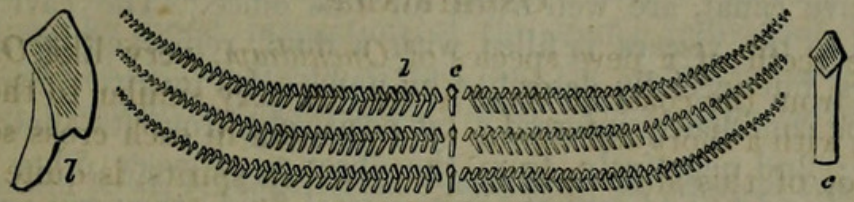
than broad, in straight cross lines, with a broad rounded lobe, rather more sinuous on the inner than on the outer side of its front edge.

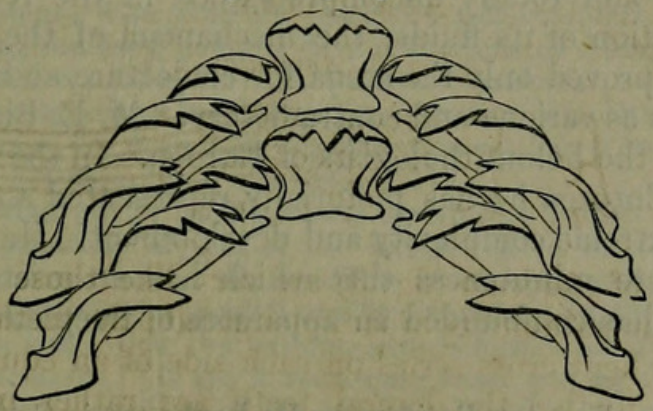
SIPHONARIADÆ.

Fig. 5. *Siphonaria.*



The teeth of *Siphonaria* are on a broad, rather long, dark brown lingual band, are numerous, equal, in a slightly arched cross line; the central tooth is narrow, elongated, with a small rhombic apex; the lateral teeth are larger, diverging, and gradually diminish in size towards the outer side of the series, and furnished with a rather oblique curved tip (see fig. 5).

Fig. 6. *Cyclophorus.*



The teeth of *Cyclophorus Inca* (fig. 6) are similar to those of *Natica* and the other marine genera belonging to the group of *Ptenoglossa.*

XXXIII.—*On the Mechanism of Aquatic Respiration and on the Structure of the Organs of Breathing in Invertebrate Animals.* By THOMAS WILLIAMS, M.D. Lond., Licentiate of the Royal College of Physicians, formerly Demonstrator on Structural Anatomy at Guy's Hospital, and now of Swansea.

[With a Plate.]

[Continued from p. 261.]

Rotifera.—It is the undivided belief of all recent observers that a blood-proper system does not exist in the Rotifera. These animalcules are provided with a rudimentary water vascular system,

which entitles them to rank near the Echinoderms. The cavity of the body is capacious; it is filled with a fluid which is sustained in motion by provisions expressly designed for this purpose. Vibratile 'tags,' accurately described by Ehrenberg and Dalrymple, aided by ordinary cilia on the external surface of the digestive canal, are well fitted for this office. The cavity external to the viscera is filled with a fluid, remarked by all observers, but specially described by none. Its nutritive character may be confidently inferred: 1st positively, from its anatomical locale; 2nd negatively, from the absence of every other fluid. 'Tags' and 'cilia' cannot aërate a vital fluid; they can only set it and maintain it in motion. Confusion has brooded over this simple point. Only the thin structure forming the exterior enclosure of the body intervenes between the fluid of the visceral cavity and the surrounding element. Thus is the former submitted to the influence of the aërating agent*.

Entozoa.—Mystery has long enshrouded the natural history of the Entozoon. Living in situations beyond the access of the atmosphere, and totally uncomprehended in the real character and distribution of its fluids, the mechanism of the respiratory process has proved only the arena for conjecture and speculation as erroneous as various and contradictory. M. E. Blanchard has long misled the helminthologists of Europe. In the Cestoid and Trematoid Entozoa he has pictorially represented a *blood-proper* system of extreme complexity and development. He has figured with elaborate minuteness that which has no existence in nature†. He has confounded an apparatus of irregular, ramifying

* See the excellent Art. *Rotifera*, by Dr. Lankester, in Cyclop. Anat. and Phys. "Contributions to the Anatomy and Physiology of the *Rotifera*," by Mr. Huxley in Micros. Journal. Annales des Sciences, 1851, Art. *Lacinularia*, par M. Udeken. Leydig on *Lacinularia socialis*, in Siebold and Kölliker's Zeitschrift, Feb. 1852.

