Developement

of

Entozoa.

Vol: II

By

Henry Nelson

Edinburgh 28 March 1850

On The Development of Entozoa: their Metamorphoses and Migrations.

Also Microscopic Researches into The Formation of the Ovum

By
Henry Nelson.

Illustrated with Two Hundred and Twenty Drawings.

Edinburgh 28 March 1850.

Introduction.

Three periods are said to have existed in the History of Science; through which it has passed from the earliest to the present Era.

The First Period was characterised by the Confusion of Sciences, in which all knowledge lay confounded in one crude heterogeneous mass.

During this state of things the learned used Hypothesis as the instrument of investigation, & the results they obtained were Systems.

The Second Epoch was that of the Division of Sciences, wherein the most strenuous efforts were made to disentangle, to unravel, to separate the elements of this incongruous mass; to purify it from the dross of ignorance, superstition & folly; hoping by such means to arrive at a clearer understanding of its true constitution.

To effect this object Analysis was employed; & Facts, inestimable in value, were obtained.

Another Period now began to dawn. Men became aware that isolated Facts could not constitute true Science; that, although Science could only be formed out of facts, yet something was needed to unite them, a generalization by which they could be combined in an orderly, connected, & intelligible manner. This Third & Present Epoch in the march of human Knowledge is characterised by the Association of Sciences.

By Synthesis we now combine Facts, & thus form Theories.

While theorizing however we must not forget the importance of facts; for as the Ocean is formed of single drops, & a heap of sand of individual particles, so is Science built up of individual facts. Facts alone can swell the size of the heap, can raise the height of the edifice; although, to prevent their dispersion, & to retain each in its place, Theory is essential.

Our first endeavour should be the discovery of new facts, which may augment in some measure however small the present amount of human knowledge, although the extent of that increase be hardly appreciable. Let each therefore add his grain of sand to the heap, trusting that some one else will add another, & that thus Science will continue to expand as it has done hitherto.

If however events preclude the addition of anything original each may remember that the character of the present Era is Association, the mode of effecting it Synthesis, & its consummation Theory. Let each commence to collect, to arrange, to theorise the innumerable facts that yet remain isolated, never yet amalgamated with the growing whole.

With this view the present Essay has been commenced. Though I may hope to add a grain of sand to the heap, it will be my chief aim to unite & arrange the very valuable contributions of others, so as to render the whole, if possible, a little clearer.

Fond of Natural History, a succession

of events have led me to the present attempt. A most interesting course of Lectures delivered four winters ago in this University, by Professor Goodsir, first awakened me to the beautiful forms, wonderful adaptation, & surprising changes which the Entozoa undergo. I obtained then a general insight into the nature of this remarkable class of beings, which I have ever since found of the greatest use. More than once has a reference to the notes of those lectures solved an apparent difficulty.

Shortly after this I was in a manner forced into the study by finding two cysts in the liver of a mouse, each of which contained a worm. Like all beginners I thought I had made a discovery, & drew up an account of my investigations. Great was my disappointment on being shown the very animal in the works of Dujardin, as the commonest & best known of all the cysticerci. Notwithstanding this I proceeded with my examinations obtaining an important insight into the development of those entozoa, which was communicated to the Royal Medical Society in the beginning of 1849.

It was however only at the

commencement of the present Session that having shown my observations on this Cysticercus to Dr Allen Thomson, he strongly advised me to continue my investigations. Acting on this recommendation I devoted myself afresh to the study, & now venture to present the result of my labours.

I may be allowed to take this opportunity of stating the obligations I am under to Dr Thomson. When Professor of Physiology in this University he first taught me the principles of those changes in the human embryo, which I shall have to describe in the egg of the worm. The ovum has been & still is his principal study; & greatly am I indebted to his skill, caution, & experience in that part of my research which relates to the changes incident on fecundation. The confirmation of microscopic observations on the ovum by one who has given so much time to its investigation must be acknowledged by all, & to me is, invaluable.

The following is a list of the works I have consulted, with the names of their Authors; all of them, except two, are to be found in the magnificent library of the Royal Medical Society. Of the two exceptions I owe Sobernheim's Physiology to the kindness of Professor Bennett; while the other, Steenstrup, was obtained from the library of the University.

In all my researches I have invariably used a French Microscope, made by Nachet; the clearness & definition of which I have very seldom seen surpassed. While on the other hand accuracy of delineation has been secured by the employment of a Camera Lucida, adapted to one of Powells' splendid Microscopes, especially lent to me for the purpose by my esteemed friend Mr Nasmyth.

Although a large part of this Essay is the result of the valuable investigations of much abler Authors, I claim originality in having first successfully traced the development of the Cysticercus into a Tænia; the formation of the Spermatic particles in the Ascaris; as well as the internal changes in the ovula incident on fecundation. The propriety of this claim I leave for the judgment of those far better acquainted with the subject than myself.

List of Works consulted.

P. J. Van Beneden. Sur le dévelloppement des Tetrarhynques.
Ann. des Scien. Nat. Jan 1849.

P. J. Van Beneden. Sur le devellopement des Linguatules.
Ann. des Scien. Nat. Mai & Juin 1849.

E. Blanchard. Sur l'Organization des Vers. Decembre 1848

M. Bremser. Traité Zoologique & Physiologique sur les Vers Intestinaux de l'Homme.

J. Capelle.

Trans. Philad. College of Physicians.

Carlisle.

Trans. of the Linnean Society.

J. Cloquet. Anatomie des Vers Intestinaux.

F. Dujardin. Histoire Naturelle des Helminthes.
Suites à Buffon.

I. F. Sobernheim. Elemente der allegemeinen Physiologie.

H. D. S Goodsir. On the Anatomy & Development of the Cystic Entozoa.

R. Owen. Lectures on the Comparative Anatomy & Physiology of the Invertebrate Animals.

K. B. Reichert. Zur Entwickelungs-geschichte der Saamenkörperchen bei den Nematoden.
Muller's Archiv. 1847.

C A Rudolphi. Entozoorum Historia Naturalis.

C A Rudolphi Entozoorum Synopsis.

J. J. S. Steenstrup. On the Alternation of Generations
Roy. Society's Works. 1845.

R Wagner. Article, Semen
Todd's Cyclopedia of Anatomy & Physiology. Part 34.

On The Development of Entozoa.

The Development of Entozoa was once a subject so little known that we find the best authorities of the period giving way to most extravagant conjecture & vain speculation.

Two opinions have been held with regard to their origin. First, That all entozoa are generated from similar parents. Secondly, that they are the products of equivocal or spon=taneous generation.

No one maintained the latter opinion more strongly than Bremser, nor carried his imagination to a greater length. "Knowing as we do", says he, "that the world existed without form " before the development of organised beings, &

"consequently, that these beings must have
"originated out of amorphous matter, are we
"to be astonished if the same thing occurs at
"the present time; if new individual lives are
"produced, & new organisations are developed?"

To prove that such organisms do owe their existence to spontaneous generation he gives the example of the non-fecundated egg becoming developed in the oviduct of the Fowl. If it be objected that the production of the egg is the natural function of that organ, he replies, so does the development of tæniæ & ascarides belong to the function of the intestinal canal, & the formation of flukes & hydatids to the function of the liver. On the other hand if it be argued that intestinal worms are not met with in every creature, he would reply, that neither are all animals capable of fecundation, or of producing ova.

He therefore considers every living organised body as an integral part of the vivified earth viewed as a whole; within which is reproduced in miniature what takes place without on the great scale. Within each organised being a continual fermentation goes on; during which new substances are admitted, precipitated, assimilated, dissolved, decomposed, excreted. Its life in short consists of a continual decomposition & a perpetual recombination of matter.

What took place in the Macrocosm takes place in the Microcosm. Not only do Entozoa originate, but different kinds appear at different periods. Thus the Oxyuris and Ascaris are as much the product of a fermentation occurring in Infancy, as the formation of the Primitive Rocks; which were precipitated after the first great fermentation of the then amorphous globe. The Cystica & Cestoidea would, on the same hypothesis, be the result of a second precipitation, occurring at a later period during Adult life.

It is surprising that, while so many have laboured with the greatest success to refute the notion of equivocal generation, there should be found any who hold this opinion, however modified. Helminthologists have long given up the spontaneous evolution of several orders of Entozoa in which ova have been discovered. None now maintain the

Nematoidea, Acanthotheca, Trematoda, Acanthocephala, & most of the Cestoidea, to be produced in any other manner than by sexual reproduction.

The Cystica & the Cysticerci have hitherto been the great arguments in favour of equivocal generation. The Cysticercus I have attentively followed in its development; & hope to show in the course of this treatise that it does not originate spontaneously, but from an ovum. This will therefore no longer be a difficulty, especially as we can readily account for their presence in such inaccessible parts of the body as the brain & eye by the circulation of their ova & embryos within the blood vessels: now that we know them to be only four times the size of a blood globule, & not ten thousand times, as stated by Rudolphi.

With regard to the Cystica, the development of the Echinococcus from an microscopic animalcule is well established, while the Acephalocyst is confidently affirmed by several modern authors to be identical with it.

Of this opinion is Siebold Mayor, &

Livois; the latter of whom states that he never failed to detect animalculae in the so called Acephalocysts, when the microscope was employed. Although, following the division of Professor Owen, they have been separated into two distinct genera in the subsequent pages, I am yet strongly inclined to the opinion that they are the same. The spontaneous formation of the "gigantic organic cell", as the Acephalocyst is graphically termed by that distinguished Naturalist, must therefore be laid aside.

Lastly, the Coenurus Cerebralis is the only species whose origin is unknown; but that this should form a solitary exception, & be the product of equivocal generation, while the other species, 1100 in number, are the offspring of similar parents, can hardly be maintained; & even if proved would not at all invalidate the truth of the general rule.

The arrangement I have followed is principally that of Owen; beginning with the lowest degree of organisation & passing on to the higher. But at the same time I have made some material changes in several of the genera; the reasons for which will be given when treating of them in detail. From the great extent of the subject, & the shortness of the time at my disposal, many of the genera have been unavoidably left out. It has not been my intention to write a systematic work; but merely to give a general outline of the researches of others with some facts & generalisations of my own on the Development & Metamorphoses of Entozoa.

I propose therefore to divide my Essay into the following Orders and Genera; treating of the development of each in its turn.

Page

Contents.

II Order. Cystica.

