in a troop with great gravity like a flock of sheep; and in the human semen, Dalenpatius actually saw one indignantly burst its wormy skin, and issue forth a perfectly formed human being. The little creatures would swim in shoals towards a given point, turn back, separate, meet again, move on singly, jump out, and dive in again, spin round and perform various other feats, proving themselves, if not the most delicate, at least the most droll beings that ever engaged the attention of philosophers. Their strength of constitution being an important object of enquiry, they gave proofs of their vigour not only by surviving their rough passage through the urethra three, four, and seven days, but by impregnating a female at the end of this time, and on being removed from her, by impregnating even a second. Sure never was so much folly and bestiality before committed under the name of philosophy.

A. Kauw Boerhaave, Maupertuis, Lieutaud, Ledermuller, Monro Secundus, Nicolas, Haller, and indeed nearly all the philosophers of Europe, were satisfied of the existence of the animalcules. Buffon and his followers, prejudiced in favor of an hypothesis, although they did not deny that the semen contained innumerable rapidly moving particles, contended that these were not animalcules but organic particles, and Linnæus imagined them to be inert molecules thrown into agitation by the warmth of the fluid. Their reality, however, might be regarded as established. But finally to determine the question, and accurately to ascertain every circumstance relating to them, the celebrated Spallanzani began a long course of observations and experiments about the middle of the last century, unbiassed in favor of any opinion, and endeavouring to forget entirely all that had been written upon the subject. The human semen he procured from bodies immediately after death, and that of animals either after death or during life.

He found in the former, innumerable animalcules with an oval body and a tail or appendix tapering to a point. This appendix by moving from side to side propelled them forwards. They were in constant motion in every direction. In about twenty-three minutes their movements became more languid, and in two or three hours they generally died, sinking to the bottom of the fluid, with their appendices extended. The duration of their life, however, depended much upon the temperature of the weather; at 2 below o (Reaumur) they died in ¾ of an hour; while at 7° they lived 2 hours, and at 12½ 3 hours and three quarters. If the cold was not too intense, they recovered upon the temperature being raised; when only 3 or 4 below o, they recovered after a lethargy of fourteen hours and upwards: and according to the less intensity of the cold, they might be made to pass from the torpid to the active state more frequently. They were destroyed by river, ice, snow, and rain-water; by sulphur, tobacco, camphor, and electricity. Even the air was injurious to them; in close vessels, their life was prolonged to some days, and their movements were not constant and hurried. They were of various sizes, and perfectly distinct from all species of animalcules found in vegetable infusions, &c. The seminal animalcules of different kinds of animals had generally each some peculiarity. In short, Spallanzani completely confirmed the chief observations of Leuwenhoeck, and satisfactorily explained the sources of the inaccuracies of other enquirers.*

Although these beings are most numerous in the semen, he detected them occasionally in other fluids;—in the mesenteric blood of female frogs and salamanders, and in the blood of a tadpole and a calf.

It were to be wished that another Spallanzani would prosecute these enquiries.

According to Vauquelin's analysis of the semen, 100 parts contain,

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* *Opuscules de Phisique animale et vegetable*, par M. l'Abbé Spallanzani, *traduits de l'Italien*, par Jean Senebier. T. ii. *Observations et experiences sur les petits vers spermatiques de l'Homme et des Animaux.*

Of water - - - -	9 . 0
Mucilage - - -	6
Phosphate of lime - - ..	3
Soda - - - -	1

In some days it putrifies and becomes covered with the byssus septica.*

(H) Mr. Hunter's arguments are very forcible. 1. "The semen, first discharged from the living body, is of a blueish white colour, in consistence like cream, and similar to what is found in the vasa deferentia after death; while that which follows is somewhat like the common mucus of the nose, but less viscid. The semen becomes more fluid upon exposure to the air, particularly that first thrown out; which is the very reverse of what happens to secretions in general. The smell of the semen is mawkish and unpleasant, exactly resembling that of the farina of a Spanish chesnut; and to the taste, though at first insipid, it has so much pungency, as, after some little time, to stimulate and excite a degree of heat in the mouth. But the fluid contained in these vesiculæ in a dead body, is of a brownish colour, and often varies in consistence in different parts of the bag, as if not well mixed. Its smell does not resemble that of the semen, neither does it become more fluid by being exposed to the air." On opening two men immediately after death, the contents of the vesiculæ were of a lighter colour than he usually found them in persons who had been some time dead, and in one of the instances so fluid as to run out upon cutting the vesiculæ, but they were similar to the semen neither in colour nor smell. An examination of the vesiculæ of the horse, boar, rat, beaver, and guinea-pig, afforded the same results. In the last animal, the

* *Annales de Chemie.* T. x.

contents near the fundus of the vesiculæ were viscid, and gradually firmer, till, near the opening into the urethra, they were as solid as common cheese, and no such substance could be detected in the vagina of the female after her union with the male. 2. During lasciviousness, the testicles swell, and they become painful, if the semen is not discharged; in coition, it may be added, they are drawn forcibly by the cremaster against the pubis, as if to assist the discharge of their contents at the period of emission. 3. In the old and debilitated, the vesiculæ are as full as in the young and vigorous. 4. Nay, in four men who had each lost a testicle, the vesicula on one side was equally full as on the other, although they had survived the operation a considerable length of time. The same was discovered in two cases, where, by mal-formation, one testicle had no communication with the corresponding vesicle. In the gelding and the stallion their contents are similar and nearly equal in quantity. The vas deferens has no communication in some animals with the vesiculæ, and in others, as the horse, where a communication does exist, the common duct is not of sufficient length to permit the regurgitation of the semen into the vesiculæ. 4. Some animals, especially among the carnivora, have no vesiculæ seminales, yet in their copulation they differ not from those which have. M. Richerand indeed asserts, that animals destitute of these organs are longer in coition than others, from having no reservoir for an accumulation of semen.* But he is mistaken. For on inspecting Cuvier's account of animals without and with vesiculæ, no connection whatever appears between their presence or absence and the length of copulation.

In opposition to these arguments I have only to remark,

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* *Elemens de Physiologie.* Chapitre x.

that a fluid gently propelled along the vas deferens, does not pass into the urethra, but regurgitates into the vesiculæ,* and that in a case of seminal weakness which I lately saw, the act of straining at the water-closet instantly discharged from the urethra, without the least sensation, a large quantity of a fluid, which the patient, who was of course unprejudiced in favour of any opinion, assured me was exactly similar in colour, consistence, and odour to that of a nocturnal emission. The compression could not have squeezed this fluid from the testes. If a partizan of Mr. Hunter should say that the extremities of the vasa deferentia afforded it, I reply that Mr. Hunter found them full of the same kind of fluid as the vesiculæ.

(I) Accumulation of blood it is supposed may be produced in three ways. 1. By an impediment to its return: but there is no reason whatever to ascribe the ordinary erection to compression. 2. By an increased flow of blood to a part, so that the vessels receive it faster than they convey it away. Here the vessels of the part in which the accumulation exists, are said by some to act more violently than usual; by others, the neighbouring larger vessels which supply these: their frequency of action, however, is not increased, but always remains correspondent with that of the heart. Were the vessels of the part itself to act more violently than usual, that is to say, to contract to a smaller and relax to a greater dimension than usual, more blood would indeed subsist in them during their relaxation, but less than usual would subsist in them during their contraction, and there could be no accumulation, no inflammation. If the neighbouring large vessels act more violently than usual, they may be conceived to produce an accumulation of blood and a

* Winslow, Ruysh, Duverney and others, quoted by Haller.

distension of the smaller vessels. 3. If the vessels of any part become dilated and do not contract in proportion, this circumstance will be sufficient to produce an accumulation, without any necessity for supposing an increased action of the neighbouring larger vessels. This explains inflammation: and in Bichat's *Anatomie Descriptive*, this explanation is given of erection. The corpora cavernosa which always contain florid blood, spontaneously dilate, and accumulation ensues. For this purpose it is not necessary that they should be muscular, but Mr. Hunter asserts their muscularity: in a horse he found them muscular to the eye, and they contracted upon being stimulated.

As to the final cause of erection, the organ, by acquiring increased bulk, firmness and sensibility, becomes adapted for both affording and experiencing to the utmost extent the effects of friction both as exciting pleasure and as stimulating the secreting vessels; the urethra, by becoming longer and narrower, renders the emission more forcible.

(K) The discharge of semen resembles the discharge of fluids from all glands. It is excited by the abundance of the fluid, by mental stimulus, or by mechanical irritation of the extremity of the excretory duct, for in such a point of view must be regarded the friction of the glans penis in copulation. The fluid is accumulated in the bulb of the urethra, for it must be accumulated somewhere to be emitted so copiously, and no other use can be assigned to the bulb, and if the vesiculæ do not receive it, no other part but the bulb can, and besides it is upon the bulb that the muscular contraction of the venereal paroxysm first acts. " The semen acting as a stimulus to the cavity of the bulb of the urethra, the muscles of that part of the canal are thrown into action, the fibres nearest the bladder probably act first, and those more forward in quick succession, and the semen is projected with some force. The blood in the bulb of the urethra is by the same action squeezed forward, but requiring a greater impulse to propel it, is rather later than the semen, on which it presses from behind; the corpus spongiosum being full of blood, acts almost as quick as undulation, in which it is assisted by the corresponding constriction of the urethra, and the semen is hurried along with a considerable velocity."*

(L) If Gall is right in placing the seat of sexual desire in the head, this kind of erection may be explained by supposing the irritation, arising in the cerebellum from the great accumulation of its blood, to produce a correspondent irritation in the organs of generation: thus the epileptic paroxysm is not unfrequently accompanied by an emission. Nocturnal emissions occur most frequently after a person has been long in bed and supine—the cerebellum the lowest part.

(M) Zeno's practice was conformable to his principles. He embraced his wife but once in his life, and then out of mere politeness.

Epicurus, Democritus, &c. were nearly of the same opinion with Zeno, and the Athletæ, that their strength might be unimpaired, never married. The rabbies, in their anxiety to preserve their nation, are said to have ordered, with the view of preventing the loss of vigour, that a peasant should indulge but once a week, a merchant but once a month, a sailor but twice a year, and a studious man but once in two years.

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* Hunter, *Observations on the glands situated between the rectum and bladder, called vesiculæ seminales. Obs.* 45.

SECT. XXXVII.

OF THE GENITAL FUNCTION OF WOMEN IN GENERAL.

539. As the male organs are fitted for affording, so the female organs are fitted for receiving, and are correspondently opposite to the former. In some parts, the organs of each sex are very analogous to each other in structure. Thus the *clitoris* lying under the pubis in the superior commissure of the labia, agrees in many respects with the penis of the male, although distinct from the urethra, and imperforate and extremely small in well-formed women. It is recorded to have been, in some adult females, of as comparatively large size as we stated it usually to be in the fœtus (492), and these instances probably gave rise to most of the idle stories of hermaphrodites.* Like the penis, it has its corpora cavernosa, is capable of erection, covered with a prepuce, and secretes a smegma† not unlike the Littrian (525).

* Vide Haller in the *Comment. Soc. Scient.* Gotting. vol. i. p. 12, sq. Plates are given by Gautier in his *Observ. sur l'hist. Nat.* 1752, 4to.

† In warm climates it too is liable to accumulation and acrimony; and has hence given occasion to the custom of female circumcision in many hot parts of Africa and Asia. Carst. Niebuhr has given a representation of the genitals of a circumcised Arabian female, eighteen years of age, whom he himself was singularly fortunate in examining during life, when on his oriental tour. *Beschreib. von Arabien.* p. 77. and Osiander's *Deukwürdigkeiten für die Heilkunde*, &c. vol. ii. tab. vi. fig. 1

540. From the clitoris the *nymphæ* descend, also occasionally of great size,* the source of other idle tales,† and, like the clitoris, possessing a high degree of sensibility. They appear in some measure to direct the stream of urine, because the *opening of the urethra*, which is very short in females, and frequently ciliated, as it were, with small papillary folds,‡ lies under their commencement.

541. Under the termination of the urethra lies the *opening of the vagina*, surrounded with various kinds of cryptæ; v. c. the lacunæ uretheriçæ of De Graaf,§ and the orifices of the prostates, as they are improperly termed, of Casp. Bartholin,|| which secrete an unctuous mucus.**

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* Their number has likewise been found various. Vide Neubauer *De triplici nympharum ordine.* Jenæ 1774, 4to.

† I allude to the singular ventral skin of the Hottentot women. Wilh. Ten. Rhyne, from personal inspection long ago, considered it as enormous pendulous nymphæ. *De promontorio b. spei.* p. 33. I have treated this point at large in my work, *De Gen. Hum. Var. Nat.* 242. ed. 3. Steller relates something similar in regard to the Kamtschatkan women. *Beschr. v. c. Lunde Kamtschatka.* P. 300. (A)

‡ I find the opening of the urethra surrounded with very beautiful cutaneous cilia of this kind, in a remarkable specimen of the genitals in a woman upwards of eighty years of age. The hymen is entire, and all the other parts most perfectly, and, as it were, elaborately formed. They are preserved in my museum, and my friend and colleague, Osiander, has represented them in a plate. Libro Citato. Tab. v.

§ See Jo. James Huber's plates of the uterus, among those of Haller. fasc. 1. tab. 2. fig. 1. g.

|| Ibid. fig. 1. b. b.—fig. 5. d.

** Such also are the two foramina, very frequently observed in living women, by J. Dryander, at the extremity of the vagina. Nic. Massa's *Epistol. Medicin.* t. 1. p. 122. b.

542. Across the opening of the vagina, the *Hymen** is extended,—a membrane generally circular, found, as far as I know, in the human subject alone, and of no physical use hitherto discovered.

The remains of the lacerated hymen become the *carunculæ myrtiformes,* which are of no regular number, and are infallible signs of the loss of virginity. (B)

543. The *vagina,* ascending between the urinary bladder and rectum, consists of a very vascular cellular parenchyma; is surrounded inferiorly by the *constrictor cunni,*† and lined internally with a very soft coat, which is marked by two *columns of rugæ,*‡ an interior and posterior,§ pouring forth a mucus into its cavity.

544. Upon the superior part of the vagina, rests the *uterus,* suspended on either side by its broad ligaments. Its cylindrical cervix‖ is embraced by the vagina, and perforated by a narrow canal, which, like the vagina, is marked by rugæ, denominated the arbor vitæ, and is generally lined with a viscid mucus at each extremity, but particularly at the superior.

545. The substance of the uterus is peculiar, a very dense and compact parenchyma,** abounding in blood-

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* John Wm. Tolberg *De Varietate Hymenum.* Hal. 1791, 4to. Osiander l. c. tab. 1.—vij.

† Eustachius. Tab. xiv. fig. 1. x. x.

Santorini. *Tab. Posth.* xvij. 1. 1.

‡ Huber *De Vaginæ Uteri Structura Rugosa, necnon de Hyeme,* Gotting. 1742, 4to.

§ Vide Haller's *Icones Anat.* fasc. ij. tab. vj. fig. 1. 2.

‖ Roederer *Icones Uteri Humani.* tab. vij. fig. 2. 3. 4.

** J. Gotter. Weisse (Præs. Rud. Boehmer) *De Structura Uteri non musculosa, sed celluloso Vasculosa.* Vitemb. 1784, 4to.

J. G. Walter *Was ist Geburtshülfe.* Berlin. 1808, 8vo. p. 54.

vessels, which run in a curious serpentine direction* and are destitute of valves. It has also a supply of lymphatics;† and a great number of nerves,‡ whence its remarkable sympathy with other parts.

546. The uterus is covered externally with peritonæum; its internal cavity is small, and lined, especially at the fundus, with a soft and very delicate spongy membrane, which is composed, according to some, (92) of colourless arteries and veins, (92) and,§ according to others, of lymphatics.||

547. With respect to its muscularity, asserted by some** and denied by others,†† I may remark that I have never yet discovered a true muscular fibre in any human uterus which I have ever dissected, whether impregnated or unimpregnated, recent or prepared; but it must be allowed, that the fibres, termed by some muscular, have qualities very different from any others observable in the system. I am daily more convinced that the uterus has no true irritability, (301) but a vita propria, (42) correspondent with the peculiar motions and functions of the uterus,

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* Id. *De Morbis Peritonæi.* tab. i. ii.

† Mascagni. tab. xiv.

‡ Walter's *Tab. Nerv. Thorac. et Abdom.* tab. 1. J. F. Osiander's *Commentatio premio Regio ornata, qua edisseritur uterum nervos habere.* Goett. 1808, 4to.

§ Ferrein in the *Mémoires de l'Acad. des Sc. de Paris.* 1741, p. 375.

|| Mascagni. l. c. p. 4.

** See v. c. Sue in the *Mem. présentés,* vol. v.

L. Calza. in the *Atti dell' Acad. di Padova.* T. 1. II.

†† Walter. *Betracht. über die Geburstheile des weibl. Geschl.* p. 25, sq.

Chr. H. Ribke. *über die Structur der Gebährmutter.* Berl. 1793, 8vo. but chiefly J. F. Lobstein, *Magasin Encyclopedique redigé par Millin.* vol. XLIX. 1803. T. 1. p. 357, sq.

which are not referrible to any properties common to the similar parts, (39-41) and which appeared to the ancient physicians and philosophers so peculiar, that the uterus was by them denominated an animal within an animal. (C)

548. From the angles of the roof or fundus of the uterus arise on each side the *Fallopian tubes*,† narrow and tortuous canals, running in the upper part of the duplicature of the broad ligaments, similar in texture to the vagina, but internally destitute of rugæ, and lined by a very soft and delicate spongy substance.

549. The extremity which opens into the abdomen is not only larger than that which opens into the uterus, but is surrounded by laciniated or digitated *fimbriæ*, singular and elegant in structure, which are probably of great importance in conception, since they appear to become turgid as well as the tubes themselves, during the venereal œstrum, and to embrace the ovaria over which they lie.

550. The *ovaria*, or, as they were termed previously to the time of Steno,‡ the female testes, are composed of a tough and almost tendinous covering, and a dense and closely compacted cellular substance, which contains in each ovarium about fifteen ovula, called Graafian, viz. vesicles, or rather drops of albuminous yellow serum, which coagulates like white of eggs, if the recent ovarium is plunged into boiling water.

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* I have treated of these points at large in my programma *De vi vitali sanguini deneganda*, &c. Gott. 1795, 4to. p. 15, sq.

† Fallopius. *Observ. Anat.* 197.

‡ Steno was the first who asserted that the testes of women were analogous to an ovarium, 1667. *Elementor. Myologiæ Specimen*, p. 117, sqq.

551. Such an albuminous drop appears to be what the female contributes in the business of conception, and it is probable, that, during the adult state, these drops become mature in succession, so that they one by one force their way and finally burst the covering of the ovarium, and are received by the abdominal extremity of the Fallopian tube.

552. Besides the albuminous drop which escapes from the ovarium, another fluid, improperly styled *female semen* by the ancients, is poured forth during the venereal œstrum. Its nature, source, and quantity, are enveloped in no less mystery than its office.*

NOTES.

(A) The Hottentot peculiarity is a prolongation of the labia.†

(B) The various size of the opening of the vagina in virgins and women, and the various firmness of the organs, must ever leave those in uncertainty who can on their marriage indulge in sensual doubts. We read in Hume that Henry the Eighth, who certainly had his share of experience, boasted his discrimination; but an eastern monarch, whose experience was infinitely greater, confessed his ignorance.

The lovers of Italian literature know how strictly natural is every description of Boccacio's, and will recollect

* Respecting this problematical fluid see Carpus in Mundinum, p. cxcviii. sqq. and cccviij.

Harvey *De Generatione Animal.* p. 95.

De Graaf *De Mulierum Organis*, p. 194.

† Le Vaillant, *Voyage dans l'Interieur d'Afrique*, Dr. Somerville, *Med. Chr. Trans.* 1816.

his story of the daughter of the Sultan of Babylon, "Essa che con otto uomini forse dicemilia volte giacuta era, a lato a lui (al Re del Garbo) si conciò, per pulcella, e fece gli credere, che cosi fosse."*

C. The muscularity of the uterus is allowed by Malpighi, Morgagni, Mery, Littre, Astruc, Ruysh, Monro, Vieussens, Haller, &c.

Mr. Charles Bell has a paper in the fourth volume of the Medical and Surgical Society, which it is necessary to quote freely, in order to give an accurate description of the muscular structure of this organ.

"The muscularity of the uterus is proved by direct ocular demonstration of the fibres in dissection, by the thickness of the fibres corresponding with their degree of contraction, by the visible action of the human uterus during life, by the resemblance of the laws of its contraction, (as felt and as perceived in its consequences) to those which govern the contraction of other hollow viscera, and lastly, by the vermicular and intestinal motions of the uterus, as seen in experiments upon brutes."

"The most curious and obviously useful part of the muscular substance of the uterus has been overlooked; I mean the muscular layer of fibres which covers the upper segment of the gravid uterus. The fibres arise from the round ligaments, and regularly diverging, spread over the fundus until they unite and form the outermost stratum of the muscular substance of the uterus."

"The substance of the gravid uterus is powerfully and distinctly muscular; but the course of the fibres is here less easily described than might be imagined. Towards the fundus the circular fibres prevail; towards the orifice the longitudinal fibres are most apparent; and, on the

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* *Decamerone*, vol. 1.

whole, the most general course of the fibres is from the fundus towards the orifice. This prevalence of longitudinal fibres is undoubtedly a provision for diminishing the length of the uterus, and for drawing the fundus towards the orifice. At the same time these longitudinal fibres must dilate the orifice, and draw the lower part of the womb over the head of the child."

"In making sections of the uterus while it retained its natural muscular contraction, I have been much struck in observing how entirely the blood vessels were closed and invisible, and how open and distinct the mouths of the cut blood vessels became when the same portions of the substance of the uterus were distended and relaxed."
"A very principal effect of the muscular action of the womb is the constringing of the numerous vessels which supply the placenta, and which must be ruptured when the placenta is separated from the womb."

"Upon inverting the uterus and brushing off the decidua, the muscular structure is very distinctly seen. The inner surface of the fundus consists of two sets of fibres, running in concentric circles round the orifices of the Fallopian tubes. These circles at their circumference unite and mingle, making an intricate tissue. Ruysch, I am inclined to believe, saw the circular fibres of one side only,* and not adverting to the circumstance of the Fallopian tubes opening in the centre of these fibres, which would have proved their lateral position, he described the muscle as seated in the centre of the fundus uteri. This structure of the inner surface of the fundus of the ute-

* Discovered by Weitbrecht, and first accurately observed by Dr. Hunter.

rus is still adapted to the explanation of Ruysch, which was, that this produced contraction and corrugation of the surface of the uterus, which the placenta not partaking of, the cohesion of the surface was necessarily broken."

"Further, I have observed a set of fibres of the inner surface of the uterus which are not described. They commence at the centre of the last described muscle, and having a course at first in some degree vorticose, they descend in a broad irregular band towards the orifice of the uterus. These fibres co-operating with the external muscle of the uterus, and with the general mass of fibres in the substance of it, must tend to draw down the fundus and lower segment of the uterus over the child's head."

"I have not succeeded in discovering circular fibres in the os tunicæ corresponding in place and office with the sphincter of other hollow viscera, and I am therefore inclined to believe, that, in the relaxing and opening of the orifice of the uterus, the change does not result from a relaxation of muscular fibres surrounding the orifice. Indeed, it is not unreasonable to conceive that the contents of the uterus are to be retained during the nine months of gestation by the action of a sphincter muscle. The loosening of the orifice, and that softening and relaxation which precede labour, are quite unlike the yielding of a muscular ring."

SECT. XXXVIII.

OF THE MENSTRUA.

553. An important, and indeed the most frequent function of the uterus, is to afford a menstrual fluid during about thirty years,—a law imposed upon no other species of animal.*—Woman, in the words of Pliny, is the only menstruating animal.—The females of no nation hitherto explored, are exempt from this law,† since it is among

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* Most writers upon Natural History, and among the rest Buffon, allow the existence of menstruation in other animals, especially in the simiæ. But after carefully observing the females of the species of simiæ mentioned by him, (v. c. of the simia *sylvanus*, and *cynomolgus*, the papio *maimon*, &c.) for a number of years, I easily discovered that these supposed catamenia in some did not occur at all, and in others of the very same species, were merely a vague and sparing uterine hemorrhage, *observing no regular period.*

† There is hardly occasion at present to refute the unfounded assertion, that in some nations, particularly on the Continent of America, the women do not menstruate. This opinion appears to have originated from the circumstance of the Europeans who visited those countries and saw innumerable women nearly naked, never finding any menstrual stains upon them. For this there might be two reasons. First, the American women are, by a happy prejudice, regarded as infectious, while menstruating, and remove from society to the advantage of their

the requisites in the female sex, for the propagation of the species.