† The author would desire to speak with respect of the researches of M. E. Blanchard on the Entozoa. His memoirs on this subject enrich the pages of the 'Annales des Sciences Naturelles' for the years 1847, 1848 and 1849. His illustrative figures, which are copied into Crochard's edition of the 'Règne Animal,' executed in the highest style of French art, are designed to display the true-blood system of the Cestoid and Trematoid worms. With reference to the latter order he remarks:—"Au moyen de mes injections, je me suis assuré qu'il existait chez ces animaux un appareil de vaisseaux à parois propres, se ramifiant dans toute l'étendue du corps. *On ne distingue ici ni veines, ni artères proprement dites; les deux fonctions paraissent appartenir aux mêmes vaisseaux!*"—Is it not extraordinary that such a distinguished physiologist as M. E. Blanchard should offer *such* a definition of any apparatus designed to circulate true *blood*? where in the animal kingdom could a parallel to such a system be indicated?—"Nous le voyons consister en un ou plusieurs vaisseaux principaux, offrant de nombreuses ramifications s'anastomosant sur une infinité de points; en sorte

channels destined to contain a real chylaqueous fluid with a system of *true* blood-vessels. M. Blanchard's inferences are drawn from *injected* specimens. In such investigations the method of injection is liable to numerous fallacies; it imparts a uniform diameter to canals which are remarkable for variety of calibre. The real characters of such structures can only be determined by direct inspection of the living individual. Thus *only* can the fact be demonstrated, that the so-called *blood-vessels* of the parenchymatous worms *neither rythmically contract nor*

qu'il existe là un véritable réseau vasculaire." In principle how totally this definition differs from the former!

Bojanus and Nordmann have described almost in the same words the same system, indicating it as the apparatus for the circulation of the blood-proper. In relation to the Cestoid worms M. E. Blanchard observes: "Pendant longtemps, partageant l'erreur commune, je pensais qu'il n'existait point de système vasculaire proprement dit chez les Cestoïdes. Les canaux gastriques, communiquant de l'un à l'autre dans chaque Zoonite, étaient regardés très-généralement comme destinés à remplir les fonctions des deux appareils. Mais récemment, dans les *Tænias* du chien et de la fouine, j'ai constaté, indépendamment de ces canaux gastriques ou intestinaux, l'existence d'un système vasculaire très-complexe, consistant en vaisseaux longitudinaux pourvus de ramifications et d'anastomoses nombreuses. Ainsi ces animaux remarquables, considérés par les zoologistes les plus éminents comme des Vers *parenchymateux* complètement dégradés, sont au contraire des êtres dont l'organisation est loin d'être très-simple." (Annales des Sciences, tome viii. 1847, p. 119.)

In the *Cestoid* worms M. Blanchard describes a perfect blood-vascular system, independently of that of the straight lateral canals which constitute the gastric apparatus. He describes an artery, a vein, and an intermediate order of straight parallel capillary vessels. In the Trematoda, in one place he states that the extreme vessels form a ramifying plexus; in another he remarks, "Il est à remarquer aussi que les vaisseaux de la partie antérieure (speaking of the vessels in *Amphistoma conicum* (Règne Animal, pl. 28)), et surtout ceux de la partie postérieure du corps, *se terminent sous la peau en de petites lacunes*, du reste très-nettement circonscrites." No instance is known in the whole animal kingdom of a *blood* system terminating in cæcal extremities. The apparatus which exhibits such characters cannot fall under the denomination of a blood-proper system. The method of investigation adopted by M. Blanchard has distorted the features of the object sought to be studied. Forcible *injections* into textures fragile and delicate will enable a preoccupied fancy to construct any results, to recognise grounds for *any* conclusion. The views stated in the text are founded upon examinations conducted with extreme care, and instituted on *living* specimens. To a great extent the author's researches have corroborated the *descriptive* anatomy of M. Blanchard: in many essential respects however they stand in direct opposition. If the system of vessels depicted in the figures of M. Blanchard were really a *true blood system*, the Cestoid and Trematoid Entozoa would be entitled to rank high in the zoological scale. They stand really below the Annelida. To this position they are assigned on the ground of the *general* affinities of their organization. The author is persuaded that the French helminthologist has mistaken a *modified* chylaqueous system for a blood-proper apparatus.

pulsate. Among blood-vessels such a circumstance would constitute an irreconcileable anomaly. The blood-vessels described by M. Blanchard, and in common with him by nearly all helminthologists, in the Cestoid and Trematoid Entozoa proceed from *one or more central spaces.* When these spaces are cylindrical in figure they assume the apparent characters of blood-trunks. They *really* represent the splanchnic or visceral *cavity.* Such is the form under which this cavity, so conspicuous in the Nematoid Entozoa, occurs in the Sterelmintha. The main central channels present a general coincidence of disposition with those of the alimentary system (Pl. XIII. figs. 3, 6, 8, 9). They do not present a uniform diameter according to the customary manner of a vascular trunk. They exhibit irregular outlines, now contracting into narrow necks, and now dilating into lacunæ. This is especially true of those of the Trematoid worms. In the Cestoid orders (fig. 6) the main trunks follow the margin of the "Zoonite," the lesser crossing in the parallel spaces between the transverse annuli into which the integuments are wrinkled. These secondary channels in *Tænia* are much more irregular in outline and distribution than the blood-vessels (*sic*) depicted in the drawings of M. Blanchard: they penetrate intimately the *substance* of the integuments. With reference to these channels, large and small, one important fact should be noted: *they are not gifted with separate membranous parietes.* This fact alone is enough to prove that they are *not* channels for the conveyance of true blood. Every true blood-vessel is endowed with a special power to circulate its fluid contents. Its parietes are *contractile.* The bore of the channel rythmically increases and decreases. Such movements would be mechanically impossible if the parietes of such 'vessels' were adherent to the surrounding solid and fixed tissue. In a channel destined to convey chylaqueous fluid the latter case is the *rule.* They possess no inherent circulating power. *Their* contents are impelled to and fro under the conjoint force of ciliary and muscular action. Here then is a clearly defined distinction between a chylaqueous channel and a true blood-vessel. Let the wonderful vascular system, which M. Blanchard has delineated from artificial injections in the Cestoid and Trematoid worms, be tested by this anatomical principle. This excellent observer has omitted to investigate the histological characters of these parts. He has not in any case determined the relation between that system which he describes as the true blood system and the surrounding solid structures. In no instance has he reduced to demonstration the physical characters of the fluid by which his so-called blood-vessels are filled. The same criticism will apply with equal justice to the illustrations, by aid of which