Although Rudolphi, who first established this order, rejected the Acephalocysts, confining it to those Hydatids only in which living beings were found, capable of locomotion, & more or less armed with teeth & suckers; yet, following the example of Bremser & of Owen, I shall include under this head the various Acephalocysts, Echino-cocci & Coenurus, leaving out the Cysticerci for reasons to be afterwards explained. Having no original observations to communicate regarding this order I am yet induced to enter more fully than I should otherwise have done into the nature & mode of developement for three reasons.

1st Many, adopting the views of Professor Owen have denied the vitality of the cyst, believing it to be only a gigantic cell, similar at first to all the other cells composing the animal body, but which, instead of being metamorphosed into cartilage, muscle or bone, increases in size, becomes apparent to the senses, & assumes the form of a membranous bag. Having thus disposed of the cyst, it is not wonderful that they go a step further, & consider the organised microscopic beings sometimes contained within them as infusorial animalculae, whose presence is rather to be ascribed to accident, than to the reproductive agency of the enveloping cyst.

2nd Bremser, Blanchard & others believe the Cystica to arise from an arrest in developement of a totally distinct class of animals, the Tænia.

3rd Because Rudolphi & Bremser maintain the spontaneous origin of these as well as of all other Entozoa; although the latter has given perhaps the best account of their changes & progressive deve-lopement.

My object therefore is to give a sketch of the various notions held by different authors; to trace the developement of the Entozoa contained in this order, & by disproving that which is erroneous to arrive at a right understanding as to their true nature & origin. To accomplish this it will be necessary to examine in detail the three genera comprising the Order Cystica

Genus I. Acephalocystis

Rudolphi divides Hydatids into two Classes, "Viventes", and "Non Viventes": placing in the latter the Acephalocysts, & in the former the Echinococci & Cœnurus. From this it appears that he did not regard the cyst in which these little bodies are contained as a living being; since he denies the vitality of those cysts in which no Echinococci are found.

Himly however proves most satisfactorily that such a cyst is nevertheless a distinct being; for although the simplest of all creatures the Cephalocyst is an animal, because it lives; because it does not decay; because it has no manner of attachment to the surrounding tissues; &, lastly, because, the fluid in which it lives not being endowed with life, it must be regarded as living alone & consequently an individual being.

Home believed the Acephalocyst to be the simplest being known; composed solely of a stomach.

Bremser regards all Hydatids that are contained loosely within special capsules, without attachment either to them or to the organs in which they are found, as having a separate existence. But this definition it will be perceived excludes all those Acephalocysts which in their young state are composed simply of a spherical bladder imbedded in the tissues of an infested animal, & which consequently have no second enveloping cyst. Thus, as I shall have occasion to show immedially, the first generation, or the parent cyst of all the Class Cystica, must be excluded if this definition be adopted, & must be denied to possess vitality.

Owen divides the Acephocysts into two varieties. 1st. The Acephalocystis Endogena of Kuhn; the A. Sociales or Proolifera of Craveilhier; the Pill box Hydatid of Hunter; & the Astoma of Mr H Goodsir. This is the kind most frequently developed in the human subject, & in which the fissiparous process takes place from the internal surface of the parent cyst; the progeny being sometimes successively included. 2nd. In the Second Class he includes the Acephalocystis Exogena of Kuhn; the A. Eremita vel Sterilis of Cruveilhier; & the Diskostoma of Mr H Goodsir. These develope their progeny generally from the external surface.

The simplest form in which an Acephalocyst is met with is that of a subglobular or oval vesicle filled with fluid, Plate 1. Fig 1. a, sometimes suspended freely in the fluid of a capsule formed by the condensation of the surrounding tissues; & sometimes attached to such a capsule. They vary from the size of a pea to that of a child's head. They are of a pearly whiteness, without fibrous structure; elastic, spurting out their fluid when punctured. The tunic is studded with numerous minute globules of a clear substance. No contractile property save that of ordinary elasticity has been observed in the coats of the Acephalocyst, & no other organisation than that which has been just described. No internal cysts or young Hydatids are to be seen, & no other function apparent than that of assimilation of the surrounding fluid by the general surface, & the developement of new cells from the nuclei of hyaline. In fact, as Mr Owen observes, it resembles "a gigantic organic cell". This variety constitutes the A. Simplex of authors.

The next variety is the A. Endogena of Kuhn; the Astoma of Mr H Goodsir, Plate 1. Fig. 2. It consists of an Acephalocyst Simplex, such as has already been described, within which however other similar Acephalocysts are developed. These young hydatids originate in the substance of the parent cyst; that is to say, they are formed by the enlargement of the cells placed between the internal & external layers of the cyst.

A clear vesicle projecting from the inner surface of the internal membrane of the cyst is the first vestige of the young hydatid. Plate 1. Fig 2.a. At first it is covered by the inner membrane, but by degrees as the young hydatid grows this membrane is ruptured, & it floats in the cavity of the parent cyst. Plate 1. Fig 2.b. Smaller cells are seen within the young hydatid soon after it is thus separated from the parent. Fig 2.c. These are the Third generation. This process going on the parent hydatid becomes at length so full of young Acephalocysts as to be distended by them. A rupture then takes place, provided the surrounding capsule be not sufficiently strong to prevent such an occurrence. The young of all ages & sizes are then immediately disseminated through the cavities of the infected animal; each of which in like manner repeats the same process, developing other Acephalocysts within itself.

The distinctive character of the A. Exogena of Kuhn, & Diskostoma of Mr H Goodsir, Pl. 1. Fig. 3, arises I am led to believe, from the fact of the external membrane being the weakest, & the position of such hydatid on the surface of the peritoneum not affording a protecting capsule, the young ones, Pl. 1. Fig 3.a., as they are developed force outward the external membrane, Fig 3.b, in preference to the internal; which, being supported by the fluid within it, retains its original form & size. Fig 3.c.

These young hydatids, on attaining a certain volume, burst through the external membrane, & become free.

Hence it appears to me that the various names given to Acephalocysts are altogether superfluous, founded as they are on differences in developement wholly due to the position in which they are placed.

Let us suppose an Acephalocyst to be developed in the substance of the liver, a very common site. When it arrives at a certain size it will consist of nothing but a single cyst containing only fluid & surrounded by a dense capsule formed of the substance of the liver. This is then an A. Simplex. But in a short time the cells placed between the membranes, constituting the at present simple cyst, begin to enlarge, & being prevented by the capsule from pressing outwards, develope themselves internally, become free, & so distend the mother as to render rupture inevitable. This then is what Kuhn would call A. Endogena

A growing hydatid follows the same law as an increasing abscess. It rises to the surface of the organ in which it is placed. Thus the A Endogena, arrived at the surface of the liver, bursts into the peritonaeum. The young at first float loose as they are sometimes found; but more commonly adhesion takes place between them & the serous membrane. The development of cells still continuing young hydatids are produced which now however meeting with no opposition to their escentric progress force out the external membrane of the parent, & constitute thus the A. Exogena or Diskostoma.

If these terms be retained at all it would seem necessary to regard them as indicating merely varieties of the same species, & not, as they are now understood to mean, different species of the same genus.

Genus II. Echinococcus.

The name Echinococcus is given to a cyst resembling the Acephalocysts, when, in addition to the sero-albuminous fluid, it contains a number of microscopic organised beings, Pl. 1. Figs 4–9, floating or freely swimming in it, or adhering by special prehensile organs to the internal surface of the cyst.

Owen, following the example of Rudolphi, confines the term to these microscopic animalcula; believing as he does that the cyst in which they are found is nothing but a gigantic organic cell, &

not a distinct individual being.

Bremser however, with more propriety, gives this name to all those hydatids in which such animalculæ are present; having traced the process by which the minute animalcule is transformed into the enveloping cyst. Of this genus there are two species; E. hominis; & E. veterinorum. The characters by which these two species are distinguished are very uncertain. Rudolphi states that the animalculæ found in the human variety are furnished with only a single circle of teeth; while that of the lower animals has two rows; but I can find no confirmation of this fact by other authors. Dujardin indeed denies that there is any difference, after having examined both varieties.

Hence the evidence preponderates in favor of there being only one species of the genus Echinococcus.

An Echinococcus then consists of a parent cyst, in every way resembling an Acephalocyst, & like it capable of being split up into an internal & an external membrane. Within this parent cyst a number of smaller cysts are frequently found, but these are not necessarily present.

That however which distinguishes the Echinococcus from the preceding genus is the presence of animalculæ,

Plate 1. Figs. 4 to 9. These microscopic beings are oval cordate or oblong in shape. One extremity is furnished with a circle of spines, radiating from a centre; Figs. 4, 5, 9 a, external to which, & a little more posteriorly are four suckers, projecting slightly from the surface of the body. Figs. 5, 6, 8, 9. b. In addition to these Owen has discovered the presence of cilia, by which these minute creatures are enabled to change their position at will. On opening such a cyst these creatures are seen attached to its inner surface, forming white patches in those places where they are numerous.

A number of detached spines are likewise met with floating in the fluid of the Echinococcus; clearly indicating that after a time the animalculae lose their spines. The ovula next disappears, according to Bremser; & the little bodies, at first of such a high degree of organisation, after a time assume the appearance of smooth globules about the size of onion seeds. These gradually enlarge, till at length they entirely fill the parent cyst, & become deformed by the want of space & the consequent pressure. On opening one of these little hydatids, others still smaller escape from within its cavity: & within these again are perceived minute animalcules furnished with their spines & suckers.

Hence it appears that the animalcula is the first, or primitive form, of the Echinococcus; which after losing its cilia, its spines, & its suckers, becomes a simple Acephalocyst; developing however from its interior other animalculæ in every respect identical with its own former structure.

Genus III. Cœnurus.

The only known species is the Cœnurus Cerebralis, Plate 1. Fig. 10. It consists of a cyst about the size of a pigeons egg, situated in the brain of the Sheep, the Ox, Antilope, & Horse. Here & there scattered over its surface are a number of Tæniæform heads, Plate 1. Figs 10. 11. a; a tenth of an inch in length; &, when protruded, projecting outwards into the substance of the brain. These heads are furnished with four suckers, & a circle of teeth, Pl. 1. Fig 11. b. c; according to Rudolphi there is a double circle. A neck or body, Pl. 1. Fig 11. d, rather narrower than the heads, & composed of several joints, unites it to the common cyst, Fig 11. e. When disturbed the heads disappear, by inversion, Fig 11. f; & the bodies are then seen projecting into the cavity of the parent cyst.