554. The commencement of this function usually occurs about the fifteenth year, preceded by symptoms of plethora, by a sense of heaviness in the chest, and of tension in the loins, by lassitude of the limbs, &c. From the first of these symptoms, a reddish fluid generally flows from the genitals, becoming by degrees of a more bloody colour, and at length completely so. This has a peculiar odour, coagulates but imperfectly, and differs also in other respects from blood. It continues to flow slowly for some days, and the unpleasant symptoms above described in the mean time cease.

555. This red discharge returns after this period about every four weeks, and continues about six days, during which time a healthy woman is supposed to lose, perhaps, from five ounces to half a pound of blood.

556. This action is usually *discontinued* during pregnancy or lactation. It entirely *ceases* after existing about thirty years; that is, in our climate about the forty-fifth year.

557. By some, the vagina, by others, and with more probability, the uterus, is considered the *source* of this discharge. Arguments adduced against the latter opinion from the examples of women menstruating although pregnant, or having the uterus imperforate or prolapsed, prove only the extraordinary compensating powers of nature, who employs new ways, when the customary are im-

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health into solitary huts. Again, their extreme cleanliness and the modest position in which they place their limbs, would prevent any vestige of the catamenia from being observable, as Adr. Van Berkel expressly states in his *Reisen nach Rio de Berbice und Surinam*, p. 46.

peded. On the other hand, the dissection of many women who have died during menstruation, has discovered the cavity of the uterus bedewed with the catamenia.* I say nothing of the a priori argument,—that the purpose of menstruation is probably to render the womb fit for pregnancy and for nourishing the fœtus.† For the same reasons, the arteries rather than the veins appear to be the source of the discharge.‡

558. The investigation of the causes of the periodical return of this hemorrhage is so difficult, that we can obtain nothing beyond probability, and shall not dare to offer any thing merely conjectural.§

The proximate cause is supposed to be a *local*‖ plethoric

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* See, for example, Morgagni's *Adv. Anat.* 1. tab. iii. M. M. M.

† L. H. Chr. Niemeyer, *De menstruationis fine et usu.* Gott. 1796, 8vo.

‡ J. Fr. Osiander, on the contrary, argues on the side of the veins *Diss. de fluxu menstruo atque uteri prolapsu.* Gott. 1808, 4to. p. 14.

§ Among other writings, Abr. D'Orville's *Disquisitio causæ menstrui fluxus* (Præs. Hallero) may be consulted by those who feel interested with this enquiry. Also Gisb. Verz. Muilman. *An ex celebrata hactenus opinione de plethora universali vel particulari vera fluxus menstrui causa explicari possit?* L. B. 1772, 4to. And Theod. Traug. Jaehkel. (Præs. Krause) *Aetiol. fluxus menst.* Lips. 1784, 4to.

‖ The *universal* plethoric orgasm, as it was termed, which some formerly regarded as the cause of menstruation, has been long since refuted by more enlightened physiologists. To the arguments of the latter, I may be permitted to add the instance of the celebrated Hungarian sisters, who from monstrous formation were united together, (63 Note). Although the same blood flowed in each on account of the union of the abdominal blood vessels at the loins, they differed frequently both in the period and the quantity of their menstruation.

congestion;—an opinion with which the symptoms preceding menstruation, and the abundance and nature of the uterine vessels, agree very well.

Among the remote causes may be enumerated the erect posture peculiar to the human race; the peculiar parenchyma of the uterus, and its vita propria.

It will be better to confess our ignorance of the cause of its periodical return, than to indulge in vain hypotheses: all the periodical phenomena of health and disease, *which continue more than twenty-four hours*, are among the mysteries of animal nature.

SECT. XXXIX.

OF CONCEPTION AND PREGNANCY.

559. We now come to the functions for which the genital organs are given us—to conception and the propagation of the species,—in treating which, we shall first merely describe the phenomena which are observed in that admirable and truly divine process, and afterwards investigate the powers by which they are produced.

560. In the first place, it is worthy of remark, that the human race, unlike most animals, does not copulate at certain periods of the year,* but that with it every season is equally favourable to the flame of love.

561. When a woman admits the embraces of a man,† and both burn with that animal instinct which is superior to all others in universality and violence, the uterus, I conceive, swelling with a kind of inflammatory orgasm,‡(A)

* Unless the observation first made by Wargentin, in Sweden, that there is a greater proportion of births in September, which corresponds with the preceding December, be considered as relative to this point. Vide *Swensk. Vetensk. Acad. Hadlingar*, 1767, vol. xxviii. p. 249 et seq.

† Of the various circumstances of this act, I have spoken in my work *De gen. hum. variet. nat.* p. 17 et sq. ed. 3.

‡ v. the two instances seen by Ruysch, of uteri immediately after impregnation. The one of a common woman, murdered by her paramour immediately after connection. *Adversar. Anat. Medico Chirurg.*

and animated by its vita propria (547), draws in, as it were, the semen ejaculated by the male,* and appears to pour forth a fluid of its own against it (552); the tubes become rigid, and their fimbriæ embrace the ovaria, in one of which a ripe Graafian vesicle bursts like an abscess, and its albuminous drop of fluid, being absorbed by the abdominal opening of the tube, is conveyed to the womb.

562. After the escape of this drop from the ovarium, the lips of the wound are closed by an external cicatrix, and the remaining vascular membrane is converted into a *corpus luteum*.† This is at first hollow, and full, as I think, of a plastic lymph, which in progress of time becomes a fleshy nucleus,‡ surrounded with a thick cortex, remarkably vascular.§ (A)

Dec. i. tab. ii. fig. 3. The other of a married woman, impregnated a few hours previously, and killed in the act of adultery by her husband. *Thesaur. Anat.* vi. p. 23 et seq. tab. v. fig. 1.

* If we consider the impetus with which the semen is emitted, and as it were swallowed by the uterus, and how small a quantity is proved, by experiments on animals, to be sufficient for impregnation, we shall be able to explain those well established cases of conception, where the hymen was imperforate—cases brought forwards in support of the existence of a *seminal aura.*

† See J. Chph. Kuhlemann's *Observat. circa negot. generat. in ovib. factæ.* Gotting. 1753, 4to. c. *f. ae.*

‡ See W. Hunter's *Anatomy of the gravid uterus.* Tab. xv. fig. 5. tab. xxxix fig. 3. tab. xxxi. fig. 3.

§ It is a celebrated question of great importance both in physiology and forensic medicine, and much agitated in late years, whether a corpus luteum is the consequence of a fruitful coition alone, and therefore an infallible sign of conception, or whether it can occur independently of coition, and may therefore exist in virgins. I trust that I have settled this dispute according to the truth, and have shown the

563. After impregnation, the canal which runs along the cervix of the uterus, is thoroughly closed, especially towards its superior or internal orifice (544), so that superfœtation, properly so called,* cannot naturally take place. There are scarcely any constant and infallible signs by whch the woman herself can be very certain of the changes which occur within during conception.†

564. The internal surface of the uterus becomes lined with plastic, and, as it were, inflammatory lymph (15), which forms the tunica *caduca,* or *decidua* of Hunter.‡

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conditions under which it may occasionally take place even in virgins. *Specimen physiologiæ comparatæ inter animantia calidi sanguinis vivipara et ovipara,* in the *Commentat. Soc. Reg. Scientiar. Gotting.* vol. ix. p. 109 et seq.

* That different conceptions may occur from the repetition of coition after very short intervals, is proved by the instances of adulterous women, who have brought forth twins resembling different fathers in the colour of their skin: viz. of black women who have brought forth a black and a mulatto, and of European women who have brought forth a white and a mulatto. (B.)

† Ad. El. Siebold, *De diagnosi conceptionis et graviditatis sæpe dubia.* Wirceb. 1798, 4to.

Gm. Theoph. Kelch. *De symptomatibus et signis graviditatis earumque causis.* Regiom. 1794, 4to.

‡ Aretæus Cappadox (*De Causis et Sig. Morb. Diuturn.* l. 11. c. ii. p. 64 et seq. Boerhaave's edition) seems the first who gave a true account of the origin of this membrane, the more accurate knowledge of which we owe to Wm. Hunter.

After the revival of anatomy, Fallopius restored the knowledge of it. *Observ. Anat.* p. 207. "The *chorion* is either the chorion simply so called, or the *spongy, tomentous, fungous, filamentous,* the *reticulated* of the moderns, the *involucrum membranaceum* of Albinus." Ruysch, as far as my knowledge extends, gave the first plate of it. *Thes. Anat.* v. tab. i fig. 1. F. B. C. G.

This is said to consist of two laminæ, the *crassa* investing the uterus, excepting at the orifices of the tubes and of the canal of the cervix;* the other being, after the ovulum begins to be formed and to take root in the decidua, continued over the rest of the ovum, as the peritonæum is continued over the abdominal viscera, is denominated the *caduca reflexa*.†

565. The *ovulum* is produced before the embryo which it is intended to receive, but scarcely begins to be formed before the second week from conception. Previously to this period, I very much doubt whether any vestige of human conception has ever been visible.

566. This ovulum consists, besides the external accessary covering afforded by the *caduca* of Hunter, of two proper velamenta or membranes.

Of an exterior,—the *chorion*§ of the moderns; the external surface of which is, from the first, nearly covered with inexpressibly beautiful knotty flocculi; whence it has been called the *flocculent, leafy*, or *mossy*, *chorion*. By means of these flocculi, which are the rudiments of the fœtal portion of the future *placenta*, the ovulum takes root, as it were, in the uterine decidua (564).

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* W. Hunter, l. e. tab. xxxiv. fig. 3—6.

† See B. S. Albinus' Annot. acad. L. 1. tab. iii. fig. 1. e.
W. Hunter, l. c. tab. xxxiii. fig. 1—4.

‡ Respecting the membranes of the ovulum and their connection with the uterus and embryo, vide J. F. Lobstein, *Uber die Ernährung des fœtus*. Halle. 1804, 8vo.

§ The *Membrana media* of Rouhault, Haller, &c. For the various synonyms and homonyms of the membranes of the ovum, consult Haller's *Elem. Physiol.* Vol. viii. P. 1. p. 194. sq. and Tabarran's letter to Bartoloni, in the *Atti di Siena*. T. vi. p. 324. sq.

Of an interior, styled *amnion*, possessing no blood-vessels (5), delicate, but remarkably tough.

567. These two proper membranes of the ovulum differ very much from each other in size the first week after the formation of the ovum; the chorion appears a large bladder, to which the amnion, like a much smaller bladder, adheres in that part only which nearly corresponds with the centre of the external flocculent surface of the chorion.

The remaining space between the chorion and amnion is filled by a clear water, which may be called the *liquor chorii*, of doubtful origin and short duration.

For since the amnion increases more rapidly than the chorion, and approximates to the latter even during the first months after conception,* in proportion to its approximation must this fluid necessarily be absorbed.

568. The internal membrane of the ovum is filled, from its first formation (565) to the last moment of pregnancy, with the *liquor amnii*,† an aqueous fluid, of a yellowish colour, nearly inodorous, of a bland and scarcely saltish taste, commonly thought nourishing, and compared to albumen, from which, however, more accurate investigation proves it to differ considerably.‡

Its source is doubtful, and cannot be referred to the

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* See Hunter's figures (imaginary indeed) l. c. tab. xxxiv. fig. 9. 8. 7.

† Paul. Scheel, at the end of his *Commentat. de liquoris amnii asperæ arteriæ fœtuum human. natur. et usu.* Hafn. 1799, 8vo.

C. H. D'Zondi. *Supplementa ad anat. et physiolog. potissimum comparatum.* Lips. 1806, 4to.

‡ Steph. J. Van Geuns *De natura et utilitate liquoris amnii.* Ultraj. 1793, 4to.

fœtus or umbilical chord, since it exists in abortive ovula containing neither.

Its quantity is inversely as the size of the fœtus. Hence we may conjecture that its use is rather to defend the fœtus while nearly gelatinous and most liable to suffer from external injuries, than to afford nourishment. That the portion of fluid which occasionally, although rarely, and therefore not naturally, enters the stomach of the fœtus, is not destined to nourish it, is evident from the nature of this fluid, and from the state of the chylopoietic system of the fœtus: to omit arguments deduced from acephalous fœtuses, &c.*

569. The embryo, which swims in this fluid, suspended by the umbilical chord, like fruit by its stalk, begins to be formed from about the third week after conception:† at first it appears to be of a rather globular shape, resembling a little bean or kidney, from which the rudiments of the extremities grow and the face is at length formed, and s. p.†

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* I trust no one will adduce in objection accounts of fœtuses destitute of umbilical vessels, who has read those accounts with any attention.

† There is no occasion in our times to refute the false remarks and figures, given by Mauriceau, Kerckring, and others, of fœtuses, one or a few days old.

The reasons of my fixing upon this term, I have explained at large in the *Medicin. Bibliothek.* vol. ii. p. 673, sq. How remarkably this was afterwards confirmed by fact, will be found in the same work, vol. iii. p. 727.

Those who have not an opportunity of inspecting the fragile primordia of our race, may consult the excellent plates in Ruysch's *Thesaur. Anat.* vi. tab. ij. fig. 2. 3. 4. 5. 8. 10. *Thesaur.* x. tab. iii. fig. 1.

Also B. S. Albinus' *Annotat. Acad.* L. 1. tab. v. fig. 4. 5.

570. By nature, woman is *uniparous*, conceiving but one fœtus. Frequently, however, she produces twins, the proportion of which to single births, Süssmilch estimates as 1 to 70.* In these cases, each child has usually its own amnion, but there is a common chorion.†

571. The medium of connection between the mother and the child, are the umbilical chord and the placenta into which it is distributed.

572. The *umbilical chord*, which appears coeval with the embryo, varies exceedingly in length and thickness, in the place of its insertion into the placenta, in its varicose knots, &c. It generally consists of three blood vessels twisted spirally together, viz. a vein running to the liver of the fœtus, and two arteries arising from its internal iliacs or hypogastrics. They are separated from each other by cellular septa of various directions,‡ and are

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Trew in the *Commerc. Litter. Noric.* 1739. tab. iii. fig. 4. 5.

Abr. Vater's *Mus. anatom. propr.* tab. viij. fig. 2. 4. &c.

And, Instar Omnium, Sœmmerring's *Icones Embryon Humanor.* Francof. ad Mœn. 1799. fol.

* This proportion is not very constant, and there is some national variety in this respect. (C.)

Egede expressly mentions the infrequency of twins among the Greenlanders, in his *Descr. du Grönland*, p. 112.

Their remarkable frequency among the people of Chili is asserted by Molina, in his *Saggio sur la Storia Naturale del Chili*, p. 333.

† See Denman's *Engravings tending to illustrate generation and parturition.* Lond. 1787. fol. tab. ix.

Twins are very rarely contained in a common amnion. Vide J. de Puyt in the *Verhandel. der Zeeuwsch Genootsch. te Ulissingen.* T. ix. p. 423, sq.

‡ W. Noortwyk. *Uteri Humani Gravidi Anatome*, tab. iii. fig. 5. 6. 7.

throughout narrowed internally by nodules, or the *quasi-valves* of Hoboken.*

They are collected into a chord by means of a cellular membrane, which is full of a singular very limpid fluid called Whartonian, resembling gelatine in appearance, and is surrounded externally by a continuation of the amnion.

573. At the part of the chord which is united to the fœtus, there runs the *urachus*,† which arises from the fundus of the urinary bladder and lies between the two umbilical arteries. In the human subject, it is pervious but for a very short distance, and, indeed, soon disappears altogether. In other mammalia it leads to the allantoid,‡ which is universally acknowledged to be absent in the human fœtus. For I think that the problematical *vesicula umbilicalis*, found in human ovula between the chorion and amnion,§ is not analogous to the allantoid,‖ but to the *tunica erythroides*, found in the ova of some mammalia, and to the vitellary sac of the incubated egg. It is found in healthy human ovula, the second or third

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* Hoboken. *Anatome secundin. human. repetita.* p. 522, sq. fig. 38. 39. 40.

This structure is further displayed in the arterial branches of the placenta by Aug. Chr. Reuss in the *Nov. Observ. circa Structur. Vasor. in Placenta Humana.* Tubing. 1784, 4to.

† J. Noreen *De Uracho.* Gotting. 1749, 4to.

Ph. Ad. Boehmer on the same, at the end of his *Anatome ovi hum. fœcund. sed deformis.* Hal. 1763, 4to.

‡ Vide Fabr. ab Aquapendente. *De Formato Fœtu.* tab. xii. xiii. xiv. xvii. fig. 27. xxv.

§ Vide the *Commentat. Soc. Reg. Sc. Gottingens.* vol. ix. p. 128. fig. 1.

‖ Among the moderns who have compared it to this, is J. F. Lobstein l. c. *über die Ernährung des Foetus.* C. H. D'Zondi. *Supplem. ad Anat. et Physiol.*

month from conception, too frequently and of too constant an appearance to be regarded as accidental, morbid, or monstrous.*

574. The blood vessels of the chord pass to the placenta, of whose origin from the flocculent surface of the chorion united to the *decidua crassa*, we formerly spoke. Hence we discover how the substance of the placenta is double—the uterine portion derived from the decidua and forming a spongy parenchyma: the fœtal arising from the umbilical vessels distributed on the chorion. The increase of the ovulum is irregular, so that the smooth part of the chorion grows more rapidly than the flocculent; consequently, the size of the placenta bears a greater propor-

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* The opinions both respecting the natural constancy of the vesicula umbilicalis, and its analogy to the *tunica erythroides*, I originally, as far as I know, proposed upwards of twenty years since, in the first edition of these Institutions (1787), and in my *Specimen Physiologiæ Comparatæ* (1788), formerly quoted.

The connection of this vesicle with the intestinal canal of the embryo, and indeed with the appendix vermiformis of the cæcum, is shewn by Laur. Oken in his and Diet. G. Kieser's *Beytr. zur Vergleichenden Zoologie*, &c. Fasc. I. II. Bamberg, 1806, sq.

See likewise Kieser's *Ursprung des Darmkanals aus der Vesicula Umbilicalis, dargestellt im Menschlichen Embryo.* Goett. 1810, 4to.

But, on the contrary, Fr. Meckel shews it to be united with the diverticulum of the small intestines (Diverticulum Littrianum) in his *Beytr. zur vergleichenden Anatomie.* Vol. I. Fasc. I. Lips. 1808, p. 93; and more fully in Reil and Autenreith's *Archiv. für die Physiologie.* Vol. ix. p. 421.

Consult among others W. Hunter, *Anatomical Description of the Human Gravid Uterus* (a posthumous work edited by Matthew Baillie). Lond. 1794, 4to. p. 40, sq.

B. N. G. Schreger's letter to Soemmering, *De functione placentæ uterinæ.* Erlang. 1799, 8vo.

tion to that of the ovum, the shorter the period which has elapsed since conception, and a smaller, as the period of labour approaches.

As pregnancy advances, its texture becomes more compact, sulcated, and lobular on its uterine surface, and more smooth on its interior surface which is covered by the amnion. It varies greatly in size, thickness, figure, and situation, or place of attachment to the uterus; generally it adheres to the fundus; it is destitute of sensibility and true iritability.

575. Although all agree that the placenta is the chief instrument in the nourishment of the fœtus, the true mode of its operation, and its mutual relation to the uterus and fœtus, have given rise to great controversies in modern times. After all, the truth appears to be this,—that no anastomosis exists between the blood vessels of the uterus and of the chord: but that the oxygenized blood which proceeds from the uterus to that portion of the placenta which was originally the decidua crassa, is absorbed by the extreme radicles of the umbilical vein distributed upon the flocculent chorion, and carried to the great venous trunk of the chord; the carbonized blood returning from the fœtus, through the umbilical arteries, being poured in the same manner into the substance of the placenta, is absorbed by the venous radicles of the uterine portion of the placenta, and returned to the uterus.

This account is supported by very careful but fruitless attempts to inject the umbilical by means of the uterine vessels, and the uterine by means of the umbilical; or to tinge the bones of the fœtus with red, by giving madder to the mother during pregnancy. It is also confirmed by the difference observable between the blood of the mother and fœtus. (D)

576. During the progress of pregnancy, while the fœtus and secundines are increasing, the uterus of course undergoes important changes, not only in its size, but situation, figure, and especially in its texture, which is considerably changed both in regard to its blood vessels and the intervening parenchyma, from the constant and great congestion of fluids which occurs.

In proportion as the uterus increases, the blood vessels from being tortuous and narrow become more straight* and capacious, and the veins, near the termination of pregnancy, acquire so great a bulk † as to have been taken for sinuses by some anatomists.

The parenchyma becomes gradually more thin and lax,‡ especially in the part nearest the ovum, so that although the gravid uterus is very thick, particularly at its fundus, and in a living and healthy woman is turgid with blood and replete with vital energy, nevertheless it is soft, and its general nature, especially after death, when, as Arantius long since remarked, it almost appears lamellated in advanced pregnancy,§ extremely different from the firm and compact substance of the unimpregnated uterus.

577. The remaining important changes‖ of the gravid uterus, as well as those still more remarkable which occur to the ovum and fœtus, we shall briefly relate in the

* v. W. Hunter. *Anat. Uteri Gravidi,* tab. xvi.

† Ibid. tab. xviii.

‡ v. B. S. Albinus' *Annotat. Acad.* I. II. tab. iii. fig. 2.

§ Arantius' book *De Humano Fœtu.* p. 5, sq. 1579. Compare B. S. Albinus' *Tab. Uteri Gravidi,* ii.

‖ Among other works consult J. Burn's *Anatomy of the Gravid Uterus.* Glasgow, 1799, 8vo. a work carefully and faithfully executed.

order of the ten lunar months according to which pregnancy is at present very conveniently calculated.

578. As the uterus immediately after impregnation always becomes turgid, (561) so increasing from that period in bulk and weight, it descends into the upper part of the vagina, still retaining its former figure during the first three months, except, that, perhaps, its fundus becomes a little more convex and its anterior portion somewhat recedes from the posterior, and that its cavity, before extremely small and nearly triangular, becoming expanded by the fluids of the ovum, accommodates itself to their subglobular form.

The ovum itself, which about the termination of the first month is of the size of a pigeon's egg and possesses both deciduæ separate from each other and the minute amnion separate from the larger chorion, commonly attains, near the end of the third month, the size of a goose's egg; the decidua reflexa then closely approaches to the crassa, and the amnion to the chorion; the former is filled with the fluid which bears its name and defends from the pressure of the womb the tender embryo, now very small in proportion to it, scarcely indeed equal to the size of a young mouse, and variable and dependent * in situation.

579. From the fourth month, the uterus becomes more oval or subglobular, and its neck gradually softening, shortening, and almost disappearing, or rather distending laterally, it tends upwards and begins to rise to the superior part of the pelvis. At the same time the tubes ascend with the convex fundus of the womb, and are extended and elongated, but adhere to the sides of the uterus so

* v. Doeveren. *Specim. Observ. Academ.* p. 104, sq.

firmly, that half of their length only is separate from it; and at first sight, they appear to arise from the middle of the uterus,—a circumstance which gave occasion to an erroneous opinion of the enormous increase of the fundus of this organ. After this period, the fœtus acquires a size more proportional to the capacity of the ovum, and becoming, at the same time, conglobated together, acquires a more fixed situation, which it preserves to the end of pregnancy; the head is inclined to the chest, and the back bent, and generally rather opposite to one side of the mother.

580. In the middle of pregnancy,—at the end of the fifth month, so great has the size of the uterus become, that its fundus is nearly between the navel and pubis, and pregnancy becomes externally evident. From this period, the fœtus by its motion is generally more distinctly perceptible to the mother: this circumstance, however, occurs at no definite time.

581. During the remaining five lunar months, the uterus and fœtus continuing to increase, the fundus of the former reaches the umbilicus about the sixth month; after the eighth, having risen higher, it approaches the scrobiculus cordis. In the mean time, the cervix is gradually obliterated, flattened, and attenuated.

582. In the tenth month, the uterus, overwhelmed, as it were, with its own bulk, being eleven inches in length and nine or more in breadth, begins to subside.

Each decidua, but especially the reflexa adhering to the chorion, having for many months been growing thinner, now almost appears a net-work of short white fibres.*

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* On the various appearances of the decidua during the latter half of

The larger diameter of the placenta is now nine inches; its thickness one inch; its weight one pound or upwards.