he defines the alimentary system of *Tænia* and *Bothriocephalus*. The *blood system* described by M. Blanchard in these worms *does not exist*. That which he so beautifully pictures as the *gastric* apparatus, consisting of straight capacious lateral canals, joined by cross conduits, constitutes really an order of passages tunnelled in the solid parenchyma of the body, answering in every sense to a normal chylaqueous system. The contained liquid is not blood, but chylaqueous fluid*: it is a fluid which is devoid of every trace of morphotic elements. *Why* it is so will be immediately understood.

In the Trematoid worms the blood-vessels of M. Blanchard fall unquestionably under the denomination of a chylaqueous system. In *Distomum hepaticum* it is perfectly easy to reduce to demonstration its entire characters. A large median, irregular channel commences in *smaller* passages near the posterior or generative sucker, and proceeds as far as the caudal end of the body of the worm, exhibiting a gradually diminishing diameter. Viewing the object transparently, it may be proved first that this channel is a hollow space by the rolling to and fro of a contained fluid; the movements of the fluid being rendered apparent to the eye by the presence of minute *accidental* molecules. In other respects, it is a perfectly homogeneous non-corpusculated fluid. By Bojanus, Mehlis, Nordmann, and other observers this channel is defined as terminating in an orifice posteriorly, and the channel itself, from the limpid character of its fluid contents, is described as the great duct of an excretory system. This is an error. This system in the Trematoid Entozoa has neither an inlet nor an outlet. It is a *closed* system, but not therefore a blood-system. In *Distomum* there is only *one* central space: it is not a blood-trunk; it represents unquestionably the *visceral cavity*. These worms are not literally therefore sterelminthous, solid, or parenchymatous worms (*Vers intestinaux parenchymateux*, Cuvier). The cavity is *distributed* in form of irregular, imparietal, reticulate passages. These passages can be traced with facility throughout the whole substance of the body. They ramify profusely underneath the skin and amid the digestive diverticula. They arise in the most unequal manner from every point of the circumference of the central trunk. They end peripherally in numerous instances in *cæcal* terminations, corresponding with the mode in which the

* The author is here desirous to explain that he does not deny altogether the existence of a blood-proper system in the Cestoid worms. His researches enable him only to affirm with confidence that *those channels which are described by M. Blanchard* as constituting an independent system of blood-vessels *do not exist*; that his alimentary is really a chylaqueous system, and that his ovarium is truly a grand digestive organ.

blood-vessels (*sic*) of M. Blanchard terminate in *Holostomum alatum*, *Amphistoma conicum*, *Tristoma coccineum*; in others they form re-entering branches. The figure of M. Blanchard* represents the secondary trunks in *Distomum* as proceeding from the primary with far too great regularity. To this trunk he seems to indicate a caudal orifice, and yet calls it a *blood-vessel*! It is susceptible of proof that this central channel in *Distomum* is *not contractile*. The adjacent trunks of the *digestive* system contract and dilate in regular periods. The walls of the central channel are perfectly stationary. Its interior is not lined with cilia. Its fluid contents do not move in one systematic orbit: they oscillate to and fro. Such characters can belong only to a chylaqueous system.

In *Holostomum alatum*, *Amphistoma conicum*, in *Tristomata*, in *Brachylæmus variegatus*, sometimes found in the lung of the Frog and Toad, in *Monostoma verrucosum*, &c., the main primary channels of the fluid system coincide with those of the digestive. The latter are *embraced* by the former. This anatomical fact is significant of a physiological principle. It points to the manner in which the contents of the chylaqueous passages are derived *by exosmosis* from the chymous fluid contained in the digestive cæca. In those species of Trematoid worms in which the central conduits are *more* than one in number, it is important to observe that they are always joined together into *one* system by intervening passages. They do not convey opposite currents. In *both* the contained fluid flows and ebbs with great irregularity, in obedience to the contractions and expansions of the muscular integumentary envelope. In these essential particulars the standard definition of a true-blood system is violated. M. Blanchard defines thus the *Appareil vasculaire* of *Distomum hepaticum* :—"Cet appareil consiste en *un* vaisseau principal et médian." A *true* circulation requires *two* primary trunks, an artery and a vein. In another place this helminthologist observes generally with regard to the Trematoda—"Chez tous ces vers, le sang n'est certainement pas transporté, d'une manière régulière, d'arrière en avant par certains vaisseaux, et d'avant en arrière par d'autres, comme l'a pensé M. Nordmann. Dans les Trématodes en général, le fluide nourricier est transporté et ramené alternativement et plus ou moins irrégulièrement par les mêmes vaisseaux ; *c'est un mouvement de va-et-vient plutôt qu'une véritable circulation.*" (Annales des Sciences Nat. tom. viii. 1847, p. 336.) Ample evidence is thus drawn from his own observations to convince the physiologist that the system of vessels

* See plate 36,—Zoophytes : Crochard's French edition of the 'Règne Animal.'

described by M. Blanchard constitutes not a blood-proper but really a clearly defined chylaqueous system. The presence of this fluid implies the existence of a *visceral* cavity : it is its normal anatomical *locale*.