Mr H. Goodsir has traced the developement of the heads from cells contained between the layers of the parent cyst; but how this is formed no one has yet shown. Judging however from the analogy which this creature bears to the Echinococcus, it is probable that each head if detached would be capable of a separate existence, & would in time swell up, lose its spines, & suckers, & in the end become a polycephalous hydatid.

General remarks.

The Cystica, like all other beings, have their diseases, arising out of defective nutrition, pressure caused by the rapid increase of young, & some other unknown causes. After having traced the progress of development, I have now briefly to allude to the process of degeneration, by which this order of Entozoa lose their individual existence, decay, & disappear.

The first perceptible stage in this process is that the limpid fluid loses its transparence becomes thicker & thicker, & acquires a yellowish colour resembling soft cheese. The cyst, from being much distended, becomes flaccid & wrinkled; lastly that which was once liquid becomes entirely solidified. At first some parts of the wrinkled cysts may be distinguished, but these also disappear, & all that remains of the hydatid is a calcareous mass, covered however with a peculiar epidermis: the whole separable with as much ease from the organ in which it is found as the hydatid itself.

The healthy hydatid, filled with limpid fluid, forms a convex & elastic protuberance on the surface of the organ in which it exists; but when degenerated into an ossific mass it forms a depression encircled by wrinkles.

II. Order Cestoidea.

I Genus Tænia.

This genus contains the most remarkable of all the Entozoa, & at the same time those which are least understood. Hitherto the Cysticerci have been usually classed with the Cystica, but, as I hope to show subsequently that they are only one of the degrees in development of the true Tapeworms, I shall include them also under the generic term Tænia.

The distinctive characters of the Cysticerci hitherto regarded as a genus, are given by Rudolphi in the following terms. "An external simple cyst, containing a solitary entozoon; whose body is round or flat, ending in a caudal vesicle. The head is that of an armed Tænia, having four suckers, & the proboscis furnished with teeth." This definition however is scarcely suitable, for the Cysticercus Pisiformis has no teeth; & the C. Salmonum, according to Fröhlich, is not only unarmed, but three or four are often found inhabiting the same cyst.

Again Dujardin says that the Cysticerci are worms contained singly in cysts, of a Tæniæform body, with a double coronet of hooks, & terminated posteriorly by a vesicle more or less voluminous. I shall have occasion to point out immediately that the C. Fasciolaris has no body at one period of its development, & no caudal vesicle at another.

So fully was Blanchard impressed with difficulties of this nature that he declines definition altogether. In truth individuals of this group differ so much in conformation and shape, that the only character they can be said to have in common is a negative one, namely, the total absence of all reproductive organs.

Here we are met by a fresh difficulty. If there are no reproductive organs how are new cysticerci formed? The celebrated French Helminthologist Dujardin believes the cysticercus to be "a modified tænia, springing originally from an egg; but, from being imbedded in the substance of the tissues, incapable of attaining its normal development; & must consequently at some time or other perish as a hypertrophied embryo"

Blanchard, one of the most modern writers on the entozoa, gives it as his opinion that "when single eggs of tænia become introduced into the visceral cavities, they are developed into cysticerci. When however a mass of eggs, or an entire segment of a tænia is placed in the same circumstances an arrest of development takes place sooner, and Echinococci are the result".

That the caudal vesicle is not the result of the imbibition of fluid by the head, as was supposed by some, was first pointed out by Goetze; who states from repeated observation that the caudal vesicles are developed first, & attain a large size, while the worm is as yet imperfect. The fluid being first prepared by the vesicle the worm absorbs it, & is therefore in many cases found with the head inverted, that is, projecting into the sack. Thus, after all that has hitherto been written, we remain as ignorant as ever of the origin & final condition of the cysticercus.

By following another course, & tracing carefully the progress of their development, comparing them with the allied genera, & drawing deductions from analogy, I hope to remove some portion of the obscurity which has so long hung over this, one of the most difficult points in helminthology. Having been engaged for some time past in the examination of the Cysticercus Fasciolaris, a variety frequently met with in the liver of mice, I shall commence by describing its metamorphoses; after which the probable nature of this doubtful genus will I trust become more apparent.

Cysticercus Fasciolaris. Plate 1. Fig 12, 13.

The cysts containing this entozoon are always apparent on the surface of the liver of the mouse, Pl. II. Fig. 14; projecting somewhat, but embraced by its substance. So close is the attachment, & so great the vascularity of the liver at this part, that the cyst cannot be separated without tearing with it some of the gland. That portion however which projects beyond the surface is free from any covering of hepatic substance, & is enveloped only by the peritoneum. In one instance a small artery blood vessel was seen, spreading itself over the free portion of the cyst.

When examined microscopically the cyst is found to be composed of two layers; which can be separated with ease after being heated with a solution of caustic potash. The innermost Pl. II. Fig 15, which is also the thinnest consists entirely of cells placed side by side, & loaded with fatty granules in the normal state, not seen however after the addition of potash. The external layer on the contrary is fibrous, & is probably formed by the condensed areolar tissue of the liver.

Contained within, but perfectly separate from the cyst, an entozoon is seen, doubled up in an irregular manner. Withdrawn from its envelope, Pl. II. Fig 16, the Cysticercus presents the following characteristics. It is usually from one to two inches in length; elongated in form; Pl. II Fig 17; one extremity dilated, & resembling a bladder. This is the caudal vesicle; while the other terminates in a blunt point, the head, Pl. II. Fig. 17. a. The body, Fig, 17. c, & 23. b, when stretched is seen to be distinctly annulated; but so narrow are the segments, & so closely applied together, that in the contracted state they are hardly perceptible to the naked eye; & near the head they disappear altogether.

On the head are five elevations. The terminal one, or proboscis, Pl. II. Fig, 18. a, projects in the form of a cone, with a clear ring in the middle; round which on the outside curved teeth are arranged in a double circle.

These teeth are hard; somewhat resembling a cat's claw. Pl. II. Fig. 19. They are recurved; their concavity being towards the body; sharp at the points, & from $\frac{1}{100}$ to $\frac{1}{60}$ of an inch in length. The base of each tooth is rounded, Pl. II. Fig 19. a, & articulated to the clear cartilaginous disc occupying the apex of the proboscis, which thus acts as a most efficient fulcrum.

About the middle & on the lower side of each tooth is a projection, Pl. II. Fig. 19 b, to which the muscular fibres are attached. These fibres form a circle round the base of the proboscis, Pl. II Figs. 18. f. & 20 a. When these contract the cartilaginous disc is forced forward, & the teeth, turning on it as on a centre, become first spread out, & then drawn backwards.

When however the circular fibres relax & the longitudinal muscles of the body come into action the cartilaginous disc is drawn into the head, the points of the teeth become approximated & at the same time directed forwards, Pl. II. Fig. 20 e. If the longitudinal fibres continue to contract the proboscis is inverted, & the teeth disappear entirely within the head. Those teeth which form the outer & hindermost circle are the smallest, Pl. II Fig 18. b; & alternate with those in the front rank. Fig. 18. c

The four suckers, Figs 18 d. & 20 b, are arranged at equal distances round the base of the proboscis & outside the coronet of teeth. In a side view the fourth, Fig 18. g, is indistinctly seen, being obscured by the body. They are more transparent than the surrounding parts; they project from the surface, & are covered externally by a well defined membrane. Each sucker presents a circular or oval opening, the margin of which is formed by a reflexion inwards of the external membrane. Figs. 18h, 20d

The body is covered with a thin cuticular layer beneath which a number of oval cells are seen scattered here & there. Fig. 25. a. This membrane at the hinder extremity becomes suddenly dilated, & constitutes the caudal vesicle. Figs. 17 b, 21 a. Rudolphi states that the longitudinal fibres pass from the hinder extremity of the body in two bundles, which expand themselves over the superior portion of the vesicle. This however is denied by Goetze, & certainly none of the specimens that I have examined presented such an appearance. On the contrary all tissues of a fibrous nature ceases with the body, & the only structure that is continued to form the vesicle is the cuticular layer already described Fig. 23. c. Within the caudal vesicle is a large quantity of fluid, for the most part perfectly transparent & clear, though a few minute granules are sometimes seen.

Such are the external appearances: we now proceed to the interior ^nal^ structure. On making a cross section Fig. 24, this appears to be entirely cellular, but differing in density, or closeness, indicated by the light & shade. Thus there are two bands of close tissue on either side, Fig 24. a, & an irregular mass of the same, Fig 24. b, in the middle, separated by clear bands. At either end of the central dark part is a clear round space Fig 24. c; &, in the middle of each of these, an oval spot Fig 24. d, the intestinal canal; better observed in the more magnified drawings Figs 21, 22: where they are seen to present an annulated interior, corresponding to the segments of the body.

That the intestinal canals arise from the suckers was stated by Rudolphi; & this has of late been confirmed by Blumhard, & may be seen by pressing the cysticercus between plates of glass. Plate III Fig. 25. Originally they are four in number Fig 25. b; one from each sucker, Fig 25. c; but as they proceed downwards & the body becomes more flattened they unite to form two lateral canals. Pl. II. Fig 24. d.

This then is an outline of the anatomical structure of the Cysticercus Fasciolaris in the condition in which it is most commonly met with, as described by those who have written on Entozoa. We ^I^ now proceed to the examination of the steps by which this degree of development is attained. Goetze & Mr H. Goodsir are the only observers, who, so far as I am aware, have said anything with regard to this development of the cysticerci. The former author is said by Rudolphi to have seen a round spot in the caudal vesicle of the cysticercus, which he considered the primitive germ. Whether he traced its further progress I have no means of ascertaining, not having met with his work. After many attempts I have failed to discover any bodies presenting a spherical form, & armed with teeth, similar to those which Mr H. Goodsir has described as young cysticerci, existing between the cyst & caudal vesicle.

On examining those cysts which had not yet reached the surface, but were covered by a thin stratum of hepatic lobules, & to detach which it was necessary to extract them from the substance of the liver, I found the following appearances. Such a cyst, when separated, is of a rosy tint & rough outside from small portions of the glandular substance still adhering. When taken fresh from the mouse it is turgid & spherical, & about $\frac{1}{10}$ of an inch in diameter. Within is a flaccid vesicle of nearly the same size as the cyst, but much more delicate in appearance, more translucent; & which by a succession of changes, which I am about to describe is transformed into the Entozoon.