The length of the umbilical chord is generally eighteen inches or more.

The weight of a common full grown fœtus is usually seven pounds; its length about twenty inches.*

The quantity of the liquor amnii is too variable to be defined; but when the fœtus is strong, it seldom exceeds a pound.

NOTES.

(A) The important contents of this and the preceding paragraph demand farther attention.

Several questions occur. 1. What is the state of the female organs during the vehemence of desire? 2. How far does the semen masculinum penetrate? 3. Do the Graafian vesicles burst from the influence of the semen masculinum, or merely from the act of copulation, the semen impregnating only the contents of the vesicles after their escape from the ovaria? 4. At what period do the Graafian vesicles burst?

1. Mr. Cruikshank, on inspecting the genitals of a female rabbit during heat, observed appearances nearly similar to those described by Harvey, Graaf, Ruysch,

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pregnancy, consult W. Hunter. *Anat. of the gravid uterus.* tab. xxiv. fig. 3, 4. tab. xxix. fig. 4, 5. comparing with these, tab. xxix. fig. 2.

* This weight and volume are remarkably large in proportion to the mother, if compared with those of the offspring of many other mammalia. But, notwithstanding this, woman is so far from producing the largest fœtus in this respect among the mammalia, that she is far surpassed by some, especially of the bisulca.

Diembroeck, &c.* He found them all prodigiously turgid with blood; the vagina was absolutely of a dark mulberry colour, and on the ovaria were prominent spots which injection proved to be vascular and which were swollen Graafian vesicles; the contents of the vesicles, however, remained transparent: the Fallopian tubes were also nearly black, writhing in an extraordinary manner, having a strong peristaltic motion and embracing the ovaria with their fimbriated extremity so closely as to lacerate on an attempt to disengage them.† These observations were all confirmed by my friend Mr. Saumarez.‡ During copulation, this state of the organs must be carried to the highest pitch of intensity.

2. Harvey could never detect semen in the uterus after copulation.§ Nor De Graaf in the vagina.|| Verheyn found a large quantity in the uterus of a cow, six hours after copulation.** Galen always discovered it in the uterus of brutes after copulation.†† Lewenhoeck, in the case of rabbits. Ruysch found it not only in the uterus, but in the Fallopian tubes of two women killed in the act of adultery.‡‡ Postellus, Riolan, Carpus, and Cheselden also believed they found it in the uterus.§§ Haller once found it in the uterus of a sheep, forty-five minutes after coition,||||

* Boerhaave. *Prælectiones Academicæ*, with Haller's notes, T. vi. p. 113. sq.

† Experiments, &c. by W. Cruikshank. *Philos. Trans.* 1797.

‡ *A new system of Physiology*, &c. by R. Saumarez, vol. i. p. 337.

§ Harvey. *De Generatione*, p. 228, &c.

|| Regn. De Graaf. T. i. 310.

** Verheyn, *Sup. Anat.* tra. 5. cap. 3.

†† Galen, *De semine.* l. i. c. 2.

‡‡ Ruysch. *Thes. Anat.* p. 90. tab. vi. fig. 1.

§§ Boerhaave's *Prælect. Acad.* Haller's note to p. 182. t. 6.

|||| Haller. *Elementa Physiol.* T. 8. p. 22.

and Mr. Hunter is said to have seen it in the uterus of a bitch which he killed while united with the male, by dividing the spinal marrow.* Haller very justly remarks that some of those who assert that they saw semen in the uterus, probably saw mucus only. He inclines, however, with almost all physiologists, to the opinion that the semen does enter the uterus. The length of the penis, the force of emission, the existence of a bifid glans with two orifices in the penis of those male animals, the females of which have two ora uteri,† are circumstances of no little weight in favour of the opinion that the semen does penetrate at least as far as the uterus. But this we shall presently examine farther.‡

3. Dr. Haighton, the present lecturer on physiology and midwifery at Guy's Hospital, with the view of ascertaining whether it is necessary to impregnation that the semen

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* Saumarez. l. c. p. 429.

† Account of the structure of the Wombat, by Sir E. Home. *Phil. Trans.* 1798.

‡ Mr. Saumarez observed in two instances, when two hours and a half only had elapsed after coition, and before corpora lutea were formed, globular, pearl-coloured bodies as large as a pea's head, which, on being squeezed, burst and discharged to some distance a very subtle fluid. Dr. Haighton commonly met with them. Whether these were semen, having undergone some change, is uncertain.

The well known instances of conception without the admission of the male organ into the vagina on account of the great strength of the hymen, are sometimes cited, against the opinion that the semen passes beyond the vagina. I can scarcely say with what weight, because the most minute portion of semen is sufficient to impregnate. Spallanzani mixed three grains of frogs semen with a pound and a half of water, and with this fecundated nearly all the numerous posterity contained in the threads taken from the female; and after mixing three grains with even twenty-two pounds of water, he fecundated some. *Dissertations*, vol. 2. p. 191. English translation.

enter the Fallopian tubes, made a number of experiments on the effects of tying and dividing the tubes in rabbits at different periods relative to coition.* The peristaltic action of the tubes and their adhesion to the ovaria during the venereal ardour, argue strongly in favour of the semen being conveyed along them, because they can hardly be supposed to begin to occur at this period for the purpose of conveying the contents of the Graafian vesicle, as this does not burst till a considerable time after copulation. Dr. Haighton, indeed, says that these changes in the tubes did not take place in his experiments till long after copulation (48 hours),—till the ovaria were about to discharge into them their vesicular fluids. In this he agrees with Bartholin, De Graaf, Schurig, Deswig and Lang, who maintained, like him, that the semen, at least as far as examination went, does not enter the tubes.† But Mr. Cruikshank and Mr. Saumarez, two of the latest experimenters, assert the contrary in the detail of their experiments, and, as Haller remarks of the old partizans, the negative experiments of the former cannot overturn the positive testimony of the latter, "Eorum experimenta *negativa* non possunt affirmantium fidem evertere:" Sbaragli, Verheyn, Hartman, and Duverney could find no change in the state of the tubes at any time, although their negative observations are completely overthrown by the positive observations of all others who have enquired experimentally into the subject. Besides, the great abundance of blood in the genital organs during the sexual ardour, must cause the tubes to enlarge and apply themselves to the ovaria: this, as

* Experimental enquiry, &c. by John Haighton, M.D. *Philos. Trans.* 1797.

† Haller. *Elem. Physiol.* and notes to Boerhaave, l. c.

Haller mentions upon the authority of Hartsoeker, occurs even in the dead body by means of injection.—Dr. Haighton, however, to prevent the semen from passing along the tubes, divided one of them in virgin rabbits, and, after the wound was healed, admitted the animal to the male. The ovarium on this side contained corpora lutea equally with the other, proving that the Graafian vesicles had burst, although the semen could not possibly have reached the ovarium.* No fœtus, however, was discoverable in any instance: on the other side, fœtuses were found equal in number to the corpora lutea. Dr. Haighton concludes that impregnation may take place without the advance of semen into the tubes. And his conclusion is just according to his test of impregnation,—the escape of the contents of a Graafian vesicle. But I apprehend this to be no more deserving the title of a test of impregnation than the emission of the semen masculinum. Impregnation is that change wrought by means of the male semen in the contents of a Graafian vesicle, which enables them to become a fœtus. Now this was never effected when the tube was divided: although the presence of corpora lutea proved vesicles to have burst, yet a fœtus was in no one instance discovered: in other words, the contents of the Graafian vesicles were in no one instance impreg-

* The divided end of the tube was found totally impervious.—The experiment succeeded when one tube only was divided: the division of both deprived the animal not only of fertility but of sexual desire, and even the division of one had this effect in some instances.—If the tube was divided after coition, the result was the same, provided the operation was performed before the contents of the vesicles had entered it: for if too much time had elapsed, the ova were transmitted to the uterus and grew to maturity.

nated. Hence I infer, with Mr. Saumarez, that the conveyance of semen along the tubes, is requisite to impregnation. But Dr. Haighton likewise concludes that the bursting of the vesicle is the sympathetic effect of the semen in the vagina or uterus.* Now although on the side where the tube was divided the ovarium did discharge the contents of some vesicles, it is not proved that it did this through the operation of the semen in the vagina or uterus. The venereal ardour alone was shewn in the observations of Mr. Saumarez, as well as in those of Mr. Cruikshank, to produce, among other great changes in the sexual organs, the enlargement of the vesicles,†

* "That the semen first stimulates the vagina, os uteri, cavity of the uterus, or all of them.

By sympathy, the ovarian vesicles enlarge, project, and burst.

By sympathy, the tubes incline to the ovaria, and having embraced them convey the rudiments of the fœtus into the uterus.

By sympathy, the uterus makes the necessary preparations for perfecting the formation and growth of the fœtus, and,

By sympathy, the breasts furnish milk for its support after birth."

There is reason, however, from one passage, to suppose that Dr. Haighton believes the semen to exert all its direct effects upon the vagina. After dwelling upon the opinion opposite to his own, he says, "The difficulties which were opposed to the conveyance of the semen by the tubes, were, as we should expect, intended to prepare the way for a different explanation; therefore physiologists, by a very natural transition of thought, were led to suppose that the presence of semen in the vagina alone was sufficient to account for impregnation;" and he immediately proceeds to his experiments.

† The state of the ovaria of women who have died under strong sexual passion, has been found similar to that of rabbits during heat. In the body of a young woman, eighteen years of age, who had been brought up in a convent and had every appearance of being a virgin, Valisneri found five or six vesicles protruding in one ovarium, and the corresponding Fallopian tube redder and longer than usual, as he had

and it is highly probable that in copulation, where it is carried to its highest point, it is capable of laying the foundation for their rupture. There is more reason to believe the rupture of the vesicles to be the effect of this than of the specific action of the semen. Hen birds often lay eggs, incapable indeed of being hatched, although separated from the influence of the cock, proving that the œstrum alone is sufficient in them to apply the tube to the ovarium and convey away an ovum. Aristotle and Harvey relate that many birds lay eggs from mere titillation; the latter proved it experimentally in the thrush and the sparrow, and in a favourite parrot belonging to his wife. Blumenbach is decidedly of opinion that the contents of a vesicle may escape the ovarium and a corpus luteum be formed in virgins, not simply from the analogy of birds, but also from the accounts which we have of such examples, corresponding in climate, age, and temperament with what should be naturally expected: it is related of young women, inhabitants of warm countries, and subject to hysterical affections.*

How the semen operates upon the ovarian secretion is unknown. Whether it is directly mixed with it, or whether its influence is transmitted to the ovarium by sympathy, its specific operation, both of fecundating and of transmitting the paternal peculiarities, is a mystery impenetrably concealed from human curiosity.

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frequently observed in animals during heat. Bonnet gives the history of a young lady who died furiously in love with a man of low rank, and whose ovaria were turgid with vesicles of great size. Blancaard, Schurig, Brendelius, Santorini, and Drelincourt mention analogous facts. Haller's notes to Boerhaave's *Prælect. Acad.*

* See his note to paragraph, 562.

4. The rupture of the ovarium does not occur till some time subsequent to coition. Mr. Cruikshank did not see ova in the Fallopian tubes of rabbits, or orifices in the corpora lutea, till the third day from copulation,* nor ova in the uterus till the fourth. Dr. Haighton never found any thing of a regular form in the uterus before the sixth day.

(B) An instance of superfetation of the description granted by Bleumenbach occurred to Mr. Blackaller of Weybridge. A white woman of very gay character left her husband and sometime afterwards returned pregnant to her parish and was delivered in the workhouse of twins, "one of which," says Mr. Blackaller in an account which he very handsomely sent me, "was born of a darker colour than I have usually observed the infants of negroes in the West Indies; the hair quite black with the woolly appearance usual to them, with nose flat and lips thick;" the second child had all the common appearances of white children.

The uterus has been sometimes wanting,† sometimes destitute of anterior opening,‡ and sometimes double,§ in which case we may imagine superfetation possible at any period after the first conception, provided each uterus has a distinct orifice.

(C) During 57 years, above 78,000 women have been delivered at the Dublin Lying-in-Hospital, and the proportion of women producing twins or more is about 1 in 57.

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* De Graaf and Valisneri met with the same results.

† Lieutaud, Sandifort, Morgagni.

‡ Louis.

§ *Ephemerid. Natur. Curios.* Dec. 3. Ann. 7 and 8. Obs. 35. Cent. 9. Obs. 75. *Philos. Trans.* vol. 4. 1699.

The proportion of males to females, about 10 to 9.*

(D) Fourcroy is almost the only author who has examined the blood of the fœtus,† and his observations, as Berzelius remarks, " seem to have been made by chance, and not to be deduced from any experiment;" " credible authors have asserted that the eye cannot distinguish between the arterial and venous blood of the fœtus."‡ Bichat could observe no difference in the arterial and venous blood of the umbilical chords of several guinea pigs examined while the mother's respiration was still continuing after an opening had been made into the abdomen: " les deux sangs offroient une noriceur egale."§ So too in regard to dogs.||

The chick, however, in the egg, cut off from all intercourse with the mother, requires its blood to be purified by the external air: for if the shell is varnished, the chick dies; and if, during the latter half of incubation, the shell is carefully opened, the chorion, to use the eloquent language of Blumenbach, presents the most beautiful spectacle in the organic creation; the arteries are seen carrying blood of a bright scarlet, and the veins of a livid red.**

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* *Sketches of the Medical Schools of Paris,* by John Cross, p. 192.

† *Annales de Chimie.* T. vii. p. 162.

‡ *Animal Chemistry.* Translation, p. 41, sq.

§ *Recherches Phisiologiques,* p. 271.

|| *Anatomie Generale.* T. ii. 344.

** *Comparative Anatomy.* Translated by Mr. Lawrence.

SECT. XL.

OF THE NISUS FORMATIVUS.

583. HAVING simply described the phenomena of conception and the changes which constant observation shows to occur both to the ovum and the contained fœtus during pregnancy, we now proceed to those powers by which it appears that generation is effected.

584. Even in our memory, some physiologists of reputation have contented themselves with roundly asserting that true generation never occurs, but that the whole human race pre-existed in the genitals of our first parents, in the shape of previously-formed germs which become evolved in succession. Some of these imagined the germs to be the spermatic animalcules of the male;* others imagined them to exist in the ovaries of the mother.†

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* See W. Fr. v. Gleichen, l. c.

† v. c. The illustrious Haller, who plainly asserted, *that all the viscera and even the bones of the future fœtus, nearly fluid indeed, and therefore invisible, were pre-formed, before conception, in the maternal germ.*

In support of this hypothesis, he argued chiefly from the continuity of the membranes and blood-vessels between the incubated chick and the yolk of the egg. *Opera minora.* T. ii. p. 418, sq.

But the more frequently I have demonstrated the phenomena of incubation in my Physiological Lectures, the less strength have I found in this argument. Nor can I sufficiently wonder how this great physiologist could so constantly reject, as almost absurd, the inosculation, pro-

585. This hypothesis of the successive evolution of germs pre-formed from the creation, must,if carefully examined, be rejected.* Not only is the superfluous and useless creation, which is supposed, of innumerable germs never arriving at evolution, repugnant to reason, but so many preternatural conditions† and such a multiplication of natural powers ‡ are assumed, that it is perfectly irreconcileable with sound physiology.

Add to this, that of the phenomena adduced in its favour, no one is sufficiently consonant with the truth of nature to prove the hypothesis.§

On the other hand, we have indubitable observations which refute it directly and completely.

586. The less this hypothesis of evolution, as it is commonly termed, is found consonant with fact and the rules of philosophizing, the more strongly does the opposite opinion recommend itself to our notice by its simplicity and correspondence with nature, supposing, as it does, not an evolution of fictitious germina by conception, but a true

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perly so called, of the vessels of the chick with those of the yolk, while at the same time he admitted and defended a perfectly similar inosculation in the connection of the human ovulum with the gravid uterus. *Elem. Physiol.* Lausanne, 1788, T. viii. P. 1. p. 94, comparing p. 257.

* v. L. P. *Zweifel gegen die Entwickelungstheorie.—Aus der Französischen Handschrift von* G. Forster. Gotting. 1788, 8vo.

† v. Kant's remarks on these in his *Critik der Urtheilskraft,* page 372.

‡ This defect I have shewn at large in my *Handbuch der Naturgeschichte,* page 15, sq. 8vo. 1807.

§ Those who desire a fuller demonstration of this and other assertions, but briefly noticed in the present section, I refer to the work *über den Bildungstrieb.* (third edit.) Gotting. 1791, 8vo.

and gradual formation of a new conception from the hitherto formless genital matter.

587. This true generation by successive formation has been variously described by physiologists, but the following we consider as the true account:

1. The *matter* of which organized bodies, and therefore the human frame, is composed, differs from all other matter in this, that it alone is subject to the influence of the vital powers.*

2. Among the orders of vital powers, one is eminently remarkable and the least disputable of all,—which, while it acts upon that matter hitherto shapeless but mature, imparts to it a *form* regular and definite, although varying according to the particular nature of the matter. To distinguish this vital power from the rest, permit us to designate it by the term,—NISUS FORMATIVUS.

3. The nisus formativus occurs to the genital *matter*, when this is mature and committed to the uterus in a proper condition and under proper circumstances, lays in it the rudiments of conception, and gradually *forms* organs fitted for particular purposes; preserves this structure during life, by nourishing (455 sq.) the body; and reproduces (459), as far as it can, any part accidentally mutilated†

* See Chr. Girtanner, *über das Kantische Prinzip für die Naturgeschichte*. Gotting. 1796, 8vo. page 14, sq.

† Here allow me to make three remarks :—

1. I have used the expression—nisus formativus, merely to distinguish it from the other orders of vital powers, and by no means to explain the *cause* of generation, which I consider equally involved in Cimmerian darkness as the cause of gravitation or attraction, which are merely terms given to effects known, like the nisus formativus, a posteriori.

588. We therefore think it very probable that those fluids which, during a successful coition, are thrown into the cavity of the uterus (527, 533, 551), (A) require a certain period for becoming intimately mixed, acted upon, and matured; that, after this preparatory stage, the nisus formativus is excited in them, vivifying and shaping the hitherto shapeless spermatic matter partly into the beautiful containing ovulum (565) and partly into the contained embryo; (569) and that this is the reason of our inability, notwithstanding the present perfection of optical instruments, to discover, during the first weeks after conception, any thing more than shapeless fluids, without the faintest trace of the form of an embryo, which, however, about the third month, as it were, suddenly becomes observable.

589. We should exceed the limits of these institutions, were we to adduce many of the arguments which may be drawn from facts, to illustrate, as in our opinion, they most clearly do, the great influence of the nisus formativus in generation. We will, however, venture to mention,

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2. The word *nisus* I have adopted chiefly to express an energy truly vital, and therefore to distinguish it as clearly as possible from powers merely mechanical, by which some physiologists formerly endeavoured to explain generation.

3. The point on which the whole of this doctrine respecting the nisus formativus turns, and which is alone sufficient to distinguish it from the vis plastica of the ancients or the vis essentialis of the celebrated Wolff and similar hypotheses, is *the union and intimate co-exertion of two distinct principles in the evolution of the nature of organized bodies,—of the* PHYSICO-MECHANICAL, *with the purely* TELEOLOGICAL—principles which have hitherto been adopted but separately by physiologists, in framing theories of generation.

as briefly as possible, a few, whose weight will, on a little close reflection, be sufficiently evident.

590. Such, in the history of *hybrid* animals, is the singular experiment of impregnating those which are *prolific*, for many generations, with male semen of the same species, by means of which the form of the young hybrids become so progressively different from the original maternal configuration, as to approach more and more to that of the father, till, by a kind of arbitrary metamorphosis, it is absolutely converted into it.*

591. Such in our knowledge of *monsters*, (which, according to the hypothesis of evolution, are nearly all maintained to have pre-existed in the germs from the first creation), is the well known fact, that among certain *domestic* species of animals, and especially among sows, monstrosities are very common, while in the original wild variety they are extremely uncommon.

592. While the phenomena of *reproduction* are all much more explicable by the nisus formativus than by the pre-existence of germs for every part, some particular instances, (v. c. that of the nails, which, after the loss of the first phalanx of the fingers have been known to be reproduced on the neighbouring middle phalanx,†) admit evidently of no other solution.

593. From an impartial view of each side of the question, it will clearly appear, that the defenders of the germs must allow to the male semen, not only an *exciting* power, as they do, but likewise great *formative* powers, and thus their doctrine stands in need of the assistance of the nisus formativus; while our explanation, on the con-

* Jos. G. Kölreuter. *Dritte Fortsetz. der vorläuf. Nachr.* p. 51, sq.

† Tulpius. *Observat. Med.* L. iv. c. 55.

trary, is sufficient, without the aid of pre-existing germs, to explain the phenomena of generation. Nor can there be any reason for multiplying the *entia*, as they are called, unnecessarily (B).

NOTES.

(A) See note A. to section 39, near the end.

(B) The *nisus formativus* produces a being generally resembling the parents, but occasionally different. This subject will be fully treated of in the note on the varieties of mankind.

It is not probable that the ardour of the procreants affects the energy of the offspring. But from the days of Aristotle it has been remarked that bastards are very frequently endowed with great genius and valour, and both ancient and modern history certainly afford many such examples, and the circumstance has been commonly ascribed to the impetuosity of the parents during their embraces. Shakspeare, in King Lear, introduces Edmund bursting into this indignant soliloquy:

> "Why bastard? wherefore base?
> When my dimensions are as well compact,
> My mind as generous, and my shape as true,
> As honest madam's issue? Why brand they us
> With base? with baseness? bastardy? base? base?
> Who in the lusty stealth of nature take
> More composition and fierce quality
> Than doth, within a dull, stale, tired bed
> Go to the creating a whole tribe of fops
> Got 'tween sleep and wake?"

Act 1. *Sect*. 2.

Were this explanation satisfactory, the first fruits of wedded love would still be on an equality with illegitimate offspring. If a greater proportion of illegitimate than of legitimate persons have really rendered themselves illustrious, I should attribute their superior energy to the strength of their parents constitutions, as the weak and delicate cannot be supposed so frequently to yield to unlawful passions as the vigorous, and to the necessity in which such individuals usually find themselves to rely upon their own exertions.

SECT. XLI.

OF LABOUR AND ITS SEQUELÆ.

594. The fœtus, formed by the powers already described, and having reached the period of full maturity, has to come into the world by means of *labour*.*

595. This critical *period* occurs naturally (and physiology treats solely of natural occurrences) at the end of the tenth lunar month from conception, i. e. about the 39th or 40th week.

596. At that time, the pregnant woman is impelled to bring forth by an absolute necessity, less under the influence of the will than any other voluntary function (287).

597. Physiologists have differed in their explanations of the *causes* of so determinate and sudden an event. After all, the *exciting* cause of labour must be ascribed to an eternal law of nature, hitherto equally inexplicable as so many other *periodical* phenomena in nature; v. c. the metamorphosis of insects, the stages of exanthematic fevers, crises, &c. &c. nor has the mature ovum been inaptly compared, *ceteris paribus*, to fruit, which, when ripe, falls almost spontaneously to the ground, from the constriction of those vessels which previously conveyed its

* J. J. Römer. *Partus naturalis brevis expositio*. Gotting. 1786, 8vo.

nourishment. And in fact it has been remarked that the human placenta, at the approach of labour, is contracted, and, as it were, prepared for its separation from the uterus.

What is usually urged respecting the utmost expansion of the uterus, and other similar excitements to labour, is refuted by many circumstances, and, among the rest, by the numerous examples of extra-uterine, whether tubal or ovarian, conceptions, in which, at the expiration of ten months from impregnation, the uterus, notwithstanding its vacuity, is seized with the customary, though indeed fruitless, pains.*

598. Besides this exciting cause, other very powerful *efficient* causes are requisite, as must be manifest from the relation of the ovum to the uterus.

We are persuaded that the *proximate* and primary cause, is solely the *vita propria* of the uterus (42, 547).

Among the *remote*, the most important appears to be the respiratory effort excited principally by the great connection† of the intercostal nerve with the rest of the nervous system.

599. We formerly noticed (582) that during the latter periods of pregnancy, the uterus somewhat subsided, by which circumstance the form of the abdomen is somewhat changed, and the inconveniences induced during advanced pregnancy in the function of respiration, are relieved. At the same time, the vaginal mucus (543) is secreted more abundantly, the vagina itself is relaxed, the columns of rugæ are almost obliterated, the labia pudendi swell;

* I have recorded a remarkable instance of this kind in the *Comment. Soc. Scient. Gottingens*. Vol. viii.