With reference to the blood-proper of the Cestoid and Trematoid Entozoa the author will at present only remark, that *if it exists at all,* it must be under conditions of rudimentary abeyance. The following general statements will then serve to convey the corollaries which his recent researches appear to warrant. In the Cestoid and Trematoid worms the whole substance of the body is pervaded by a highly albuminous but homogeneous non-corpusculated fluid, which is distributed extensively by means of imparietal and irregular conduits under the entire cutaneous surface of the body, *constituting the true apparatus of respiration,* and displaying alternate flux and reflux movements under external muscular agency, and embracing in every possible direction the diverticula of the digestive system, and *from which it extracts its reinforcements.*

It is adequate in every physiological sense to the ends of a nutritive system. Abounding in albumen it is capable of ministering to the wants of the solids. Though destitute of morphotic elements, it yet conforms to all the essential characters of a chylaqueous system.

The *digestive* apparatus (Plate XIII. figs. 3, 6, 7, 8, 9) of the parenchymatous Entozoa is intimately concerned in the process of respiration. In the Cestoid and Trematoid orders it presents but one essential type. It has but one external orifice. A *stomach* properly so called does not exist. There is this remarkable and apparently anomalous fact to be stated with respect to the fluid with which the digestive cæca are filled: —it is charged *with definitely organized floating cells,* which exhibit *constant* differences in different species! These corpuscles are not formless molecules. They consist of a cell-wall and granular contents, and frequently a nucleus legible to the eye. They are flat, scaly particles, having a yellowish tinge. They are undoubtedly *not* fragments from the glandular parietes broken off by pressure. They oscillate with great regularity under the rythmic contractions and dilatations of the parietes of the cæca. It is contrary to no analogical argument to suppose that these floating cells are designed to raise the chyme in which they float to an organic standard above that of ordinary chyme. In the parenchymatous Entozoa they execute the required changes in the nutritive fluids, *while the latter are yet within the alimentary system.* Among the Annelida several exceptions occur in which the same peculiarity is illustrated. The

Nemertine orders (Plate XIII. figs. 1, 2) will be afterwards shown to fall under this category. In *Aphrodita aculeata* (fig. 5, *d*) the digestive *diverticula* are filled with a corpusculated fluid, which is exposed by an express contrivance to the agency of the surrounding aërating medium. This is also the case in several species of freshwater planariform leeches (fig. 4). It prevails too in the true marine Planariæ (fig. 3). To the value which the author has endeavoured to assign to the fluid systems of the Cestoid and Trematoid Entozoa, no sound analogy is opposed. These worms are, on the ground of the interpretation of the fluids now first offered, naturally linked into a continuous zoological chain with the lowest parenchymatous Annelids. Notwithstanding the meritorious researches of M. Blanchard, the organization of the Cestoidea is even now a theme prolific of controversy. The large, branched, flocculent organ (fig. 6) forming the bulk of each segment in *Tænia* and *Bothriocephalus* is designated by all recent writers after M. Blanchard as the ovarian apparatus. It is really the alimentary organ. It opens externally by an orifice proper to each segment. This organ in each segment is therefore independent. It sucks nourishment from without by its own separate mouth. It is a *Planaria in itself.*

What are ordinarily described as the straight canals along either edge of the body are *not gastric* but chylaqueous. They are a part of a system of open channels ramifying through the cells of the parenchyma in which the gastric cæca are lodged. The latter are almost surrounded externally by the fluid filling the former. This fluid, as formerly explained, although non-corpusculated, constitutes the real chylaqueous system of the Cestoid and Trematoid Entozoa. It is through its agency that the breathing function is chiefly accomplished.

In *Tænia* this fluid system is common to the whole body of the animal. The 'segments' therefore are separate units only as respects the alimentary and reproductive organs. The chylaqueous fluid attains its enclosing channels by exosmose from the alimentary organ, not directly *ab extra.* The *posture* of the animal in its native habitat favours this interpretation of its organism. The orifice of each segment is applied to the surface of the infested part. The necessity for the preceding explanation illustrates the intimacy with which the respiratory function is interwoven with all the other nutritive operations of the body. In the *Tæniæ* then the respiration is *cutaneous,* but *not* in the mode commonly supposed. The skin is *not* the scene of a rich plexus of true blood-vessels. It is permeated and pervaded everywhere by that fluid which embraces the alimentary organ, and which is distributed

throughout the parenchyma of the body by means of the irregular canals already described. It reaches the surface sufficiently nearly to receive the influence of the surrounding medium.