The lowest degree of development in which I have observed the Cysticercus Fasciolaris is that shown in Plate III Fig 27; where the vesicle, Fig. 27. a., is seen to present a cup shaped depression, Fig 27. b; the cavity of which is filled up with a mass of large granules. These granules were neither covered by an investing membrane, nor were they arranged in any regular manner. No such granules however were to be seen in any other part of the vesicle.

In the next stage of development the vesicle, Fig. 26. a, presented a light spot, about $\frac{1}{80}$ of an inch in diameter, Fig 26. b; the vesicle itself being about $\frac{1}{10}$ of an inch when flattened between glasses but not compressed. On placing this vesicle under a power of 120 its general structure appeared cellular; but the cells so loaded with granules of fat, or oil, as to render it nearly opake, completely hiding the cell walls so as to give the whole a granular appearance. Fig. 28. a. The vesicle had burst in one or two places but no fluid had escaped being coagulated by the spirit in which it was placed for preservation.

As already stated this vesicle was opake except in one spot, Fig 26.b; & this when magnified presented a remarkable appearance Fig 28.b. It looked like a sphere imbedded in the vesicle, that is to say, the lower surface was distinctly seen to be covered by a layer of cells, not constituting the sphere. But I could not satisfy myself as to whether the same existed on the upperside, which is the one shown in Fig 28. I am however of opinion that the external membrane or vesicle passed over the sphere, & covered it with the exception of the central light spot, Fig. 28.c. This sphere was darker at the edges than towards the middle Fig. 28.b. In the centre of all was a light spot, with a very definite margin, Fig. 28.c. This was not owing to a depression, because, when viewed as an opake object, it was seen to be on a level with the surrounding parts. The only difference seemed to be that the substance composing the central light portion, Fig 28.c, was not covered by the external membrane of the vesicle, & was more transparent from containing fewer granules, & these of a very minute size as compared with those of the surrounding tissue.

The substance of which this spherical body was formed appeared to be composed externally of very delicate cells, & polygonal from compression against each other; beneath or within which fatty granules were accumulated to such an extent as to render the cellular structure very difficult to be perceived. But that such is the true nature of the external layer I feel every confidence in affirming; for, by alteration of the focus so as to throw the granules out of sight, the polygonal cellular ~~structure~~ structure became visible.

I next isolated this spherical body, by tearing away the surrounding substance, & on examination it presented the appearance figured in Pl. III. Fig. 30: namely that of a second sphere, Fig. 30. a, within the first, of about one half its diameter; & within this again was a dark oval spot. Fig. 30. b.

On pressing the glasses this internal smaller body was forced out, as seen in Fig. 31; in form spherical & cellular in structure. The cells were nucleated, & placed so as to present an even surface externally, but not limited by any visible membrane. Fig 33. a. The granules filling these cells being smaller allowed their walls to be better seen.

On one side of this mass was the dark spot already mentioned, Figs 31 a, & 33 b: but now its structure became more apparent. The cells forming the general mass appeared to be arranged in a circle, Fig 33. c, having a well defined boundary; within which, & slightly deeper than the cells composing the circle, were the cells which constituted the dark part. Fig 33. b.

This dark spot was seen to consist of prismatic cells, Fig 33. d, arranged side by side with the greatest order, & having the ends only presenting at the opening left by the cells of the surrounding substance. These inner cells were smaller, of a dark amber colour, & together formed the hemispherical mass, Fig 33. b, which was imbedded in & slightly overlapped by the surrounding cells. On treating the whole with Aqua Potassæ, & then applying pressure, these cells were forced out in a mass; which, further magnified, is represented by Fig 29. Their walls were most distinct, & no granules were to be seen within; their cavities being filled with a clear amber coloured fluid, which made them the more remarkable, as in no other part was there the least appearance of colour.

An individual cell magnified, Fig 32. a, presented the appearance of smaller cells, Fig. 32. b, being contained within it; & nuclei again within these. Fig 32. c.

The spherical body just described after a time passes inwards towards the centre of the vesicle; & the central clear spot, caused by the reflexion of the external membrane, Fig 28. c, of the vesicle, becomes converted into a funnel shaped depression Pl. IV. Fig 34. a. On opening the vesicle, Fig 34. b, we find that the external depression, Fig. 34. & 35. a, corresponds with a club shaped body that projects into its cavity, Fig. 35. c. This is smooth on the sides, but slightly irregular & dilated at the extremity, Fig 35. c. This constitutes the Third Stage; & is in all probability the pedicle of the Sphairidium, described by Mr H Goodsir.

Fourth Stage. We now for the first time are able to distinguish the characteristic form of a cysticercus, Pl. IV. Fig. 38, consisting of a body, Fig 38 d & a caudal vesicle, Fig 38. f. But the animal before us is very different from that which has been already described as most commonly met with.

The body consists of two segments only, Fig 38 a. d, but these are most distinct, & globular. The first joint or head, Fig 38. a, presents evidences of the four suctorial organs, Fig 38. b; & a fifth transparent & slightly depressed spot in the centre indicates the cartilaginous disc. Fig. 38. c. When viewed from above, Fig 39, three concentric circles, Fig 39. d, are observed, surrounding the cartilaginous disc, Fig 39. c, indicating folds of the future proboscis. Between the two outside rings, & at equal distances from each other are the four suckers, Fig 39. b, but as yet without visible openings. The teeth likewise are absent; & a few dark marks round the edge of the disc alone point out their future site.

Between the first & second segments, Fig 38. a. d, a deep sulcus exists. On the other side of the second, & separated by a similar, though not so deep a fissure is the caudal vesicle, Fig. 38. f; flaccid, & irregular in shape, containing a granular fluid.

The next in order, or Fifth Stage of this Cysticercus is that most commonly met with, & has been already fully described, Pl II. Fig 17. It is characterised by a body, Fig 17. c, composed of numerous segments. The head, Fig 17. a, is furnished with teeth; the sucker presents orifices, & there is the constant presence of a large caudal vesicle. Fig 17. b.

In the Sixth condition the caudal vesicle very nearly, or entirely disappears. Pl. IV. Figs 40, 41. The animal is now wholly composed of segments, irregular towards the hinder extremity, terminating in a blunt point, more or less wrinkled. It is uncommon however to find the Cysticercus Fasciolaris in this state, having myself only met with it thrice. It so happened that, in the first mouse which I had an opportunity of examining, I observed two animals in the stage just mentioned, & my attention was thus directed to the subject under consideration. This condition of the cyst, in which it is entirely destitute of caudal vesicle, has been long known. It was however disbelieved by Rudolphi. Speaking of this identical Entozoon he says, "The caudal vesicle is sometimes abruptly cut off, & Leder has found perfect worms without vesicles, but this is doubtful."

Having now witnessed the formation of the jointed body, & the total disappearance of the caudal vesicle, Fig. 40. b, the question naturally suggests itself, — how are we to distinguish between this Cysticercus & a Tænia now that the characteristic caudal vesicle has disappeared? In short, are we justified in calling it a cysticercus any longer? Should we not rather term it an Encysted Tænia? But Tæniæ again commonly live in a free state in the intestinal canal, where their teeth & suckers come into play, what use are these appendages to an animal closely shut up within a cyst? If it could get out of its prison they might be employed!

Let us follow out this idea by examining the opinions of former Authors. Joseph Capelle, in the Transactions of the Philadelphian College of Physicians, date states that the larger was the worm the thinner was the cyst; which induced him to believe that in a future day it would have forced its way through, & have fallen into the abdomen. Continuing his observations with a view to this fact he mentions cases where the cyst had become ruptured. In one of these instances the worm had as yet only partially escaped through the opening. Of other three cases where they had completely freed themselves, one lay on the liver, & the other two on the intestines.

This is one step in our investigation, & an important one; proving, not only the occasional rupture of the cyst, but likewise that the cyst is not essential to the life of the animal, but that it can live in a state of freedom. But the cavity of the peritoneum is no more the habitat of a tænia than the liver is. Were it possible for the creature to pierce the coats of the intestines it would be in a much more natural position.

Blanchard endeavoured to compare a large number of Cysticerci with the Tænias usually found in the same animal, but did not succeed in obtaining sufficient evidence of their identity to lead him to the belief, that they are two conditions of the same creature; with the exception however of the Cysticercus of the Rabbit. He compared the C. Fasciolaris with the Tænia Murina, found in the intestines of the Rat & Mouse; but the single circle of teeth of the T. Murina, as well as the material difference in the form of the teeth proved that they were not the same. Hence he adopts Dujardins view, & says, "If the C. Fasciolaris is only an abnormal development of the Tænia Murina we can as readily understand the presence of the spines as its being enclosed in a cyst". It seems however a contradiction in terms to say that the C. Fasciolaris is an abnormal Tænia Murina, & then to account for the differences between the two as consequent on that abnormality.

The difference is still greater as regards the other Tænias found in the intestinal canals of the genus Mus. Hence it is to be presumed that this cysticercus does not find its way into the digestive system of the same animal in whose liver it has been formed.

It suggested itself to me whether we might not possibly find the object of our search in some of those animals which feed on Mice & Rats. Pursuing this idea I found that the Tænia Crassicollis Pl IV Fig 42, found in every Cat, corresponded very closely with the C. Fasciolaris, & especially in the character which distinguishes it from all other Tænias, the breadth of its neck.

The following as given by Dujardin are the characters of the two, contrasted, so as to give a clearer notion of their differences, as well as their points of agreement.

	Cysticercus Fasciol.	Tænia Crassicollis
	Inches (capelle)	Inches
Length	1·20 – 7·0 – 16·0	6·0 – 24·0
Breadth of hinder segments	0·08 – 0·18	0·16 – 0·24
Breadth of head	0·08 – 0·12	0·06
Number of teeth	36	48 – 52
Length of longest teeth	0·018	0·01 0·011
Corona	Double	Double

By this table it will be seen that the maximum length & breadth of the C. Fas. is greater than the minimum length & breadth of the T. Crass. The neck however of the Tænia is about one half the breadth of that of the Cysticercus. This is only the case when the former is stretched out, Pl V. Fig. 45, a; for, when contracted, I have often seen it a fifth of an inch broad. Pl V. Fig. 46. a. No dependance is to be placed on the number of the teeth. I have a prepa-ration of the head of a small tænia of this variety from the cat, in which there are only 36 teeth; another I counted had 44. Pl IV. Fig 44. I have also seen C. Fas. with 38 & 40 teeth. The length of the teeth is very nearly the same in both. Thus, according to my own measurements, they are from $\frac{1}{100}$ to $\frac{1}{60}$ in the C. Fas., & from $\frac{1}{84}$ to $\frac{1}{55}$ in the T. Crass.