† v. Camper's *Demonst. anat. pathol.* L. II. p. 9.

finally, near the approach of labour, the os uteri gradually dilates into a circular opening.

600. The *phenomena* of labour generally observe a regular order of invasion and cessation,* whence accoucheurs have divided them into *stages*, of which the moderns enumerate four, although they define them variously.

601. In the *first*, the true pains occur, peculiar in their nature, proceeding from the loins downwards in the direction of the uterus (recurring, at intervals, indeed, during the whole of labour, with various degrees of violence and frequency), at first mild, when they are called *warning* and the os uteri begins evidently to dilate. At the same time the abdomen falls still more, the urine is urgent, and abundance of mucus flows from the soft and tumid genitals.

602. In the *second*, the pains increasing, are called *preparing*, and, from the compressing effect of the respiratory organs, by means of a strong inspiration a segment of the lower part of the membranes of the ovum is protruded through the uterine orifice into the vagina.

603. In the *third*, the pains becoming more excruciating, are called *labour pains*, and act with still more violence upon the uterus, which is driven downwards and compressed against the fœtus, so that the protruded segment of membranes becomes extremely tense, is burst asunder, and the greater part of the liquor amnii escapes.

604. Finally, in the *fourth* and last stage, the pains becoming dreadfully violent and *agitating*,† are accompanied

* v. Smellie's *Set of anatomical tables*. Tab. xi.—xv.

† Although even among my own countrywomen, the symptoms

with great exertions of the woman herself; almost always too with shivering, shrieking, tremor of the knees, &c. The head of the child, now on the verge of birth, penetrates, and the face first appears, the vertex usually adhering under the arch of the pubis, and the rest of the head in the mean time being farther propelled and revolving around the impacted vertex as around an axis. Thus the child comes into the world, in the midst of a red discharge, consisting of a second portion of the liquor amnii mixed with blood.

605. Soon after the expulsion of the child, the *after-labour* commences, attended with a painful though much less violent exertion, and followed by another hemorrhage from that part of the cavity of the womb* to which the placenta had adhered by means of the decidua crassa.†

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described under these four stages, vary greatly in violence and proportionate duration; nevertheless, however naturally they take place, they universally, (excepting some extremely rare cases,) so far surpass, even under the most favourable circumstances, the pains experienced by domestic brutes in their labours, that I trust no one who has frequently witnessed labours in both, will seriously doubt the immense difference between the two in this respect.

* B. S. Albinus' *Tab. uter. gravid.* vij.

Wm. Hunter's *Anat. of the gravid uterus.* Tab. x. fig. 3.

† Nic. Massam and all since his time denominate this portion of the womb, during or shortly after pregnancy, *the cotyledons*, from the analogous appearance observable in the gravid uterus of sheep or goats, in which similar cavities *(acetabula)* exist, receiving what are called the glandular corpuscles of the chorion, corresponding with the fœtal portion of the human placenta.

Whatever was hollow, like an acetabulum, was called κοτυλη, by the ancients. Vide J. Cammerarii *Comm. utriusque linguæ*, 256, 384.

605. Immediately that both burthens are expelled, the uterus begins gradually to contract, until it acquires its original form and very nearly its original dimensions.

607. For about a week after labour, the *lochia* are discharged, for the most part very similar to the catamenia, but rather more copious, especially if the mother does not suckle her offspring. About the sixth day, their red colour becomes fainter and afterwards is converted into white. At the same time the uterus is liberated from the ramenta of the decidua, and having thus completed the function of pregnancy, is again ready for menstruation or conception.

SECT. XLII.

OF THE MILK.

608. THE *breasts*, most sacred fountains, and, as Gellius Favorinus, the philosopher, elegantly calls them, the educators of the human race, are intimately connected with the uterus in various ways. The functions of neither can properly be said to exist during infancy: at puberty, both begin to flourish,—when the catamenia appear, the breasts assume some degree of plumpness: from that period they undergo either simultaneous changes,—the breasts beginning to swell and secrete milk during the pregnancy of the womb; or alternate changes,—the catamenia ceasing while the child is suckled, or the lochia becoming copious if the child is not suckled, and s. p. Finally, when age creeps on, the function of each absolutely ceases,—when the catamenia disappear, both the uterus and the breasts become equally inert. I omit pathological phenomena; v. c. those which occur in irregular menstruation, leucorrhœa, after extirpation of the ovaria, and in other morbid affections.

609. If this intimate connection is kept in view, we shall not be astonished that nearly every description of sympathy formerly mentioned (56) exists between these organs of the female thorax and abdomen.*

* J. Anemaet *De mirabili quæ mammas inter et uterum intercedit sympathia.* L. B. 1784, 4to.

610. The influence of the anastomatic sympathy between the internal mammary and epigastric artery,* although formerly overrated,† is evinced by the change which the latter experiences in its diameter during pregnancy and lactation.

611. Both the uterus and mammæ appear to have a kind of affinity for the chyle, observable in many diseases, and nearly always in new-born children.

612. The *breast* of women,‡ belonging to the most characteristic marks of the human female both by its form during the flower of age and by the longer continuance of this form after the period of suckling than occurs in any other female animal, is composed of a placentiform series of conglomerate glands, divided by numerous furrows into larger lobes, and buried in a mass of fat; the anterior part swells out particularly with a firmer description of fat over which the skin is exceedingly thin.

613. Each of these lobes is composed of still smaller lobes, and these of acini, as they are termed, to which the extreme radicles § of the *lactiferous ducts* adhere, deriving a chylous fluid from the ultimate twigs of the internal mammary arteries.

614. These radicles gradually uniting,|| form large

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* Eustachius. Tab. xxvii. fig. 12.

Haller. *Icon. anat.* fasc. vi. tab. i

† As G. R. Boehmer properly remarks. *De consensu uteri cum mammis causa lactis dubia.* Lips. 1750, 4to.

‡ A. B. Kölpin, *De structura mammarum.* Griphisw. 1765. 4to.

Athan. Joannidis, *Physiologiæ mammarum muliebrium specimen.* Hal. 1801. 4to.

§ v. C. Avolo's two plates at the end of Santorini's posthumous works.

|| v. Mich. Girard, Tab. i. annexed to the same plates of Santorini.

trunks, corresponding in number with the lobes, about fifteen in each breast. These are every where dilated into large sinuses, but have no true anastomosis with each other.*

615. These trunks terminate in very delicate excretory canals, which are collected towards the centre by means of cellular substance, into the *nipple*,† which, supplied with extremely fine blood-vessels and nerves, is capable of a curious erection on the approach of certain external stimuli.

616. The nipple is surrounded by the *areola*,‡ which, as well as the nipple, is remarkable for the colour § of the reticulum under the cuticle,|| and contains sebaceous follicles.**

617. The secretion of the breast is the *milk*, well known in colour, watery, somewhat fatty, rather sweet, bland, resembling in all respects the milk of domestic animals, but subject to infinitely greater varieties in the proportion of its constituent parts, and far more difficult of coagulation, from the great quantity of salt which it contains, and affording no trace of volatile alkali.††

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* J. Gottl. Walter's *Observ. Anat.* p. 33. sq.

† Santorini's *Tab. posth.* viii.

‡ Ruysch. *Thes.* i. tab. iv. fig. 4.

§ In pregnant women, especially during the first pregnancy, the nipples are usually yellow. In the Samojede women, although virgins, Klingstaedt asserts that they are quite black. *Mém. sur les Samojedes et les Lappons.* p. 44.

|| B. S. Albinus' *Annotat. Acad.* L. iii. tab. iv. fig. 3.

** Morgagni's *Advers. Anat.* 1. tab. iv. fig. 2.

†† Fl. J. Volteleh (Præs. Hahn) *De lacte humano observationes chemicæ.* L. B. 1775. 4to.

Parmentier and Deyeux, *Précis d'Experiences et observations sur*

618. When coagulated by means of alcohol, it discovers the same elements as the milk of other animals. Besides the *aqueous* halitus which it gives off when fresh and warm, the *serum,* separating from the *caseous* part, contains sugar of milk,* acetic acid mixed with phosphate of lime and of magnesia and with oil and mucus. The butyraceous *cream* is said to consist of globules of various and inconstant size, their diameter ranging between $\frac{1}{103}$ and $\frac{1}{300}$ of a line.† (A)

619. The analogy between chyle and blood, and between both these fluids and milk,‡ renders it probable that the milk is a kind of reduced chyle, again separated from the blood before its complete assimilation. This idea is strengthened by the frequent existence in the milk of the particular qualities of food previously taken,§ and by the chylous appearance of the watery milk afforded by the breasts during pregnancy and immediately after labour.||

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ces différentes espèces du lait. Argent. 1798. 8vo. Thenard in the *Annales de Chimie.* T. lix. p. 262.

* Marc. L. Williamoz, *De sale lactis essentiali.* L. B. 1756. 4to.

† Senac. *Tr. du cœur.* Vol. ii. p. 276. ed. 2.

Fr. v. P. Griuthuisen. *Untersuch. über den Unterschied zwischen Eiter und Schleim durch das Microscop.* Monach. 1809. 4to. p. 16. fig. 15.

‡ Compare J. Theod. Van de Kasteele. *Diss. de analogia inter lac et sanguinem.* L. B. 1780. 4to. and Alex. Wilson, on the analogy between milk and chyle, in his *Observations relative to the influence of the climate.* p. 97. sq.

§ v. among a host of witnesses, Kölpin in Pallas', *Neuen nordischen Beyträgen.* Vol. ii. p. 343.

|| Many arguments induce me to believe, that the lymph of the absorbents is of much importance in the secretion of milk.

For instance, the swelling of the subaxillary glands almost always observable during the first months of pregnancy.

620. The reason why this bland nourishment of the fœtus becomes, by continued sucking, more thick and rich, is probably the abundance of lymphatics in the breasts. Those vessels continually absorb more of the serous part of the milk, in proportion as its secretion is more copious and lasting, and by again pouring this portion into the mass of blood, promote the secretion (477): after ablactation they take up the residual milk, and mix it with the blood.

621. The milk is secreted in greatest quantity immediately after delivery; and, if the infant sucks, amounts to one or two pounds every twenty-four hours, until the menses, which usually cease during suckling, (556) return.

Occasionally virgins, and new-born infants of either sex, nay even men,* as well as the adult males of other mammalia,† have been known to furnish milk.

622. The abundance of milk excites its *excretion*, and even causes it to flow spontaneously: but pressure, or the suction of the child, completes its discharge.

But especially the remarkable fact, that in advanced pregnancy, when, from the womb compressing through its size the large and numerous lumbar plexuses of lymphatics, the legs have swollen, this œdematous tumor so completely disappears immediately after labour that the calves of the legs hang almost flaccid from the lymph finding no impediment in the lumbar plexuses and rushing upwards, and a more copious secretion of milk instantly ensues upon the progress of the lymph.

The momentary thirst (330) experienced on applying the child to the breast, from the absorption of fluid in the fauces, may be also mentioned.

* This is asserted to be very common in Russia. *Comment. Acad. sc. Petropolit.* Vol. iii. p. 278. sq.

† I have spoken of this at large in the *Hannoversich. Magazin.* 1787, p. 753. sq.

NOTES.

(A) The lower portion of cows' milk that had stood some days was found by Berzelius* to have a specific gravity of 1.033. and to contain

Water - - - - - - -	928.75
Cheese with a trace of butter - -	28.00
Sugar of milk - - - - - -	35.00
Muriate of potash - - - -	1.70
Phosphate of potash - - - -	0.25
Lactic acid, acetate of potash, with a trace of lactate of iron - - - -	6.00
Earthy phosphates - - - -	0.30
	1000.00

The supernatant cream contained

Butter - - - - - - -	4. 5
Cheese - - - - - - -	3. 5
Whey - - - - - - -	92. 0

(B) It may be worth while here to take a general view of the subject of generation.

Life never occurs spontaneously in matter, but is always propagated from an organized system already endowed with it. Such, at least, appears to be the inevitable conclusion from the facts within our observation. No instance has been known of a plant or animal of any species whose mode of propagation is ascertained, ever springing up spontaneously; and although in many cases the origin cannot be discovered, yet surely our inability to discover the mode of

* *Medico-Chirurgical Transactions.* V. iii.

propagation does not justify us in denying the existence of it; but, the general analogy, the discovery of the modes in which many species propagate which were formerly adduced as instances of spontaneous generation, and the occasionally manifest source of the difficulties which obstruct our enquiries, lead necessarily to the belief not of the absence of the fact, but of our deficient penetration.*

The simplest mode of increase is by the detachment and independent existence of a portion of a system. In this way trees,† polypes, some worms, and many animalcules ‡ multiply.

Next comes the formation of the rudiments of a perfectly new being by the system of another. Thus we have the seed of vegetables, the ova and fœtus of animals. This occurs by means of two matters, which in some examples are furnished by the same, and in others

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* See Cuvier's *Anatomie Comparée*.—Generation.

† Hîc plantas tenero abscindens de corpore matrum
Deposuit sulcis; hîc stirpes obruit arvo,
Quadrifidasque sudes, et acuto robore vallos:
Sylvarumque aliæ pressos propaginis arcus
Expectant, et viva suâ plantaria terrâ.
Nil radicis egent aliæ: summumque putator
Haud dubitat terræ referens mandare cacumen.
Quin et caudicibus sectis, mirabile dictu,
Truditur é sicco radix oleagina ligno.

Virgil. Georgica. Lib. ii.

‡ See Spallanzani's admirable *Observations et experiences sur les Animalcules*. He found a small portion detach itself from the bodies of some, the bodies of others split longitudinally, of others transversely, of others both longitudinally and transversely into four parts, and the new animalcules soon acquired the size of the parent and experienced the same changes in their turn.

by different systems. The vegetable kingdom affords innumerable instances of the former, the acephalous mollusca and the echinus are examples in the animal kingdom.* Both the vegetable and animal kingdoms abound in instances of the latter. Here again there are three varieties. The fluid of the male may be applied to the ova of the female after they are discharged from her body, as in fish of the bony kind and cephalopodous mollusca; while being discharged, as in the frog and toad; or it may be conveyed to the female system, and this either without the contact of the male, as in vegetables, where the wind, insects, &c. convey it, or by means of copulation, as in the mammalia,† birds, most reptiles, and some fish.

In the mammalia, one copulation is sufficient for only

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* It is singular that some hermaphrodites do not impregnate themselves, but mutually impregnate and are impregnated by others; such are the gasteropodous mollusca and many worms.

† Ladies were treated formerly more politely than at present. An accidental pregnancy was often attributed to the warmth of imagination, the influence of demons, and many other circumstances supposed equally powerful as the deed of kind. Venette, in his *Tableau de l'Amour conjugal*, has inserted an *Arrêt Notable de la cour du Parlement de Grenoble*, which, upon the attestation of many *matrones* and *sages femmes* and *docteurs* of the University of Montpellier, that women often fall pregnant spontaneously, declares a lady who had brought forth a son although her husband had been absent four years, to be a woman of worth and honor, and the child to be the legitimate heir of Monsieur the husband.

Virgil believed that mares were sometimes impregnated by the west wind.

Vere magis (quia vere calor redit ossibus) illæ
Ore omnes versæ in Zephyrum, stant rupibus altis

one conception; among poultry its effects are so extensive, that a hen turkey will lay the whole season after one intercourse with the cock; in the aphis and some monoculi, it is sufficient for the impregnation of several generations.

The ovum after its formation may be nourished by a fluid enclosed within the same case, and is then hatched out of the body by the common temperature, as in insects, or by that of the parent, as in birds, or hatched within the body of the mother, as in serpents; or it may be nourished by a substance shed around it in the womb, as in the kangaroo, or by means of an attachment of some of its vessels to the maternal system, as in the mammalia; some animals being thus oviparous, others ovo-viviparous, and others viviparous.

The mode of nourishment after birth is various. Some are able, without any peculiar arrangement, immediately to support themselves, for the wisdom of nature ordains the delivery of each species of animals at that season of the year when every thing is in the most favourable state for administering to the necessities of the offspring.

Others, many insects for example, are born in the midst of food, the parent having instinctively deposited the egg in nutrient matter, either found or carefully collected by her.

Others have food collected daily by the parents. Others, as all the dove kind, are fed by a substance secreted from

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Exceptantque leves animas: et sæpe sine ullis
Conjugiis, vento gravidæ (mirabile dictu)
Saxa per et scopulos et depressas convalles
Diffugiunt.

Georg. Lib. iii.

the crops of both parents;* others by a fluid secreted by peculiar glands belonging to the female only. The instinct which leads the parent carefully to tend the offspring, ceases at the period when the system of the offspring is sufficiently advanced to supply its own exigencies.

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* Hunter, *On a secretion in the crops of breeding pigeons for the nourishment of their young.* *Observ.* p. 235.

SECT. XLIII.

OF THE DIFFERENCES IN THE SYSTEM BEFORE AND AFTER BIRTH.*

623. FROM what has been said relatively to the functions of the fœtus still contained within its mother and immersed as it were in a warm bath; there must evidently be a considerable difference between its animal functions and those of the child which is born and capable of exerting its will. The chief points of difference we shall distinctly enumerate.

624. To begin with the blood and its motion, this fluid is remarkable both for being of a darker red, incapable of becoming florid on the contact of atmospheric air, and for coagulating less readily and perfectly than after birth.† Its course too is very different in the fœtus whose circulation is connected with the placenta and who has never

* On the subject of this section consult among numerous others, Trew, *De differ. quibusdam inter hominem natum et nascendum intercedentibus*. Norimb. 1736. 4to.

Andr. and Fr. Roesslein (brothers), *De differentiis inter fœtum et adultum*. ibid. 1783, 4to.

Ferd. G. Danz. *Zergliederungskunde des ungebohrnen Kindes mit Anmerk.* von. S. Th. Soemmerring, Francof. 1792. 2 vols. 8vo.

Also Theod. Hoogeveen, *De fœtus humani morbis*. L. B. 1784. 8vo. p. 28. sq.

J. Dan. Herholdt, *De vita imprimis fœtus humani*. Havn. 1802. 8vo. p. 61. sq.

And Fr. Aug. Walter, *Annotat. academ.* already quoted, p. 44. sq.

† Fourcroy. *Annales de Chimie*. T. vii. p. 162. sq.

breathed, from its course after the cessation of this connection with the mother, and after respiration has taken place.*

625. First, the umbilical vein coming from the placenta, and penetrating the ring properly called umbilical, runs to the liver, and pours its blood into the sinus of the vena portæ, the branches of which remarkable vein distribute one portion through the liver, while the *ductus venosus* ARANTII† conveys the rest directly to the inferior vena cava.

Both canals,—the end of the umbilical vein contained in the abdomen of the fœtus, and the venous duct, become closed after the division of the chord, and the former is converted into the round ligament of the liver.

626. The blood arriving at the right side of the heart, from the inferior cava, is in a great measure prevented from passing through the lungs, and is derived into the left or posterior auricle of the heart, by means of the Eustachian valve and the foramen ovale.

627. For, in the fœtus, over the opening of the inferior cava, there is extended a lunated *valve*,‡ termed from its

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* Compare Herm. Bernard. *De eo quo differt circuitus sanguinis fœtus ab illo hominis nati.* Reprinted in Overkamp's collection. T. i.

Jos. Wenc. Czikanek, *De actuosa hominis nascituri vita s. circulat. fœtus ab hominis nati diversitate.* Reprinted in Wasserberg's collection T. iv.

Sabatier at the end of his *Tr. Complet. d'Anat.* Vol. iii. p. 386. sq. 1781, and in the *Memoires Mathemat. et Physiques de l'Institut.* T. iii. p. 337. sq.

But especially J. Fr. Lobstein, in the *Magasin Encyclopédique.* 1803. T. iii. Vol. li. p. 28. sq.

† Arantius, *De humano fœtu libellus.* 97.

Compare B. S. Albinus'. *Explicatio tabular. Eustachii.* p. 164. sq.

‡ Haller, *De valvula Eustachii.* Gotting. 1738. 4to.

discoverer,* Eustachian, which usually disappears as adolescence proceeds, but, in the fœtus, appears to direct † the stream of blood coming from the abdomen towards an opening immediately to be mentioned, existing in the septum of the auricles.

628. This opening is denominated the *foramen ovale*,‡ and is certainly the chief cause why the blood, which streams from the inferior cava, is poured into the left auricle, during the diastole of the auricles. A falciform§ valve, placed over the foramen, prevents its return, and appears likewise to preclude its course into the left auricle, during the systole of the auricles. By means of this valve, the foramen generally becomes closed in early infancy in proportion as the corresponding Eustachian valve decreases, and it more or less completely disappears.||

629. The blood which enters the right auricle and ventricle, principally proceeds from the superior cava, and flows but in a very small quantity into the lungs, while, from the right ventricle, which, in the fœtus, is remarkably thick and strong for this purpose, it pursues its course

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* Eustachius, *De vena sine pari*. p. 289. Opuscula. tab. viii. fig. 6. tab. xvi. fig. 3.

† J. F. Lobstein, *De valvula Eustachii*. Aug. 1771. 4to.

‡ Haller, *De foramine ovali et Eustachii valvula*. Gotting. 1748. fol. c. f. ae. and much more copiously in his *Opera minora*. T. i. p. 33. sq.

§ For an account of the opinion of C. Fr. Wolff, who regards the foramen ovale as another mouth of the inferior cava, opening into the left auricle in the same manner as the mouth commonly known opens into the right. Vide *Nov. Comment. acad. scient. Petropol.* t. xx. 1775.

|| H. Palm. Leveling, *De valvula Eustachii et foramine ovali*. Anglipol. 1780. 8vo. c. f. ae.

directly to the arch of the aorta, by means of the *ductus arteriosus*,* which is, as it were, the chief branch of the pulmonary artery. A few weeks after birth, this duct becomes obstructed and converted into a kind of dense ligament.

630. The blood of the aorta, being destined to return, in a great measure, to the mother, enters the *umbilical arteries*, (572) which pass out on each side of the urachus at the umbilical opening, and, after birth, likewise become imperforate chords.†

631. As the function of the *lungs* scarcely exists in the fœtus, their appearance is extremely different from what it is after the commencement of respiration. They are proportionally much smaller, their colour is darker, their substance denser, consequently their specific gravity is greater, so that while recent and sound they sink in water, while, after birth, they, cæteris paribus, swim upon its surface.‡ The right lung has the peculiarity of dilating during the first inspiration rather sooner than the left.§ The other circumstances attending the commencement of respiration were described in the section upon that function.

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* B. S. Albinus' *Annot. acad.* L. ii. tab. vii. fig. 7.

† v. Haller's *Icones anat.* fasc. iv. tab. iii. vi.

‡ This is not the proper place for explaining the conditions under which this occurs, and the cautions therefore requisite in giving an opinion in a court of justice, founded on the examination of the lungs.

Among many other writings, the very important posthumous paper of Wm. Hunter may be consulted in the *Medical Observ. and Enquiries.* Vol. vi. p. 284. sq.

§ Portal in the *Mem. de l'Acad. des sc. de Paris.* 1769. p. 555. sq.

Metzger, *De pulmone dextro ante sinistrum respirante.* Regiom. 1783. 4to.

632. From our remarks upon the nutrition of the fœtus, it is clear that its alimentary tube and chylopoietic system must be very peculiar. Thus, v. c. in an embryo a few months old, the *large intestines* very nearly resemble the small; but during the latter half of pregnancy, being turgid with meconium, they really deserve the epithet by which they are commonly distinguished.

633. The *meconium* is a saburra, of a brownish green colour, formed evidently from the secreted fluids of the fœtus, and chiefly from its bile, because it is first observed at the period corresponding to the first secretion of the bile; and in monstrous cases, where the liver has been absent, no meconium, but merely a small quantity of colourless mucus, has been found in the intestines.

634. The *cæcum* is extremely different in the new born child from its future form, and continued straight from the appendix vermiformis, &c.*

635. Other similar differences we have already spoken of, and shall now pass over. Such are the *urachus* (573), the *membrana pupillaris*, (262) the *descent of the testes* in the male, (510 sq.)

Some will be treated of more properly in the next section. Others, of little moment, we shall entirely omit.