It is impossible therefore that the blood-proper can in this worm be the immediate subject of the respiratory process. Its existence is insusceptible of demonstration. If present at all, it can only receive oxygen indirectly through the medium of the chylaqueous fluid. This explanation is simple. It is founded on fact, and supported by analogy. The organization of the Nemertine Annelida conforms in every essential particular to that of the Cestoid Entozoa * (see figs. 1, 2). The latter are illustrated and explained by the former. The ali-

* From the following extracts it will be seen how *little confident*, nay how confused and obscure, the best and latest author appears to be with respect to the real significance of the most important element of structure in the *Cestoid Entozoa*:—"On a généralement regardé les canaux longitudinaux dont il sera question après cet appareil, comme digestifs. Quelques auteurs ont même été jusqu'à leur accorder une, deux ou quatre bouches, par exemple dans les Ténias: tout récemment on leur a attribué une *quasi-bouche*, parcequ'il fallait bien trouver un moyen de faire arriver les aliments dans ces canaux. *Je crois qu'aucune de ces opinions n'est fondée, que ces vers se nourrissent par toute la surface de la peau, et qu'il n'y a pas plus d'organe spécial ou d'appareil particulier pour la digestion que pour la respiration.* Plusieurs anatomistes ont pensé, Rudolphi entre autres, que les segments qui se détachent peuvent se nourrir, pendant quelque temps, par l'ouverture qui s'est formée à la suite de la séparation; cela me paraît évidemment erroné. Quand ces segments se détachent, le corps s'est resserré de plus en plus au bout, et au moment de se séparer, il ne tient plus que par un mince pédicule!" From the above observations, it is undeniably evident that Van Beneden is perplexed with doubt as to what really *should* be regarded, and what should not, as the *digestive system* in the Cestoid worms. Without a *definitive* knowledge of this system, how is it possible to form a correct conception of the disposition and functions of the nutritive fluids? Nor are the ideas of Van Beneden with reference to the circulating system of these worms more clearly defined:—"M. E. Blanchard croit devoir admettre pour tous les animaux de ce groupe une circulation véritable ayant lieu par des troncs principaux et dans des tubes à parois propres. J'ai étudié, sous ce point de vue, les parties minces et transparentes chez des individus très-frais, et je suis persuadé que le mouvement circulatoire a lieu dans de grandes lacunes, qu'il n'existe pas de vaisseaux à parois propres, et que le liquide correspondant au sang ne peut suivre un cours déterminé; il y a plus, des brides s'étendant de l'une paroi à l'autre; elles maintiennent les organes en place, et c'est dans l'espace laissé par les brides que la circulation sanguine s'effectue. Voilà le résultat d'études faites sur des parties vivantes, minces, voisines de la périphérie du corps et sans avoir fait subir aucune préparation à l'animal." "*Je ne crois pas me tromper en disant que les Trématodes et les Cestoïdes n'ont ni appareil digestif, ni appareil circulatoire*" ! !—a conclusion perfectly marvellous, for a comparative anatomist so circumspect and laborious as Van Beneden. The preceding quotations will be found at pages 35 and 36 of his work entitled "Les Vers Cestoïdes ou Acotyles," Bruxelles, 1850.

mentary organ in the Nemertinidæ* is precisely conformable to that of *Tænia*. In the former the whole organ has but one external opening, which is situated, in form of mouth, at the anterior end of the body. In the latter each segment has its separate opening (fig. 6, *a*). In both the digestive diverticula are filled with a corpusculated fluid. In both the spongy tissue, in the midst of which the alimentary organ is lodged, is chambered into capacious areolæ in which the real chylaqueous fluid is observed irregularly to roll. In the Nemertinidæ †, however, the entire external cutaneous surface is ciliated. In the Cestoid worms no vibratile cilia in *any situation* have been proved to exist. It is a remarkable fact, that in *all Entozoa* the ciliary variety of epithelium is entirely suppressed. The agency of these organules is not essential therefore to the process of cutaneous respiration.

The *Trematoid Entozoa* are allied to the Cestoid by the most intimate affinities of structure. In the former type as in the latter, there exists but one orifice to the alimentary system. The gastric diverticula, which in several species amount only to two in number, in all Trematoid orders terminate cæcally. These cæca are filled internally by a corpusculated, and surrounded externally by a non-corpusculated fluid. The oscillations of this latter fluid have been observed by Nordmann, Dugès, Rudolphi, Blanchard, and others. It constitutes the true chylaqueous system. *Such* a development of the blood-proper system in the Trematoid Entozoa is opposed unqualifiedly by the analogy of the whole Planarian family, after whose type the former are constructed. The parenchyma, which intervenes between the digestive system and the external surface in these worms, is loose and large-celled—readily traversed by fluid. This fluid reaches the cutaneous surface; it embraces and laves everywhere the digestive cæca. The Trematoid Entozoa then, like the Cestoid, respire cutaneously. Every spot of the surface is utilized. The

* These Annelids are abundantly illustrated on our coasts by the genera *Borlasia*, *Polia*, and *Lineus*.