Both have their teeth arranged in a double corona. Pl. IV Fig 44.c.

Capelle found the C. Fas. to measure 16 inches in length; & I have found the T. Crass. of all lengths from 2 inches to two feet. Pl V. Figs. 45.46.47.48.

Lastly, I once met with a T. Crass. which presented a most distinct cyst, Pl IV. Fig 42.b, & 43.c; atrophied & wrinkled, but entire; offering a strong contrast to the usual ragged extremity of this creature. Pl V. Fig 45.c. Now as this individual, Fig 42, was taken out of the intestinal tube of a cat; & as from its size & characters no doubt could possibly be raised as to its being a T. Crass.; & as the only difference between it & the C. Fas., namely, the absence of the vesicle, was in this instance wanting, the vesicle being there Fig. 42 b, 43.c, it is impossible to classify it with either exclusively, corresponding as it does exactly with both.

Thus we have found their physical characters to agree. We have also the negative proof that no other tænia has a broad neck; & that we have found the transition state of the passage of the Cysticercus Fasciolaris of the mouse into the Tænia Crassicollis of the Cat. They are therefore identical.

As the Tæniaform condition is a subsequent stage to the vesicular form, the development of reproductive organs is not to be regarded as an indication of their non identity; but as a natural circumstance, & one which an attentive observer would be led to expect.

The T. Crass. as already stated is from two inches to two feet in length. Its head is identical with that of the C. Fas. The segments of its body become longer as we approach the tail, where they are sometimes three or four times as long as they are broad Pl V. Fig 45.d. but on the slightest irritation the creature contracts itself to such a degree that one, Fig. 45, twenty four inches in length will contract into three inches Fig 46. The whole body is covered with a fine cuticular layer, immediately under which lie a number of large nucleated cells, Fig 49, very easily detached, & perfectly transparent.

Beneath this cuticular envelope are the circular layers of contractile fibres, encircling the body; below which again are the longitudinal muscles by which the body is shortened. Pl II. Fig. 24 a. b. The walls of the suckers become thicker, Pl. IV Fig 44 a. b: the four intestinal canals are seen distinctly to originate from them, Fig 44. d. Then approaching each other they pass downwards for a short distance in two pairs, placed at opposite sides of the body. These soon unite to form the characteristic single pair of canals seen in all tænias V. Fig 51. a.

These lateral canals communicate at the junction of the segments by transverse tubes, Fig 51. b; rendering the whole system equally permeable to the nutrient fluid.

The vascular system of the Tænia, according to Blanchard consists of four delicate longitudinal canals; of which two lie externally but close to the digestive tubes; while the other pair are placed nearer the centre of the body. An immense number of branches pass off transversely, & keep up a complete as well as free communication between the different vessels.

The nervous systems of the Tænias & that of the Cysticerci are the same; consisting, according to the author just quoted, of a nervous band extending between two very minute ganglia, placed at the base of the proboscis. From these ganglia nerves pass to four other nervous centres, placed behind the four suckers. There are also two very delicate filaments, which pass down the whole length of the body, supplying the various segments. The suctorial ganglia supply those organs with nervous filaments; influencing & regulating their action.

The reproductive organs of the Tænia Crass. are unilateral; that is to say, each segment presents only one genital orifice, & that is on the margin, Fig 51. c. These orifices are very minute, & circular; situated nearly in the centre of the margin of each segment, & slightly depressed. Fig 50. a. They do not alternate regu-larly, nor follow any rule; but are found sometimes on one margin sometimes on the other. Fig 45. f. From this orifice, 51. c, a straight tube passes inwards towards the centre of the segment, 51. d, dilated near the margin, & becoming gradually narrower towards both extremeties.

This tube is the oviduct, & passes into the ovary, which is dendritic, 51. f, occupying the whole segment; & containing an immense number of eggs. A little anterior to the oviduct is a much finer tube, 51. g, leading from the seminal vesicle, 51. h, & opening into the dilated portion of the oviduct, close to the external orifice.

In confirmation of the general belief that the different segments of the same tænia are capable of fecundating each other, it may be as well to mention what I have several times noticed with regard to the Tænia Crass. In those cases where only one solitary worm exists it is generally so doubled up in the intestine that the head & tail occupy nearly the same spot; the rest of the body being applied margin to margin. When however several are found together I have never seen any doubling, their bodies being extended side by side.

The ova of this taenia though known to exist have not been examined by any Author. The following are my own investigations upon the subject.

The ova are minute & are seen to be adherent to the walls of the ovarium, as well as filling its cavities, V. Figs 52 to 55. When magnified they are seen to be globular, & to consist of three envelopes. The outer one is transparent; forming a vesicle $\frac{1}{400}$ of an inch in diameter; membranous, & very easily ruptured. Figs 52 to 55. a. The second measures is only $\frac{1}{1000}$ of an inch across in diameter: it is thick, brittle, granular, & opake 53 to 57. b: completely hiding the embryo within. Between this & the outer membrane are a number of loose globules, Fig 53 to 55. c, resembling oil, & floating in a transparent fluid. When this second or middle envelope is ruptured by pressure, Fig 54, 55, 57 b, the inner membrane is forced out entire, Fig 55, 57. 58 d; along with a very fine granular fluid.

This inner vesicle membrane is only $\frac{1}{1600}$ of an inch in diameter. It is perfectly transparent, & very thin. Fig. 59. 60. d. Contained within & nearly filling this membrane is the embryo, Figs 55 to 60. f; of a slightly oval form; granular in substance, & furnished with six spines or teeth, radiating from the centre. Figs 58 to 60. h. Sometimes these spines are placed side by side in the substance of the embryo. At others their points are seen projecting slightly into the cavity of the inner membrane.

All that I have been able to trace as to the formation of the ovum is, that at first the outer membrane alone exists, Fig 52. a; containing within it a granular fluid, 52. g, that in all probability this is the yolk membrane, & that the large globules it afterwards contains, 53 to 55. c, are portions of the yolk which have not been transformed into the embryo & its two proper coverings. The outer membrane is very easily destroyed, so that it is most common to see the ova without it. Fig 56.

The embryo when very young consists only of a membrane, contained within & entirely filling the inner envelope, & containing nothing but a granular fluid. As it progresses in development six granules appear larger than the others, & these by degrees become elongated into the six spines or teeth. At this period the embryo is semi transparent & darker towards the centre, from the presence of a few granules.

We have now traced the cysticercus Fasciolaris through a series of changes. We have seen it encysted in the liver of the mouse, Pl II Fig 14; at first consisting only of a vesicle with a patch of granules at one point Pl. III. Fig 27. We have followed the successive formation of the head III. Fig 28; the segments, IV. Fig 38; the suckers, IV. Fig 39; the teeth, II. Fig 18. We have witnessed the disappearance of the caudal vesicle IV. 40. 41; & the occasional rupture of the enveloping cyst. Then follows the migration, the translation of the Cysticercus from the liver of the mouse into the intestinal canal of the cat, & its consequent transformation into the Tænia Crassicollis. V. 45. We have proved the identity of the two. We have observed the gradual formation of reproductive organs in the Taenia, V. 51; & the development of the ovum, V. 53.

It only remains to investigate the way in which the embryo Tænia, V. 59. 60 f, cast off by its parent assumes the cystic form to complete the remaining portion of this wonderful & beautiful circle of development.

It is highly probable that the last segments of the tænia become detached from the fact of the posterior extremity almost always presenting as ragged & uneven appearance. Whether this takes place or not; whether the ova are thrown off singly or in masses still contained within the ovary that gave them birth, they yet leave the system of the infected animal as ova, presenting externally the opake granular membrane, V. 56. In this state I have met with them disseminated through the fæces of the cat.

The eggs produced by a single segment are innumerable; how many then must be contained in each tænia; & how great the number that pass off in the excretions of a single cat, containing as it often does from 3 to 12 of these tænia.

Let us take the cubic contents of one of the posterior segments to be $\frac{3}{10}$ of an inch. The cubic contents of the ovary will form one third of this, or $\frac{1}{10}$ of an inch; & assuming the mean diameter of the ova at $\frac{1}{500}$ of an inch linear, the number of eggs contained in a single segment will be 125,000. Now as it is impossible to estimate exactly the number of segments in each tænia, from the fact that they become shorter the nearer they approach the head, we shall be greatly within the mark in estimating them at one hundred. This will give us the enormous number of 12,500,000 as the produce of each tænia crassicollis. Dujardin estimated the ova contained in the Tænia Serrata of the Dog at 25,000,000.

This calculation, startling as it may seem shows how wide & universal must be the spread of these ova. The whole neighbourhood round the dwelling of a cat must be swarming with them. Their number alone defies all the various destructive agencies put together; to say nothing of their minuteness & of the admirable manner in which they are encased & protected.

Are we then to wonder that they should again enter the body of the mouse; whose vicinity is courted by the cat; whose food is picked up from the ground; whose drink is the drainage of the neighbourhood; & whose only method of cleansing itself consists in licking the dust from off their fur. This last is the method in which I suspect the ova enter the intestinal canal of the mouse. But it matters little as to the means so long as entrance is effected. Many eggs doubtless are destroyed in the passage through the stomach; but from the nature & consistence of their envelopes many more must arrive safely in the small intestines.

Once there in the circumstances most favorable for incubation it is no great presumption to suppose that the egg membranes rupture & that the embryo, furnished with its six teeth, becomes free. The softening of the membranes, consequent on the action of the intestinal juices, no doubt, contributes much to the facility with which they may be torn; but I believe the rupture is effected by means of the teeth already mentioned.

Dujardin, in his investigations on the ova of the Tænia Cucumerina, notices that he has seen the teeth moving within the egg. He states that they appear to be placed in three pairs, but in all probability are really situated at equal distances. He observed their points to approach each other, & the six teeth became parallel, caused by the contraction of the embryo; that these points began slowly to separate, & finished by occupying the transverse diameter of the ovum as at the first.