636. This is a favourable opportunity for briefly noticing some remarkable parts which are out of all proportion larger in the fœtus and appear to serve important purposes in its economy, although their true and principal design deserves still further investigation. They are usually styled glands, but their parenchyma is very different from true glandular structure, nor has any vestige of an excreting duct been hitherto discovered in

* B. S. Albinus' *Annotat. Acad.* L. vi. tab. ii. fig. 7.

them. They are the thyreoid, the thymus, and the supra-renal glands.*

637. The *thyreoid gland* † is fixed upon the cartilage of the same name belonging to the larynx, has two lobes, is, as it were, lunated,‡ and full not only of blood, in which it abounds in the fœtus, but of lymphatic fluid, and becomes, as age advances, gradually less juicy.§

638. The *thymus* is a white and very tender structure, likewise bilobular, sometimes completely divided into two parts, occasionally containing a remarkable cavity,|| placed under the superior part of the middle of the sternum, always ascending as far as the neck on each side,** of extremely great proportionate size in the fœtus, abounding in a milky fluid, becoming gradually absorbed in

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* Vide F. Mechel's *Abhandlungen aus der menschlichen u. vergleichenden Anatomie.* Halle. 1806. 8vo. He makes it probable that these three organs contribute to the chemical functions of the nervous and hepatic systems, and thus diminish the quantity of hydrogen and carbon.

† Cajet. Uttini, *De glandulæ thyroideæ usu,* in the *Comment. instituti Bononiens.* Vol. vii. p. 15. sq.

‡ Haller's *Icones Anat.* fasc. iii. tab. 3.

§ J. Ant. Schmidtmüller, *über die Ausfuhrungsgunge der Schilddrüse.* Landshut. 1804, 8vo.

|| Aug. Lud. de Hugo, *De glandulis in genere et speciatim de thymo.* Gotting. 1746. 4to. fig. 2.

Morand the younger in the *Mémoires de l'Acad. des Sc. de Paris.* 1759. tab. 22—24.

Vincent Malacarne in the *Memorie della Societa Italiana.* T. viii. 1799. P. i. p. 239. sq.

Sam. Chr. Lucae, *Anatomische Untersuchungen der Thymus.* Francof. 1811. 4to.

** Haller's *Icones Anat.* l. c.

youth, and frequently disappearing altogether in old age.*

639. The *supra-renal glands,* called also renes succenturiati and capsulæ atrabiliariæ, lie under the diaphragm on the upper margin of the kidneys,† from which, in the adult, they are rather more distant, being proportionally smaller. They are full of a dark fluid of a more reddish hue in the fœtus than in the adult. (A)

NOTE.

(A) It is singular that Blumenbach should omit to notice one of the most striking peculiarities of the fœtus—the very great proportionate bulk of its liver. The prodigious size of this organ arises from the distribution of four-fifths of the blood of the umbilical vein through it, and probably, as some think, in a certain degree, from the great quantity of meconium in its biliary ducts. After birth, no blood is conveyed by the umbilical vein, and the expansion of the thorax readily expresses the abundance of meconium; hence the liver must diminish.

This peculiarity, as well as the great size of the thyreoid, thymus, and supra-renal glands, probably serves some purpose hitherto undiscovered, but an evident good effect results from it, in relation to the organs of the thorax.

* Hewson's *Experimental enquiries.* P. iii. passim.

† See Eustachius their discoverer. Tab. i. ii. iii. and tab. xii. fig. 1. 10. 12.

Haller's *Icones Anat.* fasc. iii. tab. vi.

Malacarne, l. c.

In the fœtus the lungs are completely devoid of air, and consequently there cannot be much, if any, circulation of blood through the pulmonary artery and veins, and the liver by its magnitude protruding the diaphragm upwards renders the capacity of the chest correspondently small, and at the same time it contains an immense proportion of blood. After birth, the diminished size of the liver allows a great increase to the capacity of the chest; not only is full inspiration allowed, and consequently a free passage to the blood of the pulmonary vessels during inspiration, as Haller remarks,* but a certain degree of permanent dilatation of the lungs is allowed, (for much air remains in the lungs after every expiration), and as the liver contains, immediately after birth, so much smaller a portion of the blood of the system than before, the greatly increased supply required by the lungs is thus afforded.† See Note B. Sect. 8.

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* *Elementa Physiologiæ*. T. 3.

† See Mr. Bryce's excellent paper on this subject in the *Edinburgh Med. & Surg. Journal*, 1816, Jan.

SECT. XLIV.

OF THE GROWTH, STATIONARY CONDITION, AND DECREASE OF MAN.

640. NOTHING more remains at present than to survey at one view the natural course of the life of man, whose animal functions we have hitherto arranged in classes and examined individually, and to accompany him through his principal epochs from his birth to his grave.*

641. The *commencement of formation* appears to happen about the third week from conception (569), and genuine *blood* is first observable about the fourth, the life of the fœtus at this period being extremely faint (82) and almost merely that of a vegetable; the *motion of the heart* (98), under fortunate circumstances, has been observable at this time in the human embryo,† though long ago detected by Aristotle in the incubated egg,‡ and since his time denominated the *punctum saliens*.

The original form of the embryo is simple, and, as it were, disguised, wonderfully different from the perfect con-

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* Vide Const. Anast. Philites *De decremento seu de marasmo senili*. Hal. 1808. 8vo.

† Vide J. De Muralto, in the *Ephemerides N. C.* Dec. ii. ann. 1. p. 305.

Roume de St. Laurent, in Rozier's *Obs. et mém. s. la physique*. Juillet. 1773, p. 53.

‡ Aristotle's Hist. Animal. L. vi. cap. 3. Opera. Vol. ii. p. 326.

formation of the human frame, which deserves to be regarded as the grandest effect of the nisus formativus, and at which it arrives by gradual changes or, if we may so speak, metamorphoses from a more simple to a more perfect form.*

642. The *formation of human bone*† begins, if we are not mistaken, in the seventh or eighth week. First of

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* Hence, as I have remarked in another place, (—*Nova Litteraria Goettingensia*, a. 1808, p. 1386—), human monsters are sometimes met with, so strongly resembling the form of brutes, because the nisus formativus, having been disturbed and obstructed from some cause or other, could not reach the highest pitch of the human form, but rested at a lower point and produced a bestial shape. On the contrary, I have never once found among brutes a true example of monstrosity, which, by a bound of the nisus formativus, bore any analogy to the human figure.

For fuller information in regard to the resemblance of the very early human embryo to the larvæ of reptiles, and in some measure to the fœtuses of quadruped mammalia, consult after Harvey *De generat. animal.* p. 184, 235, sq. London, 1651, 4to.—Grew's *Cosmol. sacr.* p. 37, 47.—Lister *De humoribus.* p. 444, and others, especially Autenreith, *Observat. ad histor. embryon. facientium.* P. i. Tubing, 1797, 4to.—Fr, Meckel, both in the *Auffütz zur menschl. u. vergleich. anat.* p. 277, sq. and in the *Beyträg zur vergleich. anat.* p. 63, and elsewhere, and Const. Anast. Philites, l. c.

† I say of *human* bone; for in the incubated chick, it commences much later,—at the beginning of the *ninth* day, which corresponds with the *seventeenth week* of human pregnancy.

Observations, therefore, made on the incubated chick, must not be hastily applied to the formation of the human embryo,—an error committed by the great Haller himself, who clearly asserted that *what he had demonstrated in regard to the incubated chick, was equally applicable to other classes of animals and to man himself.*

This opinion gained so much ground subsequently, that some physicians who endeavoured to settle the forensic disputes respecting preall, the osseous fluid forms its nuclei in the clavicles, ribs, vertebræ, the large cylindrical bones of the extremities, the lower jaw, and some other bones of the face, in the delicate reticulum of some flat bones of the skull,—of the frontal and occipital, but less early in the parietal. In general, the growth of the embryo, and indeed of the human being after birth, is more rapid as the age is less, and *vice versa.* (A)

643. About the middle of pregnancy, certain fluids begin to be secreted, as the *fat* (486) and *bile.* In the course of the seventh month, all the organs of the vital, natural, and animal functions have made such progress, that if the child happens to be born at this period, it is called, in a common acceptation of the word, *vital*, and regarded as a member of society.

644. In the fœtus, near its full growth, not only is the skin covered by a caseous matter, but delicate *hair appears upon the head,* and *little nails* become visible; the *membrana pupillaris* splits (262); the cartilaginous external ear becomes more firm and elastic; and in the male the *testes* descend. (510, et seq.)

645. About the end of the tenth lunar month, the *child*, being born, (595), undergoes besides those important changes of nearly its whole economy, which were formerly described at large, other alterations in its *external appearance;* v. c. the down which covered its face at birth, gradually disappears, the wrinkles are obliterated, the anus becomes concealed between the swelling nates, &c.

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mature labour, deduced their arguments from this hasty comparison of the periods of this incubation with those of human pregnancy. Vide v. c. Hug. Marreti's *Consultation au sujet d'un enfant, &c.* Divion. 1768, 4to.

646. By degrees the infant learns to employ its *mental faculties* of perception, attention, reminiscence, inclination, &c. whence, even in the early months, it dreams, and s. p.*

647. The organs of the *external senses* are gradually evolved and perfected, as the external ear, the internal nares, the coverings of the eyes, viz. the supra-orbital arches, the eyebrows, &c.

648. The bones of the skull unite more firmly; the *fonticuli* are by degrees filled up; and about eight months after birth, *dentition* commences.

649. At this period the child is ready to be *weaned*, its teeth being intended to manducate solid food and not to injure the mother's breast.

650. About the end of the first year, it learns to rest upon its feet and *stand erect*,—the highest characteristic of the human body.†

651. The child now weaned from its mother's breast and capable of using its feet, improves and acquires more voluntary power daily: another grand privilege of the human race is bestowed upon it,—the use of *speech*,—the mind beginning to pronounce, by means of the tongue, the ideas with which it is familiar.

652. The twenty milk teeth by degrees fall out about the seventh year, and a *second dentition* produces, in the course of years, thirty-two permanent teeth.

653. During infancy, *memory* is more vigorous than

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* Consult Tiedemann *Uber die Entwickelung der seelenfähigkeiten bey Kindern*, in the *Hessisch. Beytr.* Vol. ii. P. ii. iii.

† Ger. Vrolik (præs. Brugmans) *Diss. de homine ad statum gressumque erectum per corporis fabricam disposito*. Ludg. Bat. 1795, 8vo.

the other faculties of the mind, and much more powerful than at any other period in tenaciously receiving the impressions of objects: after the fifteenth year, the fire of *imagination* burns most strongly.

654. This more lively state of the imagination occurs very opportunely at *puberty*, when the body, undergoing various remarkable changes, is being gradually prepared for the exercise of the sexual functions.

655. Immediately after the period when the breasts of the adolescent girl have begun to swell, the chin of the boy is covered with down, and the phenomena of puberty manifest themselves in either sex. The girl begins to menstruate, (554),—an important change in the female economy, accompanied, among other circumstances, nearly always by an increased brightness of the eyes and redness of the lips, and by more evident sensible qualities of the perspiration. The boy begins to secrete genuine *semen* (527), and, at the same time, the *beard** grows more abundantly, and the *voice* becomes remarkably grave.

By the spontaneous internal voice of nature, as it were, the *sexual instinct* (71) is now for the first time excited, and man, being in the flower of his age, is capable of sexual connection.

656. The *period* of puberty cannot be exactly defined: it varies with climate and temperament,† but is generally

* The fabulous report, even at this day prevalent, respecting the want of beard among some American nations, I refuted by a host of witnesses in the *Gotting. Magaz.* ann. ii. P. vi. p. 418 et seq. For I have adduced instances from the whole of America, both of nations who allow their beard to grow, at least, in part; and of others, who, upon indubitable authority, pluck out their beard by peculiar instruments, &c.

† I have inserted in the *Bibl. Medic.* vol. i. p. 558 et seq. an account

more early in the female; so that in our climate, girls arrive at puberty about the fifteenth year, and young men, on the contrary, about the twentieth. (B)

657. Soon after this, *growth* terminates; at various periods in different climates, to say nothing of particular individuals and families.* (C)

658. The *epiphyses* of the bones hitherto distinct from their diaphyses, now become intimately united, and, as it were, confounded with them.

659. At *manhood*,—the longer and more excellent period of human existence, life is, with respect to the corporeal functions, at the highest pitch (82), or, in other words, these functions are performed with the greatest *vigour* and *constancy*; in regard to the mental functions, the grand prerogative of mature *judgment* is now afforded.

660. The approach of *old age*† is announced in women by the cessation of the catamenia (556), and not unfre-

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communicated to me by G. E. ab Haller, of procreation in a Swiss girl only nine years of age.

* For man has no peculiar privilege of not experiencing the effects of climate in common with other organized bodies, which are commonly known to arrive at their growth much later, cæteris paribus, in cold than in warm climates.

As to the giants of Patagonia and the dwarfs of Madagascar, mentioned by Commerson, I have reduced the exaggerated accounts of the former to a true statement, and have shewn that the latter are diseased Cretins, in my Treatise *De gen. hum. var. nativ.* p. 253, 260. ed. 3.

† J. Bern. Fischer's *Tract. de senio ejusque morbis.* Ed. 2. Erf. 1760, 8vo.

Benj. Rush's *Medical Inquiries & Observations.* Vol. ii. Philadel. 1793, 8vo. p. 295, sq.

Burc. W. Seiler's *Anatomiæ c. h. senilis specimen.* Erlang. 1799, 8vo. Const. Anast. Philites. l. c.

quently by an appearance of beard upon the chin ;* in men, by less alacrity to copulate: in both, by a senile† *dryness* and a gradually manifested *decrease* of vital energy.

661. Lastly, the frigid condition of *old age* is accompanied by an increasing dulness of both the external and internal senses, a necessity for longer sleep, and a torpor of all the functions of the animal economy. The hairs grow white and partly fall off. The teeth gradually drop out. The neck is no longer able to give due support to the head, nor the legs to the body. Even the bones themselves—the props of the machine—in a manner waste away, &c.‡

662. Thus we are conducted to the ultimate line of physiology,—*to death without disease,*§ to the senile ευθανασια, which it is the first and last object of medicine to procure, and the *cause* of which must be self-evident from our preceding account of the animal economy.||

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* Vide J. Burlin. *De fœminis ex suppressione mensium barbatis.* Altorf. 1664, 4to. This remarkable phenomenon, which deserves further investigation, is analogous to a change frequently remarked in female birds, which, after ceasing to lay eggs, lose the feathers peculiar to their sex and acquire those characteristic of the male. Examples of this occur in the columba œnas, phasianus colchicus, pavo cristatus, otis tarda, pipra rupicola, anas boschas, &c.

† Joach. H. Gernet. *De siccitatis senilis effectibus.* Lips. 1753, 4to.

‡ I do not here repeat what I have said at large in my osteological work, p. 36, sq. upon the remarkable wasting of the bones of old men.

§ G. Gottl. Richter. *De morte sine morbo.* Gotting. 1736, 4to.

|| J. Oosterdyk Schacht. *Tr. qua senile fatum inevitabili necessitate ex hum. corp. mechanismo sequi demonstratur.* Ultraj. 1729, 4to.

Matt. Van Geuns *De morte corporea et causis moriendi.* L. B. 1761, 4to. reprinted in Sandifort's *Thesaurus,* vol. iii.

663. The *phenomena* of a moribund person* are coldness of the extremities, loss of brilliancy in the eyes, smallness and slowness of the pulse, which more and more frequently intermits, infrequency of respiration, which at length terminates for ever by a deep expiration.

In the dissection of other moribund mammalia the struggle of the heart may be perceived; and the right auricle and ventricle are found to live rather longer than the left, (117).

664. Death is manifested by the coldness and rigidity of the body, the flaccidity of the cornea, the open state of the anus, the lividness of the back, the depression and flatness of the loins (59, *Note)*, and above all, by an odour truly cadaverous.† If these *collective marks* are present, there can be scarcely room for the complaint of Pliny, that one ought not to believe even a dead man.‡

665. It is scarcely possible to define the natural *period* of life, or, as it may be termed, the more frequent and regular limit of advanced old age.§ But by an accurate

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C. G. Ontyd. *De morte et varia moriendi ratione.* Lugd. Bat. 1791, 8vo.

Curt. Sprengel's *Instit. medic.* T. 1. Amst. 1809, p. 289, sq.

* See the successive progress of the phenomena of death observed in himself, a man of middle age, dying of dysentery, in Moritz *magaz. zur Erfahrungs Seelen-Kunde.* vol. i. P. 1. p. 63, sq.

† Durondeau in the *Nouveaux Mém. de l'Ac. de Bruxelles.* vol. i. 1788, p. i.

‡ C. Himly's *Commentatio* (which gained the royal prize) *mortis historiam causas et signa sistens.* Gotting. 1794, 4to.

Sol. Anschel's *Thanatologia s. in mortis naturam, causas, genera, species, et diognosin disquisitiones,* ib. 1795, 8vo.

§ Among other well known treatises on this subject, consult J. Gesner *De termino vitæ.* Tigur. 1748, reprinted in the *Excerptum Italicæ et Helveticæ litterat.* 1759, T. iv.

examination of numerous bills of mortality, I have ascertained a remarkable fact,—that a very large proportion of Europeans reach their *eighty-fourth* year, while, on the contrary, few exceed it (D).

666. On the whole, notwithstanding the weakness of children, the intemperance of adults, the violence of diseases, the fatality of accidents, and many other circumstances, prevent more than perhaps seventy-eight persons out of a thousand from dying of old age, without disease, nevertheless, if *human longevity** be compared, cæteris paribus, with the duration of the life of any other known animal among the mammalia, we shall find that of all the sophistical whinings about the misery of human life, no one is more unfounded than that which is commonly made respecting the shortness of its duration (E).

NOTES.

(A) For a minute account of ossification I refer to Mr. Howship's papers in the sixth and seventh volumes of the *Medico-Chirurgical Transactions*, and more particularly to a review of the first paper in the first number of the *Annals of Medicine and Surgery*.

(B) Instances continually occur in both sexes of early puberty, sometimes joined with very rapid growth. The

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* Bacon de Verulamio. *Historia vitæ et mortis*. Opera. vol. ii. p. 121, sq. London, 1740, fol.

Chr. W. Hufeland's *Makrobiotik*. T. 1. p. 90. and elsewhere. Edit. 3. 1805.

mind however does not usually keep pace with the body, (or rather the brain with the rest of the body) and such individuals have commonly short lives. Some males are reported to have been adult before the completion of their first year. One of the earliest examples of female puberty is given in the Medico-Chirurgical Transactions:* the girl began to menstruate when not three years of age, and soon after acquired large breasts, broad hips, &c. Schurig relates that a little couple, each nine years of age, married and begot a son.†

The activity of the grand organs of generation,—of the testes in the male and the ovaria in the female, produces the great changes in the rest of the generative organs and in the system at large at the period of puberty, for if they are previously removed, these changes do not occur, and they appear in general proportional to the evolution and activity of those organs.‡ This is well known in regard to animals and man. We perhaps have no well authenticated instance of the castration of a woman,§ but when the ovaria have been found deficient, the signs of puberty have not appeared‖, while

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* Vol. iv. † *Spermatol.* p. 186.

‡ I say generally, because, for instance, the greatest evolution of the testes is often accompanied either with little beard, or a small larynx, or some analogous circumstance, while the other marks of manhood are strikingly manifested; and vicê versâ. A boy only six years of age without any premature evolution of the organs of generation, is recorded to have had a beard. *Philos. Trans.* vol. 19.

§ A castrator of sows and other animals in Germany is said to have been so enraged with his daughter for giving loose reins to her passions, as to have resolved to extinguish them, and to have completely succeeded by removing her ovaria. "Ita bilis mota est, ut aperto latere castraret pullam, quam ab eo tempore nulla tetigit veneris cupido." Boerhaave's *Prælect. Acad.* T. vi. p. 127.

‖ *Philos. Trans.* vol. 95.

the absence of the uterus has not been attended by any deficiency in the general changes.* I must think with Moreau † that many phenomena have been ascribed to sympathy with the uterus which are really referrible to the ovaria.

Mr. Hunter made an experiment respecting the removal of one ovarium only. He took two young sows in all respects similar to each other, and after removing an ovarium from one he admitted a boar of the same farrow to each and allowed them to breed. The perfect sow bred till she was about eight years old,—a period of almost six years, in which time she had thirteen farrows, and in all one hundred and sixty-two pigs; the other bred till she was six years old,—during a space of more than four years, and in that time she had eight farrows and in all seventy-six pigs. Thus it would appear that each ovarium is destined to produce a certain number only of fœtuses, and that the removal of one, although it does not influence the number of fœtuses produced by the other, causes them to be produced in a shorter time.‡

(C) Not only do instances of early puberty and full growth frequently occur, but likewise of deficient and exuberant growth. Dwarfs are generally born of the same size as other children, but after a few years they suddenly cease to grow. They are said to be commonly ill-shaped, to have large heads, and to be stupid or malicious,§ and old age comes upon them very early. The

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* *Memoires de la Societé Médicale d'Emulation.* Paris. Tom. 2.

† *Histoire naturelle de la femme.* T. 3.

‡ *An experiment to determine the effect of extirpating one ovarium upon the number of young produced.* *Obs.* p. 157.

§ "It will not be easy to produce me an instance of any one giant or of three foreign dwarfs lately exhibited in London, two men and one woman, had certainly large heads and flat noses, but in other respects were well made. The tallest of the three seemed a sulky creature, but the woman was very ingenious and obliging, and Simon Paap, the least of the three, appeared very amiable. He was twenty-eight inches high and twenty-six years old. They were not related to each other, and the relations of all were of the common size. Their countenances were those of persons more advanced. The smallest dwarf on record was only sixteen inches high, when thirty-seven years of age.*

The tallest person authentically recorded has never exceeded nine feet, according to Haller.

The young man from Huntingdonshire also lately exhibited in London was of remarkable height. Although only seventeen years of age, he was nearly eight feet. He had a sister of extraordinary height, and many of his family were very tall. He was, as is usual, born of the ordinary size, but soon began to grow rapidly. He appeared amiable, and as acute as most youths of his age and rank. Giants and dwarfs providentially seldom reach their fortieth year and have not very active organs of generation.†

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any one dwarf perfectly sound in heart and mind, i. e. in the same degree with a thousand other individuals who are regularly constituted. Great mental weakness is the usual portion of giants, gross stupidity that of dwarfs." Lavater's *Physiognomy*.

* Haller. *Elementa Physiologiæ*. T. 12. lib. 30.

† As the period of growth is so short in dwarfs, and the period of childhood so short in those who reach puberty early, it is to be expected that their old age will be premature—that their stationary period and decline will be likewise short. Giants do not like dwarfs, I believe, die from premature old age, but from exhaustion.

(D) Our countryman Parr married when a hundred and twenty years of age, retained his vigour till a hundred and forty, and died at a hundred and fifty-two from plethora induced by a change in his diet. Harvey who dissected him, found no decay of any organ,* and had not Parr become an inmate of the Earl of Arundel's family in London, he probably would have lived many years longer. Our other countryman Jenkins, who lived a hundred and sixty-nine years, is perhaps the greatest authentic instance of longevity.

It is unnecessary to observe that the height and the age of men at present are the same as they have been for thousands of years. It is a common custom to magnify the past. Homer who flourished almost three thousand years ago, makes his heroes hurl stones in battle which

——— οὐ δύο γ'ἄνδρε φέροιεν
Οἷοι νῦν βροτοί εἰσι.†

Yet the giant who was the terror of the Israelites, was not probably more than nine feet in height, and David, who slew him, and was nearly cotemporary with Homer's heroes, says, "The days of our years are threescore and ten; and if by reason of strength they be fourscore years, yet is their strength labour and sorrow; for it is soon cut off and we fly away."‡

(E) The functions of the human machine having now been fully described, it may be of advantage to consider it in its relation to other animated systems, and to review the chief varieties in which it appears.

Hopkins Hopkins, weighing never more than 18lbs. and latterly but 12, died of pure old age at seventeen, and one of his sisters, but twelve years of age and weighing only 18lbs. at the time of her death had all the marks of old age. *Gentleman's Magazine*, vol. 24, p. 191.

* *Philos. Trans.* vol. 3. 1699. † *Iliad*, lib. 5. ‡ *Psalm* 90.

Numerous authors have remarked that a gradation exists among all the objects of the universe, from the Almighty Creator, through arch-angels and angels, men, animals, vegetables and inanimate matter, down to nothing.