† The author is anxious here to bear witness to the excellence of the memoir by M. Quatrefages on the Nemertine Annelids (Annales des Sciences Naturelles, t. vi. 1846), with which he has only just become acquainted. While his essay is acknowledged as a master-piece of minute descriptive anatomy, the author is constrained to differ *toto cælo* from M. Quatrefages in the physiological interpretation of parts. In these worms the French naturalist indicates correctly the mechanism of the respiratory function:—"Si c'est la surface entière du corps qui joue le rôle d'organe respiratoire, il s'ensuit que la respiration doit s'exercer principalement et plus immédiatement sur le liquide qui remplit les grandes cavités que sur le sang lui-même, puisque celui-ci est renfermé dans des vaisseaux qui sont entourés par le liquide dont nous parlons."—*Op. cit.* p. 269.

chylaqueous fluid is present everywhere, and immediately underneath the cuticle. It moves to and fro in its vacuoles. It is the immediate recipient of the external oxygen. It imparts it secondarily to the true blood, if this exists. Future science may demonstrate that the properties of oxygen are intensified (*ozonized*?) by passage through, or absorption by, a living fluid. Deep meaning may yet radiate from material collocations, over which now chaos broods.

It is a remarkable fact, that the body of every Entozoon, whether imbedded in the parenchyma of solid organs or lodged in the cavitary viscera, is *immersed in a reservoir of fluid.* The *Tæniæ* and *Bothriocephali* are applied *closely to the walls* of the intestine (the orifice of each segment being adherent to the infested surface and surrounded by a mucous capsule filled with fluid). This fact is easily verified in the instance of those species of Cestoid worms which inhabit the intestine of fishes, birds and reptiles*.

The Fluke swims in a pool in the biliary ducts of the sheep. The Trichina in the substance of a muscle floats in a reservoir of fluid, and the Filaria in the cellular tissue is surrounded by a stratum of serous liquid. These enveloping fluids are effused by the living vessels of the part upon which the animal preys. These circumstances present a fact which demonstrates that the life of Entozoa is essentially aquatic. The fluid is no essential constituent of the organism of the parasite. It is extravasated by reason of the irritation excited by the presence, the worm on a living surface, or in the midst of a living organ. It is however a fundamental condition of existence. *It is the medium of respiration to the Entozoon.* How could this vital process occur if the animal were surrounded by a *solid* substance? The fluid contained in these cysts must be *frequently renewed,* because the blood-corpuscles revealed in it by the microscope are always fresh in appearance, plump and perfect in outline. This fact also proves that it is derived directly from the blood of the infested animal; it is therefore charged with oxygen in the same proportion as the latter. Thus is explained an important *external* condition of respiration in the Entozoa.

The *Nematoid Entozoa* (figs. 10, 11 & 12) are distinguished from the parenchymatous orders in one essential respect. In the Nematoidea the viscera float more or less freely in a spacious cavity filled with fluid. They agree in organic type with the cylindriform

* *Bothridium Pythonis* inhabits the large intestine of the Cod.
Acanthobothrium coronatum is found in the intestine of the Ray-fish.
Trienophorus nodulosus lodges itself on the peritoneal surface of the liver of the Perch.
Floriceps saccatus in the intestine of many fishes, &c.

Annelids. From the latter, however, they differ in one extraordinary particular. The Nemertinidæ, Planariæ and Clepsinidæ excepted, in all Annelids the chylaqueous fluid is corpusculated, and the blood-proper is entirely destitute of all morphous particles. In the Nematoid Entozoa *these conditions are reversed.*

In the Cestoid and Trematoid genera the fluid contained in the digestive *diverticula*, through its floating cells, enacts that office, which, in the example of the Nematoid worms, is transferred to the blood-proper, and in that of the Annelids in general to the chylaqueous fluid. This circumstance, however, does not imply that in the Nematoidea the blood-proper system is preponderantly developed. It consists only of two principal longitudinal trunks, adherent at the ventral and dorsal median lines to the internal surface of the integumentary cylinder. Cloquet has described the blood-system in several species. Ecker* has also defined a blood-system in a species of *Filaria*. The blood-*vessels* of the Nematoid worms exhibit a distinct red colour. It is not yet certain that the contained *blood* partakes of the same colour†. Rudolphi has characterized these and all Entozoa as white-blooded worms. The primary trunks are connected together by means of transverse secondary branches: these latter can only be discovered in the substance of the integuments, not on or in the parietes of the viscera. The blood-proper of the Nematoid worms is indeed a very subordinate constituent of the organism, quite insufficient to supply the solids with the materials of increase, and not less unequal to the function of breathing. A few blood-vessels distributed scantily over the cutaneous surface would present too limited a surface of contact with the surrounding element to receive a proportion of oxygen adequate to supply the wants of an organism so large as that of *Strongylus Gigas*. By inference it becomes obvious that some other fluid element of nutrition in these genera is required to minister to the exigences of the solid parts. It is accordingly found that in the Nematoid orders the chylaqueous fluid is relatively abundant in quantity: this fluid is contained, as in the cylindriform Annelids, in the peri-intestinal or visceral cavity (figs. 10, *c*; 11, *d*; 12, *c*). In the round worms this cavity occurs under two distinct anatomical conditions. In one case, illustrated in the example of *Ascaris Lumbricoides* (fig. 11), the intestine is tied by frequent transverse bridles to the integumentary cylinder: these bridles intersect the cavity, and limit the motion of the contained fluid. They stretch outwards through

* Müller's Archiv, Ueber ein Gefässystem in eingepuppten Filarien, S. 506. t. 15. figs. 3, 4, 1845.