Although Dujardin does not indicate any result as likely to follow these motions of the teeth, it appears to me that this movement must be intended for the rupture of the egg membranes, since it is the precise motion that is calculated to effect this object. The contraction of the embryo collects the teeth together, directs their points against the enveloping membrane, into which they are forced by the consequent elongation of the body. The teeth are then separated, they tear the membrane acting against each other as fulcra, thereby effecting an opening large enough for the exit of the embryo. At the same time that the rupture is being effected the embryo will by the same means be forced out of the fissured membrane.

That this does take place is proved by the fact that Dujardin saw embryos of the tænia Serpentalus which had, Pl. VI. Fig 65, just escaped from the egg, Fig 64, moving about in a state of freedom armed with their six large teeth, Fig 65. a. At the hinder extremity was a vesicle, 65. b; caused as he supposed by the action of the water in which they had been placed for examination, & not present in the normal condition.

Thus then the embryo of the Tænia Crass. forces itself out of the ovum, & floats freely in the cavity of the intestine; presenting an oval form; from one end of which project the six spines, & composed internally of granules. Still there remains the difficulty of explaining how these little bodies are transported into the liver. Three ways present themselves, all of which are followed by different species of entozoa.

1st. The embryo tænia may ascend the bile duct; & thus enter the liver, as is done by the

Distoma Hepaticum.

2nd - It may pass directly through the coats of the intestine, & penetrate the adjoining portion of the biliary organ.

3rd - It may bore its way into one of the mesenteric veins, & be carried by the current of the blood, along the Vena Porta, nearly to the limits of the portal system; the minute size of the capillaries precluding its further progress.

With regard to the first of these methods it must be objected, that the bile duct at first very difficult of entrance, must be still more difficult to ascend. The embryo tænia is also very minute, & its teeth are not adapted for locomotion along membranous surface. Suckers are at this period absent; for although Dujardin has figured two granular masses in the embryo of the T. Pistillum, Pl VI. Fig 70. a, his observations have not hitherto been confirmed. None of the other varieties of tænias, while in the embryonic condition, are found to present a similar appearance.

My own observations also with regard to the embryos of the tænia crassicollis enable me to state positively that they have no suckers at the period now indicated. The difficulty of entrance, the distance to be traversed by the individual exertions of the young tænia, & against the current of the bile, render it improbable that this is the route selected.

With regard to the 2nd method, the Echinorhynchi are known to pass from one organ to another through the tissues of the body. But, if the young tænia passed directly into the liver through the walls of the adjoining intestine, we should find the young cysts situated at first on the surface of that organ, & not, as is really the case, imbedded in it. The fact also of the intestines being in constant motion, & of course as continually changing their relation with the adjoining viscera is greatly against the possibility of any such passage.

The 3rd route is that which appears to me to be most easy of accomplishment, & best adapted to the organs with which the embryo of the Tænia Crass. is provided. The vessels of the intestinal canal are so close together, & their ramifications so numerous, that it would be hardly possible for the young tænia to penetrate further than the submucous coat without encountering a vein. Hidden amongst the villi, or embedded in a follicle, the teeth can be used with advantage. On all sides they have something to lay hold of. The same process by which the envelopes of the egg were pierced will enable the little creature to penetrate the mucous coat, whose texture is most easily torn of all the organic membranes, & therefore best adapted for such penetration. Once in the vein no great difficulty is to be apprehended, as the embryo is only 3 or 4 times larger than a blood globule.

Sobernheim states that entozoa bore into the blood vessels by means of their hooks, without leaving any perceptible traces, & may be thus carried to any part of the body. Schmitz found worms in the capillaries of the yellow toad: and Valentin observed young individuals of the Anguillulae Intestinales circulating with the blood corpuscles in the foot of a frog. Gluge also found one of these Entozoa, mentioned by Valentin, within the heart of a frog. Gruby & Delafond found young entozoa in the blood of a dog. Lastly Klencke completed the investigation of this subject by the discovery of living infusorial entozoa in his own blood, as well as in that of five of his friends. He describes them as elongated, varying in shape, & measuring in length three times the diameter of a blood corpuscle.

Dr Allan Thomson informed me that he also had seen entozoa in blood drawn from a frog. My own observations on this subject have not been very satisfactory; but, in the blood drawn from the jugular vein of a mouse, I found bodies that must be regarded as entozoa; & of the forms of which I have given a sketch in Pl. VI Fig. 73.

These were from 4 to 8 times the size of a blood disc; round, Figs 73.b.d.l; oval, 73.a.c.g; or flattened, 73.f.h.k.m: with a dark spot or depression near one extremity. No motion was visible but this might have arisen from the pressure of the superimposed plate of glass, which from their relatively great size rested almost entirely on them. Some appeared to be formed of a double membrane Fig 73.g.m.

I do not bring these minute bodies forward as embryonic tænias, but merely to prove the possibility of an embryo tænia circulating with the blood. On the other hand it is just possible that they may be young tænias which have lost their hooks, & are thus carried along by the blood, ready to undergo further change should they find a fit locality.

From the observations of the various authors I have just enumerated the possibility of the passage of the embryo tænia into & of its circulation within the veins is fully established. That they do so enter & circulate is rendered probable from their being developed in the liver, through which the visceral blood passes. The cysts also are at first embedded in the liver, & only by degrees rise to the surface. In short, all the arguments urged against the likelihood of the two other ways in which the young tænia might arrive at the liver are so many negative proofs in favour of this route.

It only remains therefore to trace the transformation of the embryo into the primitive cyst of the Cysticercus Fasciolaris.

The first change is the loss of the teeth, which probably is effected while yet in the veins. It is now established that these six embryonic teeth are caducous. Dujardin first pointed out the difference in actual size between the teeth of the embryo & that of the adult; as well as the fact of the ova of the unarmed tænias containing the usual complement of six teeth. The number six seems to be universal with all the embryonic tænias, whatever the number with which they are furnished later on in their development.

Beyond this nothing is known positively; but judging from the change which the young Echinococcus, Pl. I. Fig. 9, undergoes, when it leaves its spines & suckers,

& swells up into a cyst, we may I think with propriety conclude that the embryo tænia does in like manner swell up & constitute that vesicle with its patch of granules whose development I have investigated.

Setting out therefore with the egg the metamorphoses of the Tænia Crassicollis are as follow.

1. The ovum with its three membranes, & included embryo, armed with six teeth, V. 53; leaving the digestive system of the cat, & entering still as an egg into the intestinal canal of the mouse.

2. The rupture of the egg membranes by the embryo & its consequent freedom. The embryo is now composed of a globular or ovoid body, armed with six large teeth. In this state it passes through the mucous membrane, enters a vein, & circulates with the blood.

3. When in the vein the embryo loses its teeth, swells up, & forms a vesicle with a granular spot. This becoming arrested in one of the hepatic capillaries, distends the surrounding tissues, which thus form the investing capsule or cyst.

4. The inversion of that portion of the vesicle, Pl III. Fig. 27, with the granular patch. The narrowing of the mouth of the inverted portion. III. 28. The development of cells among the granules, III 33; & the formation of the head, IV. 35. The eversion of

the head. IV. 38; & the formation of segments, by constrictions of the vesicle. II. 23. The successive development of the suckers; lateral canals; the proboscis, & the teeth, III 25; the gradual diminution & total disappearance of the caudal vesicle, IV. 40.

5. The passage of the entozoa into the intestine of the cat; the rupture of the cyst, & the second free state of the animal; its rapid increase in size; the appearance of reproductive organs, V. 45; the dendritic ovary, 51 f; dilated oviduct, V. 51 d; the seminal vesicle, & vas deferens, 51, h. g.

The development of the ovum, V. 51. 52, within the ovary, & its expulsion or escape from the body of the parent tænia.

The first stage of the Tænia Crassicollis is therefore an ovum, V. 53; within which an embryo is contained. 59. 60 f.

The second stage is analogous to the larval condition; & in this state the young tænia is armed with six teeth, adapted for boring into the blood vessels.

We have next the pupa, or third stage, when the embryo loses its spines, & locomotive powers, & becomes a simple vesicle.

The fourth stage is still a portion of the pupa condition, but that in which the development of the tæniaform body, & head takes place, & in which state it has hitherto been called Cysticercus Fasciolaris. II.14.

In the fifth stage we find the adult animal free, rapidly enlarging, making great use of its suckers & teeth, & above all perpetuating its species, by throwing off mature ova. V.45.

This then is the mode of development of a tænia, traced through all its changes; that is to say, one of the ways in which a tænia is produced. Before entering however on the other modes of development I shall say a few words on the remaining Cysticerci likewise found in the animal kingdom.

Cysticercus Fistularis, Rudolphi.

This cysticercus is found inhabiting cysts in the mesentery, omentum, & spleen of the horse. It is four or five inches long, & three or four lines thick behind. The head is small & quadrangular having four suckers only. The body itself is about half an inch in length, round, presenting the appearance of segments, increasing gradually in size, & then passing by degrees into a long, cylindrical caudal vesicle, 3 to 4½ inches long. This vesicle becomes larger at its termination in a rounded extremity, &, although it appears smooth to the naked eye, when magnified it presents very fine transverse rugæ throughout its whole length, differing in nothing from the body except in softness of texture, & its hollow form.

This creature is contained, folded up, within a thick & strong cyst. It is evidently the young of some tænia corresponding to the fourth stage, or pupa condition of the Tænia Crassicollis. To what tænia it belongs will still remain obscure; but what I wish to be remarked is the continuity, or rather absolute identity of the body & caudal vesicle, which is better seen in this than in any other cystic entozoon. The formation of the body, by the doubling up of the caudal vesicle into segments, is also very evident.

We are not to suppose however that this entozoon must inevitably belong to an unarmed tænia because no teeth have as yet been discovered; for, in my investigations with regard to the development of the Tænia Crassicollis, I have shown that at one period of its cystic condition it has no teeth at all, although the suckers & body are present. Still I do not mean to say that the Cysticercus Fistularis may not be when fully developed a tænia of the unarmed variety; but merely to guard against laying too much stress on the presence or absence of teeth.

Cysticercus Pisiformis. Zeder.

This creature is found in the peritonæal cavity & liver of the hare & rabbit. It is commonly situated on the peritonæal surface of the intestines, in the omentum, & even in the cellular tissue round the uterus. It is thus described by Rudolphi. Head globular, furnished with four suckers & a proboscis armed with a double corona of 36 teeth. The head & body are attenuated; the latter articulated, round, & of nearly the same length as the globular caudal vesicle. Blanchard however states that there is no proboscis, nor teeth; that on the contrary there is a slight central depression. But he has in all probability been misled by his desire to establish the identity of this cysticercus with the Tænia Pectinata, which is commonly found in the intestinal canal of the rabbit. The very fact of there being a central depression is sufficient to prove that there must be a proboscis which has been inverted, & this inversion would account for the supposed absence of teeth.