> "Vast chain of being which from God began,
> Natures ethereal, human, angel, man,
> Beast, bird, fish, insect, what no eye can see,
> No glass can reach, from infinite to thee,
> From thee to nothing."*

Yet this gradation deserves not the epithet regular or insensible. "The highest being not infinite must be, as has been often observed, at an infinite distance below infinity." "And in this distance between finite and infinite there will be room for ever for an infinite series of indefinable existence. Between the lowest positive existence and nothing, wherever we suppose existence to cease, is another chasm infinitely deep; where there is room again for endless orders of subordinate beings, continued for ever and ever, and yet infinitely superior to non-existence." "Nor is this all. In the scale, wherever it begins or ends, are infinite vacuities. At whatever distance we suppose the next order of beings to be above man, there is room for an intermediate order of beings between them, and if for one order then for infinite orders; since every thing that admits of more or less, and consequently all the parts of that which admits them, may be infinitely divided. So that as far as we can judge, there may be room in the vacuity between any two steps of the scale, or between any two points of the cone, for infinite exertion of infinite power."†

* Pope's *Essay on Man*, Epistle 1.

† Dr. Johnson's *Review of a Free Enquiry into the nature and origin of evil.*

In fact, at how vast a distance do we see the innate mental properties of man standing above those of the most sagacious animal: how immensely does the volition of the lowest animal raise it above the whole vegetable kingdom; and how deep the chasm between the vital organization of the meanest vegetable and a mass of inanimate matter. Gradation must be admitted, but it is far from regular or insensible. Neither does it regard the perfection nor so much the degree, but the excellence and combination, of properties,—man placed at the summit of the terrestrial gradation by the excellence of his mind and the combination of the common properties of matter, of those of vegetables and of those of animals, with those peculiar to himself, is surpassed by the dog in acuteness of smell and by the oak in magnitude, nor is he more perfect than the gnat or the thistle in its kind.

Bodies consist of particles endowed with certain properties without which their existence cannot be conceived, viz. extension and impenetrability; with others which proceed indeed from their existence, but are capable of being subdued by opposing energies, viz. mobility, inertness; and with others neither necessary to their existence nor flowing from it, but merely superadded, for example, various attractions and repulsions, various powers of affecting animated systems.

Inanimate bodies have no properties which are not either analogous to these or dependent upon them; are for the most part homogeneous in their composition, and disposed to be flat and angular, increase by external accretion, and contain within themselves no causes of decay.

Vegetables, in addition to the properties of inanimate matter, possess those of Life, viz. sensibility (without perception) and contractility;* their structure is beautifully organized and their surfaces disposed to be rounded; they grow by internal deposition and are destined in their nature for a period of increase and decay.

Animals, in addition to the properties of vegetables, enjoy MIND, the indispensable attributes of which are the powers of consciousness, perception, and volition; the two former without the latter, were, like vegetable or organic sensibility without contractility, useless, and the latter could not exist without the two former any more than vegetable or organic contraction could occur without sensibility; nor can the existence of mind be conceived without the faculties of consciousness, perception, and volition, any more than the existence of matter without extension and impenetrability. The possession of mind by animals necessarily implies the presence of a brain for its performance, and of a nerve or nerves for the purpose of conveying impressions to this brain and volitions from it to one or more voluntary muscles. A system which is not thus gifted certainly deserves not the name of animal.†

* By the former, stimuli act upon them, and by the latter, they upon stimuli:—by the sensibility and contractility of the vessels, substances are taken up by the roots, circulated through the system and converted into the various parts of the vegetable. Yet this does not imply perception or will; the sensibility and contractility of the absorbents and secretories of our own system carry on absorption and secretion without our consciousness or volition.

† I cannot conceive an animal without perception and volition; nor can I conceive these in an animal without a brain, any more than the secretion of bile without a liver or something analogous. I contend not for the name, but the thing. Comparative anatomists indeed affirm, that many internal worms and all the class of zoophytes have no nervous system. But comparative anatomy is yet imperfect, the examination

Notwithstanding the vast interval which of necessity exists between the animal and vegetable kingdoms, the lowest animals approach as nearly as possible in organization and consequently in function to vegetable simplicity. They possess merely consciousness, perception and volition, with the instinct for taking food, and multiply by shoots, fixed like vegetables to the spot which they inhabit. The five senses, instincts, memory, judgment*

of minute parts is extremely difficult, and new organs are daily discovered. Blumenbach, after remarking that except those animals which inhabit corals, and the proper zoophytes, most genera of the other orders of the class of vermes are found to possess a distinct nervous system, adds: "Although former anatomists have expressly declared in several instances that no such parts existed." (*Comparative Anatomy*, cxvi. F.) Again some beings are denominated animals without any very satisfactory reason. Where the nervous system of an animal cannot be readily detected, its presence may be inferred from motions evidently voluntary, such as the retraction of worms into the earth upon the approach of footsteps, proving the existence of an organ of hearing, a brain and nerves: motion in a part *directly* stimulated, as the contraction of an hydatid upon being punctured, is no proof of an animal nature, for this is common to vegetables, for instance, the leaves of the *Dionæa Muscipula*, which contract forcibly on a slight irritation. It may likewise be inferred from the presence of a stomach, because where there is a stomach, the food is taken in not by absorbing vessels constantly plunged in it, but by a more or less complicated and generally solitary opening regulated by volition. John Hunter contended that the stomach was the grand characteristic of the animal kingdom.

* I see daily instances of reason in animals; to the sceptical I offer the following anecdote in the words of Darwin. "A wasp on a gravel walk had caught a fly nearly as large as itself. Kneeling on the ground I observed him separate the tail and the head from the body part to which the wings were attached. He then took the body part in his paws and rose about two feet from the ground with it; but a gentle

and locomotive power, with the necessary organs, are variously superadded, and endless varieties of organization constructed, so that air and water, the substance and the surface of the earth, are all replenished with animals calculated for their respective habitations.*

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breeze wafting the wings of the fly turned him round in the air and he settled again with his prey upon the gravel. I then distinctly observed him cut off with his mouth first one of the wings and then the other, after which he flew away with it unmolested with the wind." DARWIN's *Zoonomia.*—Instinct. Consult the works of the two Hubers *Sur les abeilles* and *Sur les fourmis.*

* An error has been committed not only in supposing the gradation regular, but in supposing every species of animal to constitute a distinct step in the gradation. "The whole chasm in nature," says Addison, (*Spectator, No.* 519,) "from a plant to a man, is filled up with divers kinds of creatures, rising one above another, by such a gentle and easy ascent, that the little transitions and deviations from one species to another are almost insensible." "All quite down from us," remarks Locke, (*Essay on the Human Understanding*, B. 3. c. 6.) "the descent is by easy steps, and a continued series of things, that in each remove differ very little one from the other. There are fishes that have wings, and are not strangers to the airy region; and there are some birds, that are inhabitants of the water; whose blood is cold as fishes, and their flesh so like in taste that the scrupulous are allowed them on fish days. There are animals so near of kin both to birds and beasts, that they are in the middle between both: amphibious animals link the terrestrial and aquatic together, seals live at land and at sea, and porpoises have the warm blood and entrails of a hog; not to mention what is confidently reported of mermaids or sea-men." Now the various kinds of animals do certainly run into each other; no two are so different but that daily discoveries are made of a third intermediate. But connection is not gradation. Many kinds, for instance, birds and beasts, and the intermediate ones by which they are united, are all on a level in point of excellence, so that a single step in the gradation may comprehend a great number of kinds;—the whole vegetable kingdom forms but one step.

Man, besides the common properties of animals, has others which raise him to an immense superiority. His mind is endowed with powers of the highest order which they have not, and his body being, like the bodies of all animals, constituted in harmony with the mind that the powers of the latter may have effect, differs necessarily in many points of construction from the body of every animal. Well might the greatest of all uninspired poets exclaim, "What a piece of work is man! How noble in reason! how infinite in faculties! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals!"*

The true ourang-outang *(simia satyrus)* approaches the nearest of all animals to the human subject. Curious, imitative, covetous, social, placing sentinels and disposing themselves in a train for the propagation of alarm, sometimes seeming to laugh,† walking occasionally erect, defending themselves with sticks and stones, copulating face to face,‡ carrying their young either in their arms or on their backs, possessing teeth of the same number and figure as our own, and very lascivious in regard to our species, the ourang-outangs at first sight afford, if any of the genus can afford, a little probability to the opinion of a close connection between monkeys and the human race. Uncivilized men, too, make a slight approach in many corporeal particulars, as we shall hereafter find, to the

* Shakspeare, *Hamlet.* Act, 2. Sc. 2.

† Le Cat (*Traité de l'Existence du fluide des nerfs.* p. 35,) asserts that he had seen the jocko (*Simia Troglotydes)* both laugh and cry.

‡ Fouche d'Obsonville. *Obs. philos. sur les mœurs d'anim. etrangers.* p. 167.

structure of other animals, and since also the circumstances of their existence call into action few of the peculiar mental powers of our nature, they have been adduced in corroboration of this opinion. But an attentive examination displays differences of the greatest magnitude between the human and the brute creation. These we shall review under two divisions, the first embracing the mental, and the second the corporeal characteristics of mankind.

In judging of the mental faculties of mankind, not merely those should be considered which an unfortunately situated individual may display, but those which all the race would display under favourable circumstances. A seed and a pebble may not on a shelf appear very dissimilar, but if both are placed in the earth, the innate characteristic energies of the seed soon become conspicuous. A savage may in the same manner seem little superior to an ourang-outang, but if instruction is afforded to both, the former will gradually develope the powers of our nature in all their noble superiority, while the latter will still remain an ourang-outang. The excellence of man's mind demonstrates itself by his voice and hands. Witness the infinite variety and the depth of thought expressed by means of words: witness his great reasoning powers, his ingenuity, his taste, his conscientious, religious, and benevolent feelings, in his manufactories, his galleries of the fine arts, his halls of justice, his temples, and his charitable establishments. Besides the qualities common to all animals, each of which he, like every animal, possesses in a degree peculiar to himself, and some indeed in a degree very far surpassing that in which any animal possesses them, for instance, benevolence, mechanical contrivance, the sense for music, and the general power of observation and inference, he appears exclusively gifted with feelings of religion and justice, with taste, with wit, and with the faculty of comparing things and diving into their causes.*

The corporeal characteristics of mankind are not less striking and noble.† Among the beings beheld by Satan in Paradise,

"Two of far nobler shape, erect and tall,
Godlike erect, with native honour clad
In naked majesty seemed lords of all."‡

The erect posture is natural and peculiar to man.§ All nations walk erect, and among those individuals who have been discovered in a wild and solitary state, there is no well authenticated instance of one whose progression was on all fours. If we attempt this mode of progression,

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* Consult Spurzheim's *System of Physiognomy*, passim.

† Consult Blumenbach's Treatise *De Generis Humani Varietate Nativa*. Sect. 1. De hominis a cœteris animalibus differentia.

‡ Milton's *Paradise Lost*. Book iv. 288.

§ There is no necessity to attempt the refutation of the ridiculous opinion that man is destined to walk on all fours. But I do so for the purpose of displaying many peculiarities of our structure.

It is almost incredible that any thinking man could have entertained it for a moment. Yet such is the fact, and it was in vain even that Hudibras, after proving to his mistress by his beard that he was no gelding, urged his erect posture in proof that he was not a horse.

"Next it appears I am no horse,
That I can argue and discourse,
Have but two legs, and ne'er a tail—
Quoth she, That nothing will avail;
For some philosophers of late here
Write, men have four legs by nature,
And that 'tis custom makes them go,
Erroneously but upon two."

Hudibras. Part ii. Canto 1.

we move either on the knees or the points of the toes, throwing the legs obliquely back to a considerable distance; we find ourselves insecure and uneasy; our eyes instead of looking forwards are directed to the ground; and the openings of the nostrils are no longer at the lower part of the nose, in a situation to receive ascending odorous particles, but lie behind it. Our inferior extremities being of much greater length in proportion to the superior, and the trunk than the posterior, of animals with four extremities, even in children in whom the proportion is less, are evidently not intended to coincide with them in movement; they are much stronger than the arms, obviously for the purpose of great support: the presence of calves, which are found in man alone, shews that the legs are to support and move the whole machine; the thigh bones are in the same line with the trunk, in quadrupeds they form an acute angle; the bones of the tarsus become hard and perfect sooner than those of the carpus, because strength of leg is required for standing and walking sooner than strength of arm and hand for labour; the great toe is of the highest importance to the erect posture, and is bestowed exclusively on mankind. The superior extremities do not lie under the trunk as they would if destined for its support, but on its sides, capable of motion towards objects in every direction; the fore arm extends itself outwards, not forwards, as in quadrupeds, where it is an organ of progression; the hand is fixed not at right angles with the arm, as an instrument of support, but in the same line, and cannot be extended to a right angle without painfully stretching the flexor tendons; the superior extremity is calculated in the erect posture for seizing and handling objects, by the freedom of its motions, by the great length of the fingers above that of the toes, and by the existence of the thumb, which, standing at a distance from the fingers and bending towards them, acts as an opponent, while the great toe is, like the rest, too short for apprehension, stands in the same line with them, and moves in the same direction. Quadrupeds have a strong ligament at the back of the neck to sustain the head; in us there is no such thing, and our extensor muscles at the back of the neck are comparatively very weak.* They have the thorax deep and narrow, that the anterior extremities may lie near together and give more support; the sternum too is longer, and the ribs extend considerably towards the pelvis to maintain the incumbent viscera; our thorax is broad from side to side, that the arms being thrown to a distance may have greater extent of motion, and narrow from the sternum to the spine; and the abdominal viscera pressing towards the pelvis rather than towards the surface of the abdomen in the erect attitude, do not here require an osseous support. The pelvis is beautifully adapted in us for supporting the bowels in the erect posture; it is extremely expanded, and the sacrum and os coccygis bend forwards below: in animals it does not merit the name of pelvis; for, not having to support the abdominal contents, it is narrow, and the sacrum inclines but little to the pubis. The nates, besides extending the pelvis upon the thigh bones in the erect state of

* As the head is connected with the trunk farther back in animals than in us, the small length of lever between the occipital foramen and the back of the head, and the length of the head below the foramen, require all this power; but in us much more upholding power than we have at the back of the neck would be required for all-four progression, as the spine would be connected with the head horizontally.

standing or walking, allow us to rest while awake in the sitting posture, in which the head and trunk being still erect, our organs of sense have their proper direction equally as in walking or standing: were we compelled to lie down like brutes, while resting during the waking state, the different organs of the face must change their present situation to retain their present utility, no less than if we were compelled to adopt the horizontal progression; and, conversely, were their situation so changed, the provision for the sitting posture would be comparatively useless.

While some, perversely desirous of degrading their race, have attempted to remove a grand source of distinction by asserting that we are constructed for all fours, others with equal perverseness and ignorance have asserted that monkeys are destined for the upright posture. Monkeys, it is true, maintain the erect posture less awkwardly than other animals with four extremities, but they cannot maintain it long, and while in it, they bend their knees and body; they are insecure and tottering and glad to rest upon a stick; their feet, too, instead of being spread for support, are coiled up as if to grasp something. In fact their structure proves them to be neither biped nor quadruped, but four-handed animals. They live naturally in trees and are furnished with four hands for grasping the branches and gathering their food. Of their four hands the posterior are even the more perfect and are in no instance destitute of a thumb, although, like the thumbs of all the quadrumana, so insignificant as to have been termed by Eustachius, "omnino ridiculus;" whereas the fore hands of one variety *(simia paniscus)* have not this organ.

It was anciently supposed that man, because gifted with the highest mental endowments, possessed the largest of all brains.* But as elephants and whales surpass him in this respect, and the sagacious monkey and dog have smaller brains than the comparatively stupid ass, ox and hog, the opinion was relinquished by the moderns, and man was said only to have the largest brain in proportion to the size of his body. But as more extensive observation proved canary and other birds and some varieties of the monkey tribe to have larger brains than man in proportion to the body, and several mammalia to equal him in this particular, and as rats and mice too surpass the dog, the horse and the elephant in the comparative bulk of their brains; this opinion gave way, in its turn, to that of Soemmerring,—that man possesses the largest brainin comparison with the nerves arising from it. This has not yet been contradicted, although the comparative size of the brain to the nerves originating from it (granting that they originate from it) is not an accurate measure of the faculties, because the seal has in proportion to its nerves a larger brain than the house dog, and the porpoise than the ourang-outang.

As the human brain is of such great comparative mag nitude, the cranium is necessarily very large and bears a greater proportion to the face than in any animal. In an European a vertical section of the cranium is almost four times larger than that of the face (not including the lower jaw); in the monkey it is little more than double; in most feræ, nearly equal; in the glires, solipedes, pecora and belluæ, less. The faculties, however, do not depend upon this proportion, because men of great genius, as Leo,

* Consult Spurzheim, l. c. on the correspondence between the mind and the proportion of the brain in several particulars.

Montaigne, Leibnitz, Haller, and Mirabeau had very large faces, and the sloth and seal have faces larger than the stag, horse and ox, in proportion to the brain, and the proportion is acknowledged by Cuvier to be not at all applicable to birds. We are assisted in discovering the proportion between the cranium and face by the facial angle of Camper. He draws two straight lines, the one, horizontal, passing through the external meatus auditorius and the bottom of the nostrils, the other, more perpendicular, running from the convexity of the forehead to the most prominent part of the upper jaw. The angle which the latter,—the proper facial line, makes with the former, is least in the human subject, from the comparative smallness of the brain and the great developement of the mouth and nose in animals. In the human adult this angle is 85°; in the ourang-outang 67°; in some quadrupeds 20°; and in the lower classes of vertebral animals it entirely disappears.

Neither is it to be regarded as an exact measure of the understanding, for persons of great intellect may have a prominent mouth; it shows merely the projection of the forehead, while the cranium and brain may vary greatly in size in other parts; three-fourths of quadrupeds, whose crania differ extremely in other respects, have the same facial angle; great amplitude of the frontal sinuses, as in the owl and hog, without any increase of brain, may diminish it, and for this reason Cuvier draws the facial line from the internal table of the frontal bone.

In proportion as the face is elongated, the occipital foramen lies more posteriorly; in man consequently it is most forward. While in man it is nearly in the centre of the base of the cranium, and horizontal, and has even sometimes its anterior margin elevated; in most quadrupeds it is situated at the extremity of the cranium obliquely, with its posterior parts turned upwards, and is in some completely vertical. On this difference of situation, Daubenton founded his occipital angle.* He drew one line from the posterior edge of the foramen to the lower edge of the orbit, and another in the direction of the foramen, passing between the condyles and intersecting the former. According to the angle formed, he established the similarity and diversity of crania. The information derived from it in this respect is very imperfect, because it shows the differences of the occiput merely. Blumenbach remarks that its variations are included between 80 and 90° in most quadrupeds, which differ very essentially in other points.

The want of the os intermaxillare has been thought peculiar to mankind. Quadrupeds, and even the ape tribe, have two bones between the superior maxillary, containing the dentes incisores when these are present, and termed ossa intermaxillaria, incisoria, or labialia. Its universal existence in them, however, is not satisfactorily established. Man alone has a prominent chin: his lower jaw is the shortest, compared with the cranium; and its condyles differ in form, direction, and articulation from those of any animal: in no animal are the teeth arranged in such a close and uniform series; the lower incisores, like the jaw in which they are fixed, are perpendicular,--a distinct characteristic of man, for in animals they slope backwards with the jaw bone; the canine are not longer than the rest, nor insulated as in monkeys; the molares differ from those of the ourang-outang and

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* *Memoires de l'Academie des Sciences de Paris*, 1764.

of all the genus simia, by their singularly obtuse projections.

The slight hairiness of the human skin in general, although certain parts, as the pubis and axillæ, are more copiously furnished with hair than in animals; the situation of the heart lying not upon the sternum, as in quadrupeds, but upon the diaphragm, on account of our erect position, the basis turned not as in them to the spine, but to the head, and the apex to the left nipple; the omnivorous structure of the alimentary canal; the curve of the vagina corresponding with the curve of the sacrum formerly mentioned, causing woman to be not, as brute females are, retromingent; perhaps the hymen; the singular structure of the human uterus and placenta; the length of the umbilical chord and the existence of the vesicula umbilicalis till the fourth month; the extreme delicacy of the cellular membrane; the absence of the allantois, of the panniculus carnosus, of the rete mirabile arteriosum, of the suspensorius oculi; and the smallness of the foramen incisivum, which is not only very large in animals, but generally double, are likewise structural peculiarities of the human race.

Man alone can live in almost every climate; he is the slowest in arriving at maturity, and, in proportion to his size, he lives the longest; he alone procreates at every season, and, while in celibacy, experiences nocturnal emissions. None but the human female menstruates.

Man, thus distinguished from all other terrestrial beings, evidently constitutes a separate species,—fact harmonizes with the Mosaic account of his distinct creation. For "a species comprehends all the individuals which descend "from each other, as from a common parent, and those "which resemble them as much as they do each other," and no animal bears such a resemblance to man.*

He is subject, however, to great variety, so great indeed that some writers have contended that several races of men must have been originally created. We shall now examine the principal of these varieties.

THE most generally approved division of mankind is that of Blumenbach.† He makes five varieties; the Caucasian, Mongolian, Ethiopian, American, and Malay. The following are the characteristics of each.

1. THE CAUCASIAN. The skin white; the cheeks red, —almost a peculiarity of this variety; the hair of a nut brown, running on the one hand into yellow and on the other into black, soft, long, and undulating.

The head extremely symmetrical, rather globular; the forehead moderately expanded; the cheek bones narrow, not prominent, directed downwards from the Malar process of the superior maxillary bone; the alveolar edge round; the front teeth of each jaw placed perpendicularly.

The face oval and pretty straight; its parts moderately distinct; the nose narrow and slightly aquiline, or at least its dorsum rather prominent; the mouth small; the lips, especially the lower, gently turned out; the chin full and round;—in short, the countenance of that style which we consider the most beautiful.

This comprehends all Europeans except the Laplanders and the rest of the Finnish race, the western

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* Cuvier. *Discours Preliminaire aux recherches sur les ossemens Fossiles des Quadrupedes.*

† *De generis humani varietate nativa.* Sect. iv.

Asiatics as far as the Obi, the Caspian and the Ganges, and the people of the North of Africa.

M. de Virey subdivides this variety into two parts:* the one with very light skin and hair and great muscular strength, including most European nations, as the Cimbri and Scandinavians, Teutoni, Celts properly so called, Goths, Saxons, Icelanders, Britons, Normans, Francs, Italians, Greeks and Celtiberians, and even the Galatæ or Asiatic Gauls, who have spread themselves in Asia Minor, the Morea, Georgia and Circassia: the other not so light, including the Vandals, Illyrians or Sclavonians, Getæ, Sarmatæ, Gepidæ, Thracians, Russians, Turks, Tartars of the Crimea, Scythians, Persians, Arabians, Moors, and even the Cisgangetic Hindus.

2. The Mongolian. The skin of an olive colour; the hair black, stiff, straight and sparing.

The head almost square; the cheek bones prominent outwards; the space between the eyebrows, together with the bones of the nose, placed nearly in the same horizontal plane with the malar bones; the superciliary arches scarcely perceptible; the osseous nostrils narrow; the fossa maxillaris shallow; the alveolar edge arched obtusely forwards; the chin somewhat projecting.

The face broad and flattened and its parts consequently less distinct; the space between the eyebrows very broad as well as flat; the cheeks not only projecting outwards, but nearly globular; the aperture of the eye-lids narrow, linear; the nose small and flat.

This comprehends the remaining Asiatics, except the Malays of the extremity of the Transgangetic peninsula; the Finnish races of the North of Europe,—Laplanders,

* *Histoire Naturelle du genre humain.* Tom. 1. Sect. 1.

&c.; and the Esquimaux diffused over the most northern parts of America from Bhering's Strait to the farthest habitable spot of Greenland.

In this M. de Virey makes three subdivisions: the first short, weak, barbarous and cowardly, and lean and brown even in cold and temperate climates, embracing all the circumference of the Arctic pole, Spitzberg, Petzora and Greenland, the Esquimaux, Tschutches, Kamtschatkans, Koriaks, Ostiaks, Gakats, Jukagres, Samoides, and Laplanders: the second, for the most part horridly ugly, embracing the Eluths and Calmucks, Tunguses, Baskirks, true Cossacks, Kirghises, Tschouvachs, Burats, Soongarees, the Mantchoos people of the north of China, and the Tanjutic tribes of Thibet: the third, less ugly, enjoying a more southern climate and fixed abodes, embracing the Chinese, Japanese, Coresians, Tonguinese, Cochinchinese, the people of Jesso, many of Thibet, the Siamese, &c.