† For a further statement of the author's researches on this subject, see his papers in the 'British and For. Med. Chirur. Rev.'

the whole thickness of the integument under the character of transverse muscular fasciculi. They are accompanied by open passages by which the chylaqueous fluid reaches the cutaneous surface for the purposes of aëration. The longitudinal muscular bands, with their embracing spaces, establish between the transverse, free communications. It is thus clear, that although the integuments in certain species of Nematoid worms are remarkably dense and resisting, they are permeated by chylaqueous fluid to an extent enough to subserve the purposes of breathing. The intimate connexion which in some Nematoid worms subsists between the intestine and integument, limits the movements of the intestine. It is to this anatomical circumstance that the motionless state of the chylaqueous fluid in these worms is to be ascribed. In consequence of the absence from this fluid of all visible globules, to detect its existence is not easy to the uninitiated observer.

It is upon the freedom with which the intestinal cylinder moves within the concentric integumentary, in many species of Annelida, that the rapid and unobstructed oscillations of the interposed chylaqueous fluid depends. Why should the same fluid, occupying the same locality, be required to move so little in the Entozoa? The answer probably is, that in the two indicated instances the fluid differs materially in chemical composition. The second type (fig. 10) of Nematoid Entozoa is exemplified best in the case of the large *Strongylus*, constantly to be found in the small intestine of the sheep. Here the intestine, a straight tube, is considerably smaller in diameter than the space included by the integuments, while it is tied at few points to the latter. The visceral chamber is therefore unusually capacious in dimensions, and the enclosed fluid is considerable in bulk. It is a fact of unusual interest, that the chylaqueous fluid, whether stationary or moveable in its containing chamber, of all Nematoid Entozoa, is perfectly homogeneous and destitute of every trace of visible element. In these worms the digestive system does not lodge a corpusculated liquid, of which the suspended cells supersede the necessity for the agency of similar cells in the extra-intestinal chylaqueous fluid. It must therefore be inferred, that the true blood of these worms is the seat of the floating cell agency. If it should be hereafter proved by exact observations, that neither the true blood, nor the chylaqueous fluid, nor the intra-intestinal chyme is charged with floating cells, these animals will constitute an exception unique in the animal kingdom, in which an animal organism is sustained without a single *corpusculated* nutritive fluid.

The principle is at present inadmissible in science, which sup-

poses that the intervention of cells in the nutritive fluids is neither indispensable to the process of solid nutrition nor to that of respiration.

It is a fact of surpassing physiological interest that the chylaqueous fluid in the *Strongylus* of the sheep, which can be collected by spoonfuls, is nothing *but a thick solution of albumen*. After even prolonged standing, it does not throw down the slightest vestige of fibrine-clot. If "the blood" of the infested animal permeated through the integuments of the parasite, and thus reached the visceral chamber of the latter, it appears probable that both the fibrine and the red corpuscles of the former would be capable of detection in the chylaqueous fluid of the latter. This, however, is not the case. The cyst in which *Trichina spiralis* is lodged in the substance of the muscle is filled with a fluid in which both the fibrine and the red corpuscles of the infested animal can be readily shown to exist. The inference is obvious. The chylaqueous fluid of the worm is not derived directly from without by filtration through the partition of the cutaneous structures.

In the order of Nematoid worms, typified by the *Strongylus* of the sheep, the integuments are very thin; the spaces between the circular muscular fasciculi being covered by little more than the epidermis—conditions well-fitted to favour the interchange of gases between the chylaqueous fluid within and the aërating medium without. No indications of vibratile epithelium in any structure in any species of Nematoid worms can be discovered on the general cutaneous surface, dedicated though it be unquestionably to the office of respiration: they exist in no instance. *Why* do they *not* exist? The organic law presiding over the development of these motive organules is still beyond the ken of science.

Henceforth it will not satisfy the physiologist to affirm, in the vagueness of a general phrase, that "the respiration is cutaneous." He must know, with exact definition, by which order of fluids that function is enacted, and whether the living fluid, immediately influenced by the external element, be charged or not with morphous particles. Superstition for ages has wrapped these uninviting beings in unresolvable mist. The assertion has now been abundantly supported, that the process of respiration in *all* Entozoa is conducted on the aquatic model—that the chylaqueous fluid, though non-corpusculated, is by far the most voluminous and important fluid element in the organism, and that which directly performs the function of breathing. The true blood when it exists is only *secondarily* aërated. The 'value' of the respiratory function is directly proportional to the organic

complexity of the fluids. The figure expressive of its amount progresses upwards with the zoological standard of the organism. This principle explains the faculty conferred upon the Entozoon, by a Nature exhaustless in expedients, illimitable in resources, by which it is enabled to extract oxygen enough for *its* wants from the least oxygenated of the animal fluids—venous blood—and securely to breathe amid the pestilential atmosphere of the colonic intestine.

These parasites are capable of sustaining life in any and every recess of the animal body. This fact proves inferentially what the physiologist cannot reduce to positive demonstration, that every part, every fluid, whether in or out of the vessels, is pervaded by the electric presence of oxygen. It proves that the respiratory process is really an inseparable attendant on, and an integral and essential part of, the nutritive actions of the body—that it is ubiquitous, not partial—that it vivifies every constituent atom, fluid, and solid of the entire organism*.