I should be much more inclined to believe it to be the cysticercal state of a tænia found in some animal which commonly preys upon the rabbit. Thus the Tænia tenuicollis, infesting the different species of the Mustelidæ, is characterised by a very short proboscis armed with a double row of caducous teeth, & four very large & prominent suckers. The length of the body is from ·5 to 8·5 ~~tenths~~ of an inch, &, as its name implies, is thin.

Now the body of the Cysticercus Pisiformis is from ·1/75 to ·4/15 ~~tenths~~ of an inch in length. Its neck & body are thin, & its suckers very much excavated & vasiform. The head, according to Zeder, Goetze & Rudolphi, is furnished with a proboscis & a double circle of teeth. It is highly probable then that this is another example of the vesicular stage of a tænia being passed in a different species of animal to that which it infests in the adult condition.

Cysticercus Percæ.

This is found in the liver of the common Perch. Its body is indistinctly annulated, & is, according to Rudolphi, without a caudal vesicle. Schrank however says that a vesicle does sometimes exist, of an oval form. It is very frequently found associated with the Tricuspidaria Nodulosa & the Tænia Ocellatum; all three infesting the same animal; & all sometimes found, enclosed in cysts, in the liver of the perch.

The want of distinctive characters renders it impossible at present to hazard a conjecture as to which of the Tænias this cysticercus belongs; but an attentive comparison of these entozoa with the tænias infesting the birds & fish which feed upon the perch will in all probability be successful. I mention this creature to show that other observers have noticed that in some cases the cysticerci present no caudal vesicle.

Cysticercus Salmonum. Rudolphi.

This species is found in the liver of the common trout, varying in size from the head of a pin to the size of a pea. When contracted it is 1½ inches in length; & 5 inches when stretched. It is often found two, three, & four together in the same cyst. According to Fröhlich the head is furnished with four semilunar oscula, & is unarmed. The body is roundish with crenate margins, & transverse striæ as if articulated, but which disappear on stretching. The caudal vesicle is of a middle size, round, & puckered at the margins. If really articulated, says Rudolphi, it may perhaps be placed with the T. longicollis of the Salmon.

The question naturally arises, how does

it happen that more than one entozoon is found in the same cyst if as embryos they have an individual existence, & work their way singly into the circulation. If however we admit the notion to which I have already stated my adherence, that the enveloping cyst is formed by the distended tissues of the organ in which it is found, it is easy to see how, when one of these embryo-tænias becomes fixed in a portal vein, it will detain all the other embryos that may happen to pass, till the vessel becoming thoroughly choked up there is no more circulation through it, & consequently no more tænias can arrive. From the embryos being so closely packed together any cyst that may be formed from the surrounding tissues must of necessity enclose them all.

Cysticercus Cellulosæ.

This variety is so named from its being commonly found in the cellular tissue; but it is also met with in the muscles, & even in the brain. It is very widely spread, & occurs most frequently in the pig, often in the Herbivora, & the monkey tribe, occasionally in man, & more rarely in the dog. It is identical with the Cysticercus Tenuicollis of Rudolphi, as he himself suspected at the time.

The body is about half an inch long, with a caudal vesicle of about the same diameter, often very much larger. The head is small, furnished with four suckers, & armed with a double corona of teeth. The neck is very thin, but the body attains the breadth of the tenth of an inch, as it approaches the caudal vesicle.

Fischer found 23 cysticerci of this species in the choroid plexus of a young man. He states them to have been without any cysts; but Rudolphi & Bremser agree in thinking that external cysts were present, though from their transparency they escaped notice. Another observer Steinbüch, denies that the suckers are perforated. He evidently met with a young individual, in which the suctorial orifices had not yet appeared.

Treutler also remarked 17 cysticerci in the choroid plexuses, & describes them as having only one sucker, & a single corona of six teeth. From an unwillingness to admit the presence of a second variety differing from the cysticercus cellulosae, Rudolphi surmised that those seen by Treutler could not have been fully developed.

But from my own observations on the development of the Cysticercus Fasciolaris we are enabled to decide at once as to the exact point in their growth to which they had arrived. The six teeth are those of the embryo; while in all probability the single sucker is the inflexion of the vesicle immediately preceding the formation of the head. Pl III. Fig 28. Thus the link which in the cysticercus is almost reduced to a certainty, though not absolutely seen, appears to have been long ago observed by Treutler, though he, as well as all subsequent Helminthologists, failed to discover their actual state of development.

The head of the Cysticercus Cellulosæ resembles in every respect that of the Tænia Solium of man. The two figures given by Bremser are identical if we allow for the stretching of the neck in the latter. Both have a double circle of teeth, &, although the tænia solium is sometimes found without any teeth, Bremser has fully proved that this is the result of age, & not the original condition. He also observed that, as the worms increased in age, one row of the double corona first fell off, & was after a time followed by the other leaving the worms thus unarmed. The size of the head is the same in both, as also the attenuated neck, & the gradually increasing body.

The caudal vesicle of the cysticercus cellulosa is the largest of any of the cysticerci; &

the body of the Tænia solium is likewise the longest & broadest tænia known. Are we not justified in admitting the probable identity of the two.

It may however be objected that as the Cysticercus Cellulosæ occurs in man, judging from the analogy afforded by the cysticercus of the mouse, it cannot be a cystic condition of the tænia solium because that is likewise found infesting the human species. Man however is omnivorous; hence he is liable as the herbivora to be infested with the Cyst. Cellᵃ; But as he feeds also on animals, & on the pig, all of which are infested with this cysticercus, he renders himself also liable to be infested by their more advanced condition, in other words, by the Tænia which are developed from them.

It is however a very rare occurrence for a man to be infested with a tænia solium, though almost every European is in the constant habit of using animal food. This arises in all probability from the fact, that all races of mankind cook their food by subjecting it to the influence of heat.

Entozoa however will sustain a very high temperature without being injured. Again how often is roast meat brought to table underdone? How often does a roast leg of mutton appear raw when cut into, the central portion being hardly warm.

Cellular tissue is the favorite haunt of the Cysticercus Cellulosce; & "the Popes Eye" is equally esteemed among epicures! The sheep & pig are the animals most commonly infested with this cysticercus, & are precisely those most universally consumed among civilized nations.

Again although man masticates his food it will be found on examination that fat, from its soft, yielding, & slippery nature, is often swallowed entire, & at most is very slightly masticated. I see therefore no grounds for denying the possibility of the entrance of the Cys. Cellᵃ. into the digestive canal of the human species, & its subsequent development into the Tænia Solium.

It would be out of place here & indeed perfectly useless for me to give a description of the Tænia Solium, since it is treated of at length in every work on intestinal worms. Still however I cannot pass over one or two points in which I find the most distinguished authors differing. Thus Carlisle, Bremser, & Professor Owen state that the head is furnished with a small orbicular mouth, placed at the extremity of the proboscis, & in the centre of a double corona of teeth. Rudolphi, Dujardin, & Blanchard on the other hand most distinctly deny the existence of any such central buccal orifice.

Carlisle's observations can hardly have much weight, as they were made at a time when the microscope was very imperfect. Bremser regards the suckers as mere organs of prehension, &, although he mentions the existence of two white lines running longitudinally on either side of the segments, he regards them only as white lines, & not as intestinal canals; for he says "I possess a tænia which has only one intestinal canal, placed along the middle of the articulations". Hence he is under the necessity of establishing a mouth; & this he places in the centre of the circle of teeth. The very fact however of his having only one Tænia with a single intestinal canal, admitting that such was the case, proves that all the others he met with had more than one.

Professor Owen again states that the two lateral intestinal canals unite near the head, & form one tube leading directly to the central buccal orifice. Rudolphi denies this altogether; & maintains that instead of uniting to form one, the lateral canals bifurcate to form four tubes, the white lines of Bremser, which pass directly to the four suckers. He further states, that "in the Tænia Solium a true mouth is wanting, but that in its place are four suctorial orifices". These opinions are borne out by all the more modern investigations on the Tænias; which are now found to possess without exception four suckers, & four canals originating from those suckers, soon however uniting to form two lateral intestinal canals, situated one on either side of the ribbon shaped body.

In my observations on the Tænia Crass. instead of a mouth I have indicated the presence of a hard disc in the centre of the proboscis, to afford a firm point of attachment as well as of resistance to the teeth, which are in a measure articulated round its margin. It is also impossible that a central buccal orifice would exist, because we find, that, instead of the intestinal canals uniting to form a single tube, they subdivide into four canals, each terminating in a sucker.

Tænia Pistillum

It would be unjust towards the eminent Helminthologist Dujardin to pass by his researches on the development of this tænia in the Shrew mouse Pl. VI. Fig. 67. He found the eggs as well as the young imbedded in masses of tenacious mucus between the villosities of the intestine; which prevented his observing those which had newly left the egg.

The eggs, according to him, are $\frac{1}{500}$ of an inch in diameter, Fig. 66, 68, 69, 70, containing an embryo of half that size, or $\frac{1}{1000}$ of an inch, armed with six teeth (a) The egg is composed of three envelopes, Fig 66. d. f: the inner one spherical. This membrane he observed in some instances to have been ruptured & thrown behind the embryo. Fig 69. 70 f. He could not examine the intermediate stages on account of the rapid alterations they underwent, caused by the action of the water in which they were placed for examination, but states that he saw some not more than $\frac{1}{10}$ of an inch long, which were however already furnished with a globular head, & a few narrow segments. Fig. 71. 72. The heads were provided with four suckers; a proboscis, Fig 71. 72 a & b, & a circle of 16 to 20 teeth. Fig 71. 72. c.

Dujardin then gives it as his opinion that the embryo found in the egg, forms only the head of the young tænia, & that segments are developed afterwards.

From the metamorphoses of the Tænia Crassicollis I am led to believe that the change, which Dujardin imagined to arise from the action of water, was simply the vesicular stage of the Tænia Pistillum. This would account for his inability to discover any thing like the adult form of this tænia, with the embryo condition of which he was acquainted.

If this inference be correct we must admit that some of the Tænia undergo all their changes within the digestive system of the animal, in which they are found in the adult condition.