3. Ethiopian. The skin black; the hair black and crisp.

The head narrow, compressed laterally; the forehead arched; the malar bones projecting forwards; the osseous nares large; the malar fossa behind the infra-orbitar foramen deep; the jaws lengthened forwards; the alveolar edge narrow, elongated, more elliptical; the upper front teeth obliquely prominent; the lower jaw large and strong; the cranium usually thick and heavy.

The face narrow and projecting at its lower part; the eyes prominent; the nose thick and confused with the projecting cheeks; the lips, especially the upper, thick; the chin somewhat receding.

The legs in many instances bowed.

This comprehends the inhabitants of Africa, with the exception of those in the northern parts, already included in the Caucasian variety.

M. de Virey here also makes two subdivisions; the one embracing the people of the equatorial parts of Africa, of Nigritia and Guinea, the Madingos, Jaloffs, Caffres, Galla, the inhabitants of Conjo, Angola, the coast of Zanguebar, Monoëmugi, the interior of Madagascar and of New Guinea, and lastly, the Papoos: the other of an olive tint nearly approaching to black, embracing the Hottentots, the Namaguese, nearly the whole of New Holland and some neighbouring islands, as New Caledonia and the island of the Quirds.*

4. The American. The skin of a copper colour; the hair black, stiff, straight and sparing.

The forehead short; the cheek bones broad, but more arched and rounded than in the Mongolian variety, not, as in it, angular and projecting outwards; the orbits generally deep; the forehead and vertex frequently deformed by art; the cranium usually light.

The face broad, with prominent cheeks, not flattened, but with every part distinctly marked if viewed in profile; the eyes deep; the nose rather flat, but still prominent.

This comprehends all the Americans excepting the Esquimaux.

5. The Malay. The skin tawny; the hair black, soft, curled, thick and abundant.

The head rather narrow; the forehead slightly arched; the parietal bones prominent; the cheek bones not prominent; the upper jaw rather projecting.

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* The inhabitants of these islands are not included by Blumenbach in the Ethiopian, but in the Malay variety.

The face prominent at its lower part; not so narrow as in the Ethiopian variety, but the features, viewed in profile, more distinct; the nose full, broad, bottled at its point; the mouth large.

This comprehends the inhabitants of the Pacific, Marian, Philippine, Molucca, and Sanda isles, and of the peninsula of Malacca.

General Remarks. The colour of the hair thus appears somewhat connected with that of the skin, and the colour of the iris is closely connected with that of the hair. Light hair is common with a white and thin skin only, and a dark thick skin is usually accompanied by black hair; if the skin happens to be variegated, the hair also is variegated; with the milk white skin of the albino, we find hair of a peculiar yellowish white tint; and where the skin is marked by reddish freckles, the hair is red. When the hair is light, the iris is usually blue; when dark, it is of a brownish black; if the hair loses the light shade of infancy, the iris likewise grows darker, and when the hair turns grey in advanced life, the iris loses much of its former colour; the albino has no more colouring matter in his iris than in his skin, and it therefore allows the redness of its blood to appear; those animals only whose skin is subject to varieties, vary in the colour of the iris; and if the hair and skin happen to be variegated, the iris is observed likewise variegated.*

* The hair is frequently of different shades in different parts. John Hunter remarked that the iris in animals agrees principally with the colour of the eyelashes. However various the colour of the hair in horses, the iris, he also observes, is always of the same. But then the hair is always of the same at birth, and the skin does not participate in its subsequent changes, being as dark in white as in black horses. In cream-coloured horses, indeed, there is an exception, the iris agrees

The Caucasian variety of head, nearly round, is the mean of the rest, while the Mongolian, almost square, forms one extreme, having the American intermediate; and the Ethiopian the other extreme, having the Malay intermediate between it and the Caucasian.

The Caucasian variety of face is also the mean, while the Mongolian and American, extended laterally, form one extreme, and the Ethiopian and Malay, extended inferiorly, constitute the other. In the first of each extreme, viz. the Mongolian and Ethiopian, the features are distinct, while in the second, viz. the American and Malay, they are confused.

Although this division of mankind is well founded and extremely useful, it is liable, like every artificial division of natural objects, to many exceptions. Individuals belonging to one variety are not unfrequently observed with some of the characteristics of another;* the character-

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with the hair, but then the foals are originally cream coloured, and the skin is cream coloured. Hunter, *On the colour of the pigmentum of the eye in different animals. Obs.* 247.

* "Sooty blackness is not peculiar to the Ethiopian, but is occa-"sionally found in other varieties of men very different and remote "from each other, in the Brazilians, Californians, Indians, and some "South Sea Islanders; and among the latter, the new Caledonians "form an insensible transition with the chesnut coloured inhabitants "of Tongatabu from the tawny Otaheitans to the black New Hol-"landers. Blumenbach, *De generis humani varietate nativa.* sect. 43.

"Some tribes of Ethiopians have long hair (Bruce on the Galla; "African Institution on the people of Bornan); on the contrary, some "copper coloured people have the crisp hair of the Ethiopian. (The "inhabitants of the Duke of York's island, near new Ireland; Vide "*Hunter's Historical Account of the proceedings at Port Jackson*); "again the hair of the New Hollanders, specimens of which I have "now before me, is so perfectly intermediate between the crisp hair "of the Ethiopian and the curly hair of the islanders of the Pacific istics of two varieties are often intimately blended in the same individual (indeed all the four varieties run into

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" ocean, that there has been much diversity of opinion from the first " Dutch to the latest English travellers, to which of the two varieties " it should be referred. As to the varieties of colour existing among " nations whose hair is usually black, we have sufficient authority for " asserting, that numerous instances of red hair occur in all the three " last varieties." l. c. sect. 52.

" The Caffres and the people of Congo have hair not unlike that of " Europeans. Even the Foulahs, one of the Negro tribes of Guinea, " have, according to Mr. Park, soft, silky hair; on the other hand, the " inhabitants of many other countries resemble the Africans in their " hair, as the savages of New Guinea, Van Diemen's land, and Malli- " collo. And in the same island some of the people are found with " crisp and woolly, others with straight hair, as in the New Hebrides. " In New Holland there are tribes of each character, though resemb- " ling in other particulars." Prichard's *Researches into the physical history of Man*. p. 83.

" Many tribes of the Negro race approach very near to the form of " Europeans. The Jaloffs of Guinea, according to Park, are all very " black, but they have not the characteristic features of the Negro— " the flat nose and thick lips: and Dampier assures us that the natives " of Natal in Africa have very good limbs, are oval visaged, that their " noses are neither flat nor high, but very well proportioned; their " teeth are white, and their aspect altogether graceful. The same " Author (Dampier's *Voyages*) informs us, that their skin is black, " and their hair crisped. Nor are others of this diversity more con- " stant. In the native race of Americans, some tribes are found, " who differ not in the characters in question from Europeans. Under " the 54° 10′ of north latitude," says Humboldt, "at Cloak-bay, in " the midst of copper-coloured Indians, with small long eyes, there is a " tribe with large eyes, European features, and a skin less dark than " that of our peasantry." Humboldt's *Essay on New Spain*, translated. l. c. p. 62. note b.

" The features of the inhabitants of the Friendly Islands are very " various, insomuch that it is scarcely possible to fix on any general each other by insensible degrees);* and instances continually occur of deviation in one or more particulars from the appearances characteristic of any variety;† so that the assemblage rather than individual marks must frequently be employed to determine the variety.

Particular Remarks. The Caucasian variety is pre-eminent in all those mental and corporeal particulars which distinguish man from animals. The general aspect is dignified; the men appear formed for valour and contemplation, the women for every sweet attractive grace. The cranium is very capacious, the area of the face bears to its area but a proportion of one to four, and projects little or not at all at the lower parts: the intellectual faculties are susceptible of the highest cultivation. Philosophy and the fine arts flourish in it as in their proper soil: to it revelation was directly granted.

The Ethiopian variety when instructed by the Caucasian has produced instances of mental advancement great

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"likeness by which to characterize them, unless it be a fulness at the "point of the nose, which is very common. But on the other hand "we met with hundreds of truly European faces, and many genuine "Roman noses among them."

"Similar examples," remarks Blumenbach on this passage, (Cook's last voyage. Vol. 1. 382. l. c. § 55. note.) "are observed, among "Ethiopian and American nations; and, vice versa, the resemblance "of individual Europeans to Ethiopians and Mongoles is very frequent, "and has become even proverbial."

* "The Tartars of the Caucasian variety pass by means of the "Kirghises and neighbouring people into the Mongoles, in the same "manner as these by means of the people of Thibet into the Indians, "by means of the Esquimaux into the Americans, and by means of "the Phillippine Islanders even in some measure into the Malays." Blumenbach. l. c. § 86.

† See note, page 396.

indeed, but inferior to what the latter is capable of attaining. "There scarcely ever," says Hume, "was a "civilized nation of that complexion, nor even an individual, eminent either in action or speculation. No "ingenious manufactures amongst them, no arts, no "sciences. On the other hand, the most rude and bar- "barous of the whites, such as the ancient Germans, the "present Tartars, have still something eminent about "them, in their valour, form of government, or some "other particular."* Blumenbach, however, possesses English, Dutch and Latin poetry written by different negroes, and informs us, that, among other examples of distinguished negroes, a native of Guinea, eminent for his integrity, talents, and learning, took the degree of doctor in philosophy at the University of Wittenberg, and that Lislet of the Isle of France was chosen a corresponding member of the French Academy of Sciences. "Provinces of Europe," says he, "might be named, in "which it would be no easy matter to discover such good "writers, poets, philosophers, and correspondents of the "French Academy; and on the other hand, there is no "savage people which have distinguished themselves by "such examples of perfectibility, and even capacity for "scientific cultivation, and consequently, that none can "approach more nearly than the negro to the polished "nations of the globe."† This mental inferiority is attended of course by a corresponding inferiority of the brain. The circumference, diameters, and vertical arch of the cranium being smaller than in the European,‡ and

* Hume's *Essays*. Part 1. Essay 21. Note M.

† *Beyträge zur Naturgeschichte*. p. 118. Vide Rees's Cyclopædia.

‡ Soemmerring. *De basi cranii et originibus nervorum cranio egredientium.*

the forehead particularly being narrower and falling back in a more arched form, the brain in general and particularly those parts which are the organs of intellect properly so called,* must be of inferior size. The orbits on the contrary, and the olfactory and gustatory or rather masticatory organs being more amply evolved, the area of the face bears a greater proportion to the area of the skull,—as 1. 2. to 4.; the proportion is greater in the ourang-outang, and in the carnivora nearly equal.† The senses here situated, as well as that of hearing, are remarkably acute, and the corresponding nerves, at least the first, fifth, and facial, of great size.‡

The ossa nasi lie so flatly as to form scarcely any ridge; the face, as we have formerly seen, projects considerably at its lower part;§ the lower jaw is not only long but extremely strong; the chin not only not promi-

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* Spurzheim's *Physiognomical system.*

† Cuvier's *Léçons d'Anatomie Comparée.*

‡ Soemmerring.

§ Camper. *(Dissertation physique sur les différences reelles, que presentent les traits du visage chez les hommes de différens pays et de différens ages)* gives the following proportions of the facial angle.

European - - - - - - - -	80 or 90
Chinese - - - - - - - -	75
Negro - - - - - - - -	70
Ourang-outang - - - - - -	42

Mr. White *(Essay on the regular gradation)* states them rather differently.

Monkey - - - - - -	40	to 50
Ourang-outang - - - - -	50	60
African - - - - - -	60	70
American - - - - - -	70	75
Asiatic - - - - - - -	75	80
European - - - - - -	80	90

nent, but even receding, and the space between it and the lower teeth is small, while that between the upper teeth and the nose is large; the meatus auditorius is nearer the occiput,—more remote from the front teeth than in the European; the foramen magnum occipitale lying farther back, the occiput is nearly in a line with the spine; the body is slender, especially in the loins and pelvis, whose cavity likewise is small; the length of the fore-arms and fingers bears a large proportion to that of the os humeri; the os femoris and tibia are more convex, and the edge of the latter, which, in consequence of hearing the remark from my friend Mr. Fyfe of Edinburgh, I have frequently examined in living negroes, is very sharp; the calves are placed high; the os calcis instead of forming an arch is on a line with the other bones of the foot, which is of great breadth; the toes are long; the penis large and frequently destitute of frænum.

Mr. White, from whom many of these remarks are derived, describes the testes and scrotum as small, but this does not accord with my own experience; the skin is thicker;* and finally the term of life shorter, than in Europeans.

Nearly all these facts demonstrate a greater affinity of the Negro than of the European to the brute creation. But so slightly inferior to the Caucasians, and so immensely superior to the most intelligent animals, the poor negro might justly class those of us who *philosophically* view him as merely a better kind of monkey, or who

* The temperature of the Negro is said to be two degrees cooler than that of Europeans, and the voluptuous therefore to prefer a Negress in summer, a fair Circassian in spring and autumn, and an European brunette in winter.

desire to traffic in his blood, not only below himself but below apes in intellect, and tigers in feeling and propensity.

"Indica tigris agit rabida cum tigride pacem
"Perpetuam. Sævis inter se convenit ursis."*

The Malays have but little hair upon the chin, and possessing a great developement of the parts of the head above the ears, are, as might be expected,† signalized for their treachery, cunning and ferocity, and their passionate fondness for poetry.

The Mongolians are remarkably square and robust; their shoulders high; their extremities short and thick.

The Americans have small hands and feet, and are nearly destitute of beard. Shorter in the forehead than the Mongolians, they have not so great intellectual distinction.

Not only have the five varieties their distinctive characteristics, but the different nations comprehended in each variety have each their peculiarities, both mental and corporeal: among the Caucasians, for example, the Germans, French, Spaniards and English are extremely different from each other. Nay, the provinces of the same country differ, and the families of the same province, and, in fact, every individual has his own peculiar countenance, figure, constitution, form of body, and mental character.

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* Juvenal. *Sat.* L. xv. 163.

† Spurzheim's *Physiognomical System.*

A QUESTION here presents itself.—Are the differences among mankind to be ascribed to the influence of various causes upon the descendants of two;—or of more, but all similar, primary parents;—or to original differences in more than two primary parents? If *considerations à priori, analogical and direct facts*, and *the history of mankind*, corroborate in conjunction the first supposition, there will be no necessity to have recourse to the bolder second, nor to the third,—the boldest of the three.

Our inquiries on this point should be prosecuted, as well as all inquiries into nature, without reference to revelation. Lord Bacon has observed, that the union of religious and philosophical investigation is often detrimental to the cause of truth.*

If we resolve to make religion and philosophy harmonize before we are certain of being perfectly acquainted with the meaning of the sacred text or masters of all the facts necessary to establish legitimately a philosophical opinion, the one or the other, or perhaps both, will be strained and distorted. The truth will be more readily obtained if we examine the sense of scripture, indifferent to the conclusions of philosophy, and inquire into nature, indifferent to the pronunciations of revelation. They must ultimately agree; for the works and the voice of the Almighty cannot contradict each other. But this agreement should be spontaneous; assured that it will ultimately occur, its absence should have no other influence upon our minds than to stimulate us to farther inquiry, convincing us that either our conclusions are illegitimate or our facts deficient; but not inclining us to deviate in the least from the severest and most independent mode of

* *Cogitata et visa.*

investigation, nor to force the scripture from its well established signification.

On the point before us the Bible speaks positively and clearly, without the possibility of various interpretation or corruption of the text, and not only in the account of the creation, but incidentally in many other places.* It is

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* The writer of the article MAN in Rees's *Encyclopædia* remarks, that the book of Genesis does not clearly assert that Adam and Eve were the parents of mankind. If we read the whole Bible, we shall find our descent from Adam and Eve frequently alluded to, both in the Old and New Testament, and not merely as an indifferent fact, but as one of the fundamental truths of revelation; and thus any supposed obscurity in the book of Genesis completely dispelled. His object, however, seems not to charge Moses with obscurity, but with contradiction. He says,— 'We are told indeed that "Adam called his wife's name Eve, be- "cause she was the mother of all living." But in the first chapter 'of Genesis we learn, that God created man, male and female, and 'this seems to have been previously to the formation of Eve, which 'did not take place till after the garden of Eden had been made. 'Again we are informed, in the fifth chapter of Genesis, that "in "the day God created man, in the likeness of God, created he him; "male and female created he them; and blessed them and called their "name Adam, in the day when they were created."' Now the second chapter of Genesis is a recapitulation, and, at the same time, a more circumstantial detail of what is contained in the first. In the first, the man and woman are said to have been created on the sixth day; in the second, we are further informed how and in what order each was formed,—that the man was formed of the dust of the earth, and placed in the garden of Eden, (planted, it appears from perusing the whole of the second chapter, before his creation no less than before that of Eve) where he fell into a deep sleep, during which the woman was formed from a part of his body. Is this obscure or contradictory?

'We find also that Cain,' continues this writer, (in the words of Mr. White, of Manchester) 'after slaying his brother, was married, 'although it does not appear that Eve had produced any daughters delightful to find nature and history investigated already so far, as to harmonize with the statement of holy writ,

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'before this time.' "Cain went out from the presence of the Lord, "and dwelt in the land of Nod, on the east of Eden. And Cain knew "his wife, and she conceived and bare Enoch." Indeed, it is said (ch. 5. v. 4.) that "the days of Adam, after he had begotten Seth, "were eight hundred years, and he begat sons and daughters." 'This 'it should seem took place after the birth of Seth, and consequently, 'long after Cain had his wife; for Seth was not born till after the 'death of Abel. If Cain had sisters prior to that period, from amongst 'whom he might have taken a wife, it is singular, as some persons 'may allege, that Moses should not have noticed them.' By no means singular. Moses relates a few most important circumstances only, just sufficient to carry on the history from the creation; the first six chapters comprehend a period of no less than sixteen hundred and fifty-six years. Although the marriages of Adam's descendants are continually alluded to, yet as the successions and periods of the births of the men only were important to his history, he does not, I believe, individually mention, during the first nineteen hundred and fifty years of his history, the daughter of any particular person. His silence in this particular is conspicuously seen in the fifth chapter; for example, where after mentioning the birth of the first son, and the amount of the subsequent years of the father's life, he merely adds, "and begat sons and daugh-"ters;" not only in regard to Adam, but to his descendants. He passes over in silence even individual sons, when they constitute no link, and are connected with no remarkable circumstance, in his history of our race.

I, as a believer in the divine origin of Christianity, and, I trust, from rational conviction, earnestly entreat this writer and all others who are inclined to despise the Scriptures, to distinguish between Christianity and sanctified cant, and to suspend their unbelief and sarcasms till they have dispassionately studied at least the four gospels, and the works of Bishops Butler and Watson, of Paley, Dr. Maltby, and Mr. Leslie.

'Hume owned to a clergyman in the bishopric of Durham, that he 'had never read the New Testament with attention.'†

† (Boswell's *Life of Johnson*. Vol. ii. p. 7. fifth edition.)

but we shall detail the arguments independently of this consideration.*

A priori, I think, the universal simplicity of nature's causes would induce us to imagine, that, as, if the varieties among us are accidental, two individuals were evidently sufficient for the production of the rest of mankind, no more than two were originally created. Nor can I conceive it possible to deduce a contrary presumptive argument, from the length of time during which immense portions of the earth must have thus remained unpeopled. One of nature's objects seems the existence of as much life as possible, whether animal or vegetable, throughout the globe. For this purpose every species of animal and vegetable possesses an unlimited power of propagation, capable of filling the whole world, were opportunity afforded it. The opportunities of exertion are indeed very scanty, compared with the power; one vegetable, one animal, stands in the way of another; even the impediments to the increase of some, act through them as impediments to others. The constant tendency of the power of multiplication to exert itself, seizes every opportunity the moment it is presented, and thus nature constantly

* All the animals of each species appear descended from one stock, for the animals of the two hemispheres are all of distinct species, excepting in the northern regions, where a communication is very explicable. The same is true of the animals of the arctic and antarctic regions: prevented, like the more equatorial animals of the two hemispheres, by the intermediate climate, from communicating with each other, they are all of distinct species. In islands remote from continents, either no quadrupeds are found, or such as have been conveyed thither, or such as are different from any others; while in islands near continents, the quadrupeds are the same as in the neighbouring country.

teems with life. The slow increase of mankind could not interfere with this apparent object of nature; the deficiency of our race must have invariably been fully compensated by the opportunities which it afforded for the multiplication of other existences: for that man alone was not designed to fill the earth, is shown by the vast tracts of land still but thinly peopled. The infinitely rare opportunities afforded for the maturity of the intellectual and moral powers born with every human being, may afford still greater surprise than the extent of country unoccupied by man. After all, the originally great length of life must have contributed so much to man's multiplication, that were food sufficiently supplied, he might very speedily have covered the earth.

Analogical and direct facts lead us to conclude that none of the differences among mankind are so great as to require the belief of their originality.

Animated beings have a general tendency to produce offspring resembling themselves, in both mental and corporeal qualities.

> "Fortes creantur fortibus et bonis;
> "Est in juvencis, est in equis patrum
> "Virtus: nec imbellem feroces
> "Progenerant aquilæ columbam."*

An exception occasionally occurs, much more frequently indeed in the domestic than the wild state,—the offspring differs in some particular from the parents; and by the force of the general tendency transmits to its offspring its own peculiarity. By selecting such examples, a breed peculiar in colour, figure, the form of some one

* *Horace*, L. iv. od. 4.

part, or in some mental quality, may be produced. Thus by killing all the black individuals which appear among our sheep and breeding only from the white, our flocks are white; while, by an opposite practice pursued in some countries, they are black: thus a ram accidentally produced on a farm in Connecticut, with elbow-shaped fore-legs and a great shortness and weakness of joint indeed in all four extremities, was selected for propagation, and the ἀγκών breed, unable to climb over fences, is now established:* thus some breeds of hares have horns like the roebuck: the Dorking fowl has two hind claws; and fowls indeed are bred in every conceivable variety.† Individuals, distinguished from others by no greater differences than those which thus spring up accidentally, cannot be supposed to belong to a separate species. Upon the comparison of these differences depends the analogical argument first employed by Blumenbach. Finding the ferret *(mustela furo)* to differ from the pole cat *(putorius)* by the redness of its eyes, he concludes it is merely a variety of the same species, because instances of this deviation are known to occur accidentally in other animals; but he concludes the African elephant is of a

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* Thomson's *Annals of Philosophy*, No. 2.

† The offspring most frequently resembles both parents, but the proportion of resemblance to each is extremely various, some children favouring the father most, some the mother, though all sufficiently resembling each to preserve a family likeness; some stamped by any accidental singularity of one parent, others not; and it is remarkable that the resemblance to the parents, whether in regard to usual or singular peculiarity, is occasionally not observed in the immediate offspring, but reappears in the third or even some later generation.

species distinct from the Asiatic, because the invariable difference of their molar teeth is of a description which naturalists have never found accidental. Now there exist among mankind no differences greater than what happen occasionally in individual species of animals.

The colours of the animals around us, horses, cows, dogs, cats, rabbits, fowls, are extremely various, black, white, brown, grey, variegated.

The hair of the wild Siberian sheep is close in summer, but rough and curled in winter;* sheep in Thibet are covered with the finest wool, in Ethiopia with coarse stiff hair;† the bristles of the hog in Normandy are too soft for the manufacture of brushes;‡ goats, rabbits, and cats of Angouri, in Anatolia, have very long hair, as white as snow and as soft as silk.§

The head of the domestic pig differs as much from that of the wild animal, as the Negro from the European in this respect;|| so the head of the Neapolitan horse, denominated rams head on account of its shape, from that of the Hungarian animal, remarkable for its shortness and the extent of its lower jaw;** the cranium of fowls at Padua is dilated like a shell and perforated by an immense number of small holes;†† cattle and sheep in some parts of our own country have horns, in others not; in Sicily sheep have enormous horns:‡‡ and in some instances this

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* Pallas. *Spicileg. Zoologica.* † Blumenbach. l. c. § 28.

‡ l. c. § l. c. || l. c. ** l. c.

†† Pallas. *Spic. Zool.* fasc. iv. p. 22. Sandifort. *Museum Anatonicum acad.* Lugd. Batav. T. 1. p. 306.

‡‡ Blumenbach. l. c. § 30.

animal has so many, as to have acquired the epithet polyceratous.

The form of other parts is no less various. In Normandy, pigs have hind legs much longer than the fore;* at the Cape of Good Hope, cows have much shorter legs than in England;† the difference between the Arabian, Syrian and German horses is sufficiently known; the hoofs of the pig may be undivided, bisulcous, or trisulcous.