* In order to facilitate the repetition of the observations upon which the general conclusions stated in the text are founded, the author appends here a short list giving the name and place of abode of the most familiar Nematoid Entozoa :—

Name.	Habitat.
Ascaris megalocephala (Cloquet) ...	Intestines of the Horse.
—— *lumbricoides*	Small intestines—Man.
—— *Salaris* (Blanchard)	In intestines of several fishes.
Filaria equina (Rudolphi)	Folds of the peritoneum of the Horse.
—— *attenuata* (Blanchard)	Air-cells of carnivorous birds.
Spiroptera sanguinolenta (Rudolphi)	Stomach of Dog and Wolf.
Spirura Talpæ (Blanchard)	Stomach and intestines of the Mole.
—— *Megastoma* (Rudolphi)	Stomach of Horse.
Oxyuris vermicularis (Dujardin) ...	Rectum—Man.
Sclerostoma Equinum (Rudolphi) ...	Cæcum of Horse.
Cucullanus Percæ (Müller)	Pyloric appendages of common Perch.
Angiostoma entomelas (Dujardin) ...	Lungs of Reptiles.
Cyathostoma lari (Blanchard)	Orbital cavity of Sea-Gull.
Strongylus Gigas (Rud. & Müller)...	Kidneys of Horse, Dog, and Man.
Trichostoma ærophilum (Rudolphi) .	Trachea of Fox.
Trichocephalus hominis (Rudolphi)...	Cæcum of Man.

The order *Nematoidea, Cælelmintha* (Owen), includes the principal internal parasites of the human subject, viz. *Trichina spiralis, Filaria medinensis* (Guinea worm), *Filaria oculi, Spiroptera hominis, Filaria bronchialis, Trichocephalus dispar, Strongylus Gigas, Ascaris lumbricoides*, and *Ascaris vermicularis*. The Entozoa found in the blood have been recently described under the class-name of *Hæmatozoa*. Several species of *Filariæ, Monostomata, Distomata*, and Infusoria, have been discovered in the blood of frogs, dogs, fishes, and mollusca (Micr. Journal, Oct. 1st, 1853).

EXPLANATION OF PLATE XIII.

This plate is designed to express, in outline plans, the natural manner in which the *alimentary* system of the Cestoid and Trematoid Entozoa passes into that of the Nemertine and Planarian Annelida—that they are really constructed upon one and the same principle. Though not represented in this series of figures, the system of the nutritional fluids in these Entozoan and Annelidan groups conforms to one type. The channels for the fluids differ little in distribution from those of the alimentary system.

Fig. 1. Alimentary system of *Nemertes Camillæ*, the cæca (*b*) of which are charged with a *corpusculated* chyme; *e*, space external to the latter system filled with the chylaqueous fluid; *d*, shows that the true alimentary organ of this worm, in common with that of all Nemertine Annelids, is *closed* at *all* sides; *a*, œsophagus entering the proboscis.

Fig. 2. The *caudal* end of the alimentary organ of another Nemertine Annelid, *Borlasia* ——?, proving it to be cæcal also at this extremity: *a*, cavity; *c*, cæca of this organ filled with a corpusculated fluid; *b*, space external to the alimentary cæcum filled with chylaqueous fluid.

Fig. 3. Alimentary system of a *Planaria*: *b*, mouth; *c*, cæca; *a*, areolæ external to the digestive diverticula.

Fig. 4. Digestive system of a freshwater leech, *Clepsina* ——?: *a*, cæca filled with corpusculated chyme.

Fig. 5. Ideal, transverse, section of *Aphrodita aculeata*, showing the distribution of the alimentary system, and its relations to that of the nutritional fluids: *a*, stomach; *b*, visceral cavity; *c*, scales, by the rising and falling of which a strong current of sea-water is maintained through the dorsal channel (*e*), by which current the fluid contents of the digestive cæcum (*d*) are aërated.

Fig. 6. Alimentary cæcum of one segment of *Tænia Solium*: *a*, *mouth of this segment* leading into a short œsophagus (*b*), and thence into the ramifications (*c*) of the digestive system.

Fig. 7. Alimentary system of a Trematoid Entozoon: *a*, œsophagus; *b*, digestive cæca.

Fig. 8. Ditto of *Amphistoma*: *a*, *b*, cæca of digestive system.

Fig. 9. Ditto of *Bothriocephalus latus* (a sterelminthous worm): *a*, *mouth of a single segment*; *b* & *c*, cæca of digestive system.

Fig. 10. Plan of a Nematoid worm, showing the great difference between the diameter of the intestine (*a*) and that of the space (*c*) enclosed by the integuments; *b*, reproductive organ.

Fig. 11. Another type of a Nematoid Entozoon (*Ascaris lumbricoides*), in which the intestine (*a*) is larger in diameter, and tied by frequent bridles (*b*) to the dense integuments (*c*).

Fig. 12. Transverse section of the same.

[To be continued.]

PROCEEDINGS OF LEARNED SOCIETIES.

ZOOLOGICAL SOCIETY.

July 22, 1851.—J. E. Gray, F.R.S. &c., Vice-President, in the Chair.

On the Arrangement of the Edentate Mammalia. By H. N. Turner, Jun.

In offering to the Society a summary of my observations on the craniology of the Edentate order, I have not so great a number of