This is a most important point, & one on which I am inclined to lay much stress; namely, that, while some of the tænias pass their vesicular condition in the bodies of other animals, others do so within the intestinal canal of the same animal. In this way we can explain the occurrence of adult tænias in the herbivora, which could not have existed if all tænias had to pass their vesicular condition in ~~to~~ another animal to that which they infest when fully developed.

General Remarks.

There exist some difference of opinion as to the mode in which the segments are developed. Thus Andry believed that new segments were formed by the subdivision of the old segments; but this change, if it exists at all, must be progressive, & it has never been seen. The experiment he adduces in confirmation of his view has been confuted by Rudolphi & Bremser.

Brera maintains that renewal takes place at the caudal extremity by the formation of a bud or germ on one of the margins at the point of union between two segments; that this bud increases, pushes aside & separates by degrees the adjacent segments; &, not only takes its place, but also its form & position. This opinion also is purely hypothetical, & contrary to observation.

Lastly Rudolphi & Bremser maintain that new segments are constantly produced by the head; that as the neck increases under the influence of the head its posterior extremity subdivides to form new segments. In this way we can explain the gradually increasing development of the reproductive organs, the further the segments are removed from the head.

The analogy likewise which Professor Owen & others endeavour to draw between the Tænias & the Trematoda, considering the former as a compound Distoma, falls to the ground: the facts upon which their conclusions were based having been proved erroneous. For the Distoma has a single intestine, originating in a central buccal orifice, & dividing afterwards into two lateral canals. The Tænia has four intestinal canals, originating in four peripheral mouths, & uniting to form two longitudinal tubes.

The four suckers, or oscula, as Rudolphi called them, are not as usually supposed mere organs of prehension, but the true mouths of the tænia; those by which food is imbibed & nutrition effected. The following is their mode of acting, according to my own observations made on the Tænia Crassicollis.

Within each sucker, or osculum, is a cup shaped cavity; opening externally, that is on the exterior of the animal, by a round or oval orifice when expanded, Pl. IV. Fig 44. h; & presenting a mere slit when the sucker is contracted, 44. b. This contraction & dilatation may either be a property inherent in the transparent substance forming the osculum, or dependent upon the extent of their inclusion within, or protrusion from the head of the tænia. This last I think the most probable, that the mouth of each sucker will be closed when that sucker is drawn into the head by the action of the circular fibres, Fig 44. b; & that this constitutes the narrow slit so often remarked: while when protruded by the action of the longitudinal muscles or the retraction of the proboscis, the orifices of the oscula will expand, & assume the circular form.

Internally the cavity of each osculum is in direct communication with one of the tubes which are seen in the neck, Fig 44. d, & which are more or less contracted previously to opening into the sucker. Fig 44. f. I have already fully described how the tubes from the four oscula, Pl III Fig 25. c, are continued along the neck of the taenia, at first in two pairs, 25. b, but, by the union of the contiguous tubes, the two lateral longitudinal canals are formed. V. 51. a. As long as the four tubes remain separate there are no transverse communications; but when the unions take place, & segments begin to appear, transverse tubes are also formed, along the posterior margin of each joint V. 51. b.

Now when the creature is feeding all the suckers except one appear to be closed, that is to say, are so contracted as to preclude the entrance of fluid; as in IV. 44; which was taken from a living specimen. That sucker which remains open is applied against the coats of the intestine, & is retained in one spot by the teeth.

A peristaltic contraction then takes place, commencing at the head, & passing gradually along the body. V. 47. By this contraction the fluid contained in the four tubes, & in the two longitudinal canals is forced towards the tail, Fig 47.c; but the elastic cellular tissue which surrounds the canals, Pl II. Fig 21.22, causes them to expand again immediately after the annular contraction of the body has passed.

The dilatation of the canals must naturally cause a vacuum, to fill which the fluid rushes in at the open osculum, that being the only available entrance; for the contraction of the body as it passes forces the fluid it & thus prevents all regurgitation. Any fluid contained in the longitudinal canals, & which is not taken up or assimilated by the segments in its passage, is probably forced out thro' the torn extremity visible in all adult tænias.

I am led to believe that the Tænia Crass. does not imbibe the chyme existing in the intestine of the cat; but that one or more of the intestinal villi are drawn into the cavity of the dilated osculum,

& being ruptured by the motion, a direct drain is thus established on the lacteals. The taenia hereby obtains a continuous supply of nutrient fluid, already elaborated by the digestive apparatus of the animal which it infests.

The reasons for this supposition are that we never find the oscula full of the thick & dark coloured fluid, loaded with the debris of animal tissues, which fills the small intestines during digestion. Yet it is then that the taenias feed, because it is then only that they are seen to be plump & turgid & active. When the animal has been fasting they are on the contrary, flaccid, & elongated, & contract feebly on irritation.

The distribution of the nervous system also is in favour of this view of the action of the oscula; for, according to Blanchard's observations, there is a separate ganglion situated immediately behind each; communicating by filaments with the central pair of ganglia; & this again giving rise to two long slender nerves which pass down the whole length of the body, contiguous to & parallel with the lateral canals.

Each osculum having a separate ganglion can act separately. Again, when one sucker is in position, by the influence of the central pair of ganglia the others are retracted & closed, & the wavy contraction of the body regularly enforced by means of the long nervous filaments.

The fluid contained in the lateral canals of the Tænia Crassicollis is transparent & slightly milky; but homogeneous, & never containing any undigested particles or biliary matters, such as are always to be seen filling the intestinal canal of the Ascaris which infests the same animal.

With regard to the male organs of the Tænia very little has been made out; consisting, as seen & described by all authors, of a seminal vesicle, Pl. V. Fig. 51. h, which however is seldom distinct, & a vas deferens, Fig 51. g, opening into the dilated portion of the oviduct, near the margin of the segment, Fig. 51. c. This is very well seen in the Tænia Elliptica, Pl. VI. Figs. 74. 75, another variety likewise found in the cat; but which has two genital pores on the opposite margins of the same segment, Fig. 77. a.

There is no distinct ovary. The ova are formed in masses, several together, Fig. 77. g, appearing at first entirely granular Pl. VII. Fig 78. Then the external envelope becomes transparent from the disappearance of the granules, 79.a, & the ova are distinctly seen, each composed of two membranes, Figs 79.80.a.b; within which is the embryo with its six teeth. Figs 79.80.81.c.

When these egg masses are visible, Pl VI. 77.g, the seminal tube is long & narrow, 77.c, presenting a dilatation of its upper extremity, 77.d; the exact confines of which can never be clearly determined.

On examining some of the segments however in which the egg masses had not as yet appeared, Pl VI. 74.a. 76, I found a large, well defined, round body, of a yellowish hue, 76.f, crenated on the margins, & communicating by a tube, 76c, with the oviduct, which even at this early period was fully developed. 76.b. This body, apparently the testicle, is formed before the ovula are visible, & disappears entirely, except a small portion of its investing membrane, 77.d, after fecundation has been effected, & the ova developed. The so called seminal vesicle has often attracted attention; but I am not aware of any previous mention of a distinct testicle.

When a segment of a taenia becomes detached it constitutes, according to Dujardin, a Proglottis; according to Professor Owen, a Trematoda: thus maintaining the Tænia to be an imperfect animal, from which other perfect beings are detached.

I have already shown the want of analogy between the Tænias & the Trematoda; it remains for me to prove that the Proglottis is not an animal at all.

In the first place it has no mouth; as is seen by reference to the drawing of a Proglottis of the Tænia Elliptica, Pl. VII. 82. Both extremities of this oval body are exactly alike; each presenting two round depressions, Fig 82. a, with a groove between, 82. b; the whole surrounded by the puckered integument. The round depressions are the torn lateral canals; & the groove is one half of the transverse tube, for that being the weakest part separation of the segments takes place there only.

They are never met with in the intestinal canal higher than the tænias from which they are derived; but on the other hand are commonly seen in the fæces, being ejected through the deficiency of organs by which to maintain their position.

The only motion these supposititious Proglotti are capable of is caused by a wavy contraction, which commences at one end, & passes to the other. But this is not a voluntary motion. It is merely a portion of that irritability which remains in a member after separation from the trunk. Yet it is on this contractility & consequent motion that the chief argument rests for the existence of the Proglottis.

Many of these detached segments, especially those found in the colon & lower portion of the small intestines, have not this power, but have lost all contractility, & have therefore ended their existence; yet the ova within them have undergone no change, nor has the segment itself become altered.

The segments therefore only become detached when the ova are mature. Though still possessing some measure of contractile irritability, they do not possess an individual life; for they are incapable of voluntary motion; incapable of taking in food from the absence of a mouth; unable to retain their position in the intestinal canal; & they soon lose the small amount of contractility they possess. They become inanimate masses, although they have not undergone any change in form, organisation, or development; which would have been the case had each segment been a separate animal. Hence the Proglottis is not an animal: only a part of one.

With this I must conclude my remarks on this Genus; trusting that my investigations have in some measure cleared up the gloom, which has hitherto enveloped the closely allied forms of the Cysticercus & the Tænia.

The remaining Cestoidea have been classed under two heads, or genera; The Bothriocephalus, & The Rhynchobothrius; on each of which I shall have to be very concise from the presence of more important subjects.

II Genus Bothriocephalus.

This Genus, according to Dujardin, is characterised by an elongated body, composed of numerous segments; an oblong head, square or flattened on the sides, & furnished with two narrow elongated bothria, or four ear like projections, or four suckers armed with teeth. The genital pores are situated in the middle of each segment. These are the characteristics of the adult forms of the Bothriocephalus: let us endeavour to trace the changes they undergo previous to the perfect condition.

An Entozoon has been detached, by Creplin & Dujardin, from the present genus, under the name of Schistocephalus Dimorphus; so named from the head being cleft at the extremity, & being without the lateral bothria. But Rudolphi, Abilgaard & others have called this entozoon a Bothriocephalus; because it has the two characteristic bothria, but, from their being placed very much in front, they appear to divide the head into two lobes. This fully accounts for the cleft head, & the absence of other depressions lower down.

This creature, the Bothriocephalus Nodosus of Abilgaard, is met with in the intestinal canals of the Gasterosteus Class of Fishes. It is composed of a head, as already described; & an elongated body, divided into obscure segments, in the centres of which is the solitary & characteristic generative pore. But while this Bothriocephalus remains in the fish no