These are regarded by naturalists as but accidental varieties, yet they equal or surpass the varieties existing among mankind. We are consequently led by analogy to conclude, that the differences of nations are not original but acquired, and impose no necessity for believing that more than one stock was at first created.

Direct facts harmonize with this conclusion. All races run insensibly one into another, and therefore innumerable intermediate examples occur, where the distinction between two varieties is lost. Again, no peculiarity exists in any variety which does not show itself occasionally in another; many instances of these facts have been related in the notes to page 396. The difficulty of regarding the negro as of the same stock with ourselves, vanishes on viewing these circumstances and on reflecting that he and ourselves are two extremes, one of which may have sprung from the other by means of several intermediate deviations, although experience may not justify the belief that any single deviation could be of sufficient magnitude. An instance, however, is related, in the Philosophical Transactions, of a black family, which lived where Europeans had never approached, and from time to time pro-

* Blumenbach, l. c. § 30. † l. c.

duced a white child.* Lastly, all the varieties breed together readily and in perpetuity,†—an assertion which cannot be made in regard to any different species of animals.

The cause of the differences of our species has been more or less sought for in climate, alone or in conjunction with other external circumstances, by Aristotle, Hippocrates, Cicero, Pliny, Plutarch, Galen, nearly all the Greek and Roman historians and poets, Montaigne, Montesquieu, Buffon, Zimmerman, Blumenbach, Dr. Smith of America, &c. Lord Kaimes has denied the power of these circumstances to produce the diversities of either mind or body; and Hume has expressly written an essay to prove the insufficiency of climate with respect to the varieties of national character. Now the intensity of light unquestionably affects the colour of the surface, although not to the degree of Ethiopian blackness; heat the texture and growth of the hair; and quantity of nourishment the size. But the effects of these circumstances are superficial, even

* Two blacks marrying produced a white child: the woman, fearing her husband's resentment, endeavoured to conceal it from him. The man, however, insisted upon seeing the infant, and finding it white, said, 'I love it the better for that; for my own father was a white 'man, though my grandfather and grandmother were as black as you 'and myself; and although we come from a place where no white 'people were ever seen, yet there was always a white child in every 'family that was related to us.' *Phil. Trans.* Vol. 55.

An instance is likewise very credibly stated of an adult negress, who, from no evident cause, grew white, and in the course of fifteen years, became scarcely inferior in any part of her surface to an European. *Phil. Trans.* Vol. 51.

† An instance has already been mentioned of what is a still stronger argument,—the simultaneous production of two individuals of different varieties by the same mother.

on animals necessarily less protected against their influence than man. The skulls of foxes belonging to northern regions are not different from those of France or Egypt: the tusks of the elephant, and the horns of the stag and rein deer, may acquire a larger size when the food is more favourable to the production of ivory or horn, but the number and articulations of the bones, and the structure of the teeth, remain unaltered.* Nor are these changes, any more than those induced by mechanical means, as pressure, division, &c. transmitted to the offspring: the child of the most sunburnt rustic is born equally fair with other children; even all the children among the Moors are born white and acquire the brown cast of their fathers only if exposed to the sun;† although the Jews have most religiously practised the rite of circumcision from the days of Abraham, their foreskin still remains to be circumcised. Were it therefore true that all dark nations are the inhabitants of hot climates, as the confined knowledge of the antients justified them in believing, it would still be untrue that the change effected, for instance, in the colour of the parent's skin, had descended to the offspring. But modern discovery has made us acquainted with light nations, inhabiting the warmest regions, with dark nations inhabiting the coldest, and with others of various shades of colour, although in the same climate.‡ Nor

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* Cuvier. *Discours Préliminaire aux Récherches sur les Ossemens Fossiles des Quadrupedes. Natural varieties* only are meant. Local situation can produce the most intimate structural *diseases*; witness Cretinism.

† Poiret's *Voyage en Barbarie.* T. i. p. 31. Vide Blumenbach, l. c.

‡ Lord Kaimes, M. de Virey, and Dr. Prichard have quoted many in-

are the varieties of mankind more connected with the varieties of food. In the present state of our knowledge, it is impossible fully to account for them.

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stances of these facts. 'We found,' says Humboldt, 'the people of the 'Rio Negro swarthier than those of the lower Orinoco, and yet the 'banks of the first of these rivers enjoy a much cooler climate than the 'more northern regions. In the forests of Guiana, especially near the 'sources of the Orinoco, are several tribes of a whitish complexion, the 'Guiacas, Guajaribs and Arigues, of whom several robust individuals 'exhibiting no symptom of the asthenical malady which characterizes 'Albinos, have the appearance of true Mestizos. Yet these tribes have 'never mingled with Europeans, and are surrounded with other tribes 'of a dark brown hue. The Indians, in the torrid zone, who inhabit 'the most elevated plains of the Cordilleras, of the Andes, and those 'who under the 45° of south latitude, have as coppery a complexion as 'those who under a burning climate cultivate bananos in the narrowest 'and deepest vallies of the Equinoctial region. We must add that the 'Indians of the mountains are clothed, and were so long before the 'conquest, while the Aborigines, who wander over the plains, go quite 'naked, and are consequently always exposed to the perpendicular rays 'of the sun. I could never observe that in the same individuals those 'parts of the body which were covered were less dark than those in 'contact with a warm and humid air. We every where perceive that 'the colour of the American depends very little on the local position in 'which we see him. The Mexicans, as we have already observed, are 'more swarthy than the Indians of Quito and New Granada, who in'habit a climate completely analogous, and we even see that the tribes 'dispersed to the north of the Rio Gila are less brown than those in 'the neighbourhood of the kingdom of Guatimala. This deep colour 'continues to the coast nearest to Asia, but under the 54° 10′ of north 'latitude, at Cloak bay, in the midst of copper coloured Indians, with 'small long eyes, there is a tribe with large eyes, European features, 'and skin less dark than that of our peasantry.' *Political Essay on New Spain*, translated.

The Jews settled in the neighbourhood of Cochin "are divided into 'classes, called the Jerusalem or white Jews, and the antient or black

With civilization and barbarism, however, they appear intimately connected. We should beforehand be inclined to suppose that the most excellent developement of every animated species would be effected where all its wants were best supplied, its powers all duly called forth, and all injurious or unpleasant circumstances least prevalent: and vice versa. But experience teaches us that no change can by any means be brought about in an individual, and transmitted to the offspring: the causes of change in a species must therefore operate, not by altering the parents, but by disposing them to produce an offspring more or less different from themselves. Such is Mr. Hunter's

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'Jews.'—'The white Jews look upon the black Jews as an inferior 'race, and not as a pure cast, which plainly demonstrates that they do 'not spring from a common stock in India.'

The white appear to have resided there upwards of seventeen hundred years. Buchanan's *Christian Researches in Asia*, 219, &c.

Dr. Shaw and Mr. Bruce describe a race of fair people in the neighbourhood of Mount Aurasius, in Africa, who, 'if not so fair as the 'English, are of a shade lighter than that of any inhabitants to the 'southward of Britain. Their hair also was red, and their eyes blue.' They are imagined to be descendants of the Vandals. Bruce's *Travels*.

The Samoiedes, Greenlanders, Laplanders, Esquimaux, &c. are very swarthy; nay, some of the Greenlanders are said to be as black as Africans.

'Do we not in fact behold,' says the learned and eloquent M. deVirey, 'the tawny Hungarian, dwelling for ages under the same parallel and 'in the same country with the whitest nations of Europe; and the red 'Peruvian, the brown Malay, the nearly white Abyssinian, in the very 'zones which the blackest people in the universe inhabit. The natives 'of Van Diemen's land are black, while Europeans of the corresponding northern latitude are white, and the Malabars, in the most burning climate, are no browner than the Siberians. The Dutch, who view of the question,* and it is certainly confirmed by every fact. Uncivilized nations exposed to the inclemency of the weather, supported by precarious and frequently unwholesome food, and having none of the distinguishing energies of their nature called forth, are almost universally dark coloured and ugly; while those who enjoy the blessings of civilization, i. e. good food and covering, with mental cultivation and enjoyment, acquire in the same proportion the Caucasian characteristics. The different effects of different degrees of cultivation, says Dr. Smith, 'are most conspicuous in those countries in 'which the laws have made the most complete and permanent division of ranks. What an immense difference 'exists in Scotland between the chiefs and the commonalty of the highland clans. If they had been separately 'found in different countries, the philosophy of some 'writers would have ranged them in different species. A

'have resided more than two centuries at the Cape of Good Hope, 'have not acquired the sooty colour of the native Hottentots; the Guebres and Parsees, marrying only among themselves, remain white in the 'midst of the olive-coloured Hindus.' *Histoire Naturelle du genre humain.* par J. T. Virey. Tome premier, page 124.

* "As animals are known to produce young which are different from themselves in colour, form, and disposition, arising from what may be called the unnatural mode of life, it shews this curious power of accommodation in the animal economy, that although education can produce no change in the colour, form, or disposition of the animal, yet it is capable of producing a principle which becomes so natural to the animal that it shall beget young different in colour and form; and so altered in disposition, as to be more easily trained up to the offices in which they have been usually employed; and having these dispositions suitable to such changes of form." Hunter's *Observations, &c.* on the wolf, jackall, and dog.

'similar distinction takes place between the nobility and 'peasantry of France, Spain, of Italy, of Germany. It 'is even more conspicuous in eastern nations, where a 'wider difference exists between the highest and the 'lowest classes in society. The naires or nobles of Calicut, 'in the East Indies, have with the usual ignorance and pre-'cipitancy of travellers been pronounced a different race 'from the populace; because the former, elevated by their 'rank, and devoted only to martial studies and achieve-'ments, are distinguished by that manly beauty, and ele-'vated stature so frequently found with the profession of 'arms; especially when united with nobility of descent; 'the latter poor and laborious, and exposed to hardships 'without the spirit or the hope to better their condition, 'are much more deformed and diminutive in their per-'sons, and in their complexion much more black. In 'France, says Buffon, you may distinguish by their aspect 'not only the nobility from the peasantry, but the supe-'rior orders of nobility from the inferior, these from citi-'zens, and citizens from peasants.'—The field slaves in America, continues Dr. Smith, 'are badly clothed, fed, 'and lodged, and live in small huts on the plantations, 'remote from the example and society of their superiors. 'Living by themselves, they retain many of the customs 'and manners of their ancestors. The domestic servants, 'on the other hand, who are kept near the persons, or 'employed in the family of their masters, are treated with 'great lenity, their service is light, they are fed and 'clothed like their superiors, they see their manners, 'adopt their habits, and insensibly receive the same ideas 'of elegance and beauty. The field slaves are in conse-'quence slow in changing the aspect and figure of Africa. 'The domestic servants have advanced far before them in

'acquiring the agreeable and regular features, and the
'expressive countenance of civilized society. The former
'are frequently ill shaped, they preserve in a great degree
'the African lips, and nose and hair. Their genius is
'dull, and their countenance sleepy and stupid. The
'latter are straight and well proportioned, their hair ex-
'tended to three or four, sometimes even to six or eight
'inches: the size and shape of their mouth handsome,
'their features regular, their capacity good, and their
'look animated.'*

Dr. Prichard has 'been assured by persons who have
'resided in the West Indies, that a similar change is very
'visible among the Negro slaves of the third and fourth
'generation in those islands, and that the first generation
'differs considerably from the natives of Africa.'†

The South Sea Islanders, who appear to be all of one family, vary according to their degree of cultivation. The New Hollanders, for example, are savages and chiefly black; the New Hollanders are half civilized and chiefly tawny; the Friendly Islanders are more advanced and are not quite so dark; several are lighter than olive colour, and hundreds of European faces are found among them.

The people of Otaheite and the Society isles are the most civilized and the most beautiful: the higher orders among them have a light complexion and hair flowing in ringlets; the lower orders less cultivated are less pleasing.

"The same superiority," says Captain King;‡ 'which

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* *On the Causes of the variety in the Complexion and Figure of the human species*, p. 85. sq.

† l. c. p. 227. note.

‡ Cook's *Voyages*. Vol. 3. book 5. ch. 7.

'is observable in the Erees (nobles) throughout the other 'islands, is found also here (Owyhee). Those whom we 'saw, were, without exception, perfectly well formed; 'whereas the lower sort, besides their general inferiority, 'are subject to all the variety of make and figure that is 'seen in the populace of other countries."

Climate, however, has not been shewn to have no effect: but its power being greatly inferior to that of civilization and barbarism, cannot strongly manifest itself, when acting in opposition to these. In fact, a diminution of the sun's influence does dispose to the production of light varieties: the inhabitants of hilly situations are, cæteris paribus, fairer than the people below, and persons of the same tribe and degree of civilization are whiter in the northern parts of Europe and Asia than their more southern neighbours; whiteness, too, is very common in the north among animals, which nearer the equator are variously coloured; a pair of brown mice kept in a dark place, generate a white offspring.

Perfection, in other words, the highest compatible point of utility or agreeableness, or of both, is nature's universal aim in her productions, but it is in general obtained slowly, and the more so in proportion to the excellence or degree of the qualities to be perfected. Animals and vegetables have to pass one period before they burst into birth, and another before their full powers and proportions are reached; and man, whose perfections are very excellent, arrives at his acmé very late,

It is in this respect with species as with individuals,—their improvement is gradual. In conformity with these observations, we must suppose that man was once far below the excellence of which he is susceptible,—that this was to be acquired slowly; and that in consequence the Caucasian variety did not once exist.

If we believe that he was created in perfection, we must believe that after the fall his nature experienced the general change; that he became destitute and wretched, and destined to reach perfection by slow degrees. That he was once black, is rendered extremely probable by the analogy of animals, among which Mr. Hunter remarked, that the changes of colour were always from the darker to the lighter tints.*

It would appear also from history, that the most ancient people of the earth,—from whom Europeans are descended, were genuine Ethiopians or Negroes.†

* 'Animals living in a free and natural state are subject to few deviations from their specific character; but nature is less uniform in its operations, when influenced by culture. Considerable varieties are produced under such circumstances; of which the most frequent are changes in the colour.

'These changes are always, I believe, from the dark to the lighter tints; and the alteration very gradual in certain species, requiring in the Canary-bird several generations; while in the crow, mouse, &c. it is completed in one. But this change is not always to white, though still approaching nearer to it in the young than in the parent; being sometimes to dun, at others to spotted, of all the various shades between the two extremes. This alteration in colour being constantly from dark to lighter, may we not reasonably infer, that in all animals subject to such variation, the darkest of the species should be reckoned nearest to the original; and that where there are specimens of a particular kind, entirely black, the whole have been originally black? Without this supposition it will be impossible, on the principle I have stated, to account for individuals of any class being black. Every such variety may be considered as arising in the cultivated state of animals.' Hunter, *On the colour of the pigmentum nigrum of the eye. Obs.* p. 243.

† See Pritchard's *Physical History of Man.* Ch. vii. viii. ix.

I shall take this opportunity of noticing monsters.

Mr. Lawrence has collected most of the remarkable and well authenticated instances of monsters, in a paper published in the fourth volume

The history of mankind supports the same inference, as considerations a priori, and analogical and direct facts. All the nations of the earth appear to have branched forth from one quarter. Dr. Pritchard has traced them with great learning and judgment, and as the

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of the Medico-Chirurgical Transactions. To this I refer for examples. He divides monstrosity into unnatural formation, unusual position of certain organs, deficiency, redundancy, and a mixture of these.

No one in the present day would ascribe monstrosity to any thing else than an error in the original materials of the embryo,—to a mixture of the whole or a part of the materials of two or more embryos, to a deficiency in the materials, or to a derangement of them. (See Sect. xl. 587. 3. 588. 591.)

Culture we find produces alterations in animated beings. If it proceeds no farther than to afford a supply to all the natural wants of a system, it improves the species, as is exemplified daily in vegetables "It may certainly be laid down, says Mr. Hunter, (l. c. p. 245. note.) as one of the principles or laws of nature to deviate under certain circumstances. It may also be observed, that it is neither necessary nor does it follow, that all deviations must be a falling off: it appears just the contrary, therefore we may suppose that nature is improving its works, or, at least, has established the principle of improvement in the body as well as in the mind." If, however, luxurious abundance is supplied or important natural habits of the system prevented, as is not rarely the case in domesticated animals and civilized man, deviation may advance beyond improvement and actually become degeneration or monstrosity. Hence the commonly known fact (591) of monsters being frequent among domesticated animals and rare among the wild. As man by his depravity commits errors and excesses of every description, unnecessarily mingling ill effects with the benefits of civilization, no wonder that monsters are common among the human species. The evils of civilization are not necessarily united with it, and great as they are, they fall infinitely short of its benefits. Without civilization population must be wretchedly small, exigencies and comforts miserably supplied, and none of the noble characteristics of the heart and mind fully called forth: in the uncivilized state, on which Mr. Lawrence is dissubject has not been made by myself a matter of original research, and is far too extensive to be handled here as it deserves, I must refer to his work which is both the most recent and the best, contented with simply inserting his

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posed to bestow such eulogies, this gentleman's superiority would not have been conspicuous.

Mr. Lawrence, I mention it with pain, draws from the occurrence of monsters, an argument unfavourable to the belief of the goodness of the Almighty. This, I am aware, is not the place to 'assert eternal providence, and justify the ways of God to man;' but in recommending the student to a work, it is my duty to guard him against its disadvantages. "Neither should we overlook these productions (says this gentleman) in our attempts to infer from the phenomena of nature, and particularly from organized beings, the character of the cause which has produced them. Creatures so imperfectly constructed, as to be incapable of independent vitality, and consequently perishing immediately after they are born; and those whom the malformation of some organ draws, after a life of pain and misery, afflicting to themselves and burthensome to others, to a premature death, offer an apparent exception to the inferences, which have been drawn from the animal kingdom in general, concerning some attributes of the creating power." "Archdeacon Paley has passed over the subject in silence."

The world it must be remembered is governed not by partial, but by general laws, and the least reflection will shew that any alteration which a human being could propose in them, would produce infinite mischief. In particular circumstances, however, the good they generally cause, is certainly converted into evil. Hunger is one of the great sources of activity and enjoyment among men and animals, but in particular circumstances, where it cannot possibly be gratified, it is a torment. The laws of each species of organic formation produce the beautiful animated system, but these same laws under particular thwarting circumstances,—when crossed by other general laws, produce monsters. The case of monsters is but one of numerous similar examples, and although the great Paley has not noticed this example individually, he notices all such in general.

conclusion, which is the same as Bryant's, although founded on different principles.

"The countries bounded on the east and west by the Ganges and the Nile, on the North by the Caspian lake,

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"Contrivance proves design; and the predominant tendency of the contrivance indicates the disposition of the designer. The world abounds with contrivances, and all the contrivances which we are acquainted with, are directed to beneficial purposes. Evil, no doubt, exists; but is never, that we can perceive, the object of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps inseparable from it, or even, if you will, let it be called a defect in the contrivance; but it is not the *object* of it. This is a distinction which well deserves to be attended to. In describing implements of husbandry, you would hardly say of the sickle, that it is made to cut the reaper's fingers, though, from the construction of the instrument, and the manner of using it, this mischief often happens. But if you had occasion to describe instruments of torture or execution, this engine you would say, is to extend the sinews; this to dislocate the joints; this to break the bones; this to scorch the soles of the feet. Here pain and misery are the very *objects* of the contrivance. Now nothing of this sort is to be found in the works of nature. We never discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a system of organisation (i. e. no species of system of organisation, for the laws of the formation of an individual are the general laws of the species to which it belongs) calculated to produce pain and disease; or in explaining the parts of the human body, ever said, this is to irritate; this to inflame; this duct is to convey the gravel to the kidneys; this gland to secrete the humour which forms gout. If by chance he come at a part of which he knows not the use, the most he can say is, that it is useless: no one ever suspects that it is put there to incommode, to annoy, or to torment. Since then God hath called forth his consummate wisdom to contrive and provide for our happiness, and the world appears to have been constituted with this design at first, so long as this constitution is upholden by Him, we must in reason suppose the same design to continue." *Moral Philosophy*, vol. i. p. 76.

and the mountainous ridges of Paropamisus and Imaus, and on the south by the Erythræan sea, or Indian ocean, appear to have been the region in which mankind first advanced to civilization. It is highly probable that these countries were the primitive abode of our species, in which alone therefore it can properly be considered as indigenous.

"In the first ages, previous to the origin of the most simple arts, while men were as yet too rude to acquire their sustenance by hunting (or if we receive the scriptural account of the deluge, before the woods were filled with wild animals), they apparently obtained their food chiefly by fishing along the sea shores, or depended for a still more precarious supply on the scanty fruits of the earth. In this state they would of necessity lead a wandering life

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Even where evil is produced, such is the mighty universal plan, that it proves not simple, solitary evil, but becomes the cause of innumerable good effects. A severe misfortune has often converted a proud and prejudiced man into one of modesty and candour. Again the stupendous wisdom and the benevolence of the Almighty are continually manifested in the operation of one general law preventing the *particular* evil resulting occasionally from the clashing effects of others. Thus the greater number of monsters perish in the womb; of those which are born, many die the moment of their birth or a few afterwards; of those which survive, many die during childhood; and of those few which grow up, very few reach, and perhaps none, whose singularity is very great, pass the middle period of life, and their organs of procreation are often languid, if not perfectly inefficient: nor in fact do I believe from my observation that many of them are at all less happy than other people.

But I blush to think it has been necessary to advocate the cause of the Almighty. Can any one refuse to

Find tongues in trees, books in the running brooks,
Sermons in stones, and good in every thing?

and extend themselves widely. Different tribes of ichthyophagi or of roaming savages were scattered on each side of the primitive region, wherever an easy progress lay open to them, along the coast or through the woods of Africa, and around the shores of the Indian islands, of New Guinea, and Australasia. The descendants of these dispersed races are still found in the same abodes nearly in their original unimproved condition, savages and negroes, such as we have seen that the stock of their ancestors, the primeval inhabitants of Egypt and India, were.

"These were the most ancient colonies which emigrated into the distant parts of the earth. Accordingly they exhibit no affinities with the central nations in their languages, manners, or superstitions. For they went forth when language was as yet imperfectly formed, before manners had acquired any peculiar character, and previous to the age of idolatry.

"The condition of mankind in their primeval seats improved. They became hunters, and afterwards shepherds. Sabaism, or the worship of the heavenly bodies, now prevailed among them. Some tribes of hunters and perhaps of shepherds, ascended the chain of Paropamisus, and spread themselves gradually over the high central plains of Asia, on one side into Siberia and Scandinavia, and on the other into Kamtschatka, and through the adjacent and probably then connected continent of America. These are the Mongoles and other similar races whom we have traced through Asia and the north of Europe, and the primitive inhabitants of the New World. In the languages of these nations, though much diversified and very imperfect in structure, a certain degree of affinity may be clearly marked. In their superstitions, vestiges remain of the primitive Sabaism, even in their more distant settlements. Their physical characters resemble. In other particulars proofs may be collected in many remote regions of the common origin of these races.

"Meanwhile agriculture was invented in Asia, and the division of labour connected with the institution of casts, which seems to have extended through all the primitive regions, gave a new character to human society. The establishment of a governing or military class, and of a sacerdotal class, gave birth to political order. The priests mingling allegory and fable with the early Sabaism, and with the relics of genuine theism and true historical tradition, which had probably been preserved in a few families, formed a complex system of mythology. The mysteries were invented. Philosophy began to be cultivated, and a more perfect language was formed.

"The Celtæ under their Druids, a branch of the eastern hierarchy, advanced into the furthest west, where perhaps some vestiges of previous colonists may be found. They carried with them the mysteries, the doctrine of metempsychosis, the rites of polytheism, the philosophy and the language of the east.

"The Pelasgian and Thracian races established themselves in Asia Minor and passed the Hellespont into Thrace. The former colonized Greece and Italy; the latter passed to the northward of the Danube into the Dacian or Getic country. Tribes of this nation wandered at a later period through the forests of Germany, where they multiplied and encroached upon the Celtæ. Lastly the Medes, delighting in their herds of horses, advanced through the Euxine borders into Scythia and Sarmatia.

"That all these nations, the Celtæ, the Pelasgi, the Goths and the Sarmatæ were comparatively late colonists from Asia, we may safely assert, when we consider the strong affinities discoverable in their systems, in their religious rites and doctrines, and in their dialects which are clearly branches of the Sanscrit and old Persic, and when we remark that most of them may be traced in history still preserved, from their primitive settlements in the East."

Our inevitable conclusion thus coincides with the Mosaic account—that the whole human race is the offspring of the same parents.

THE END.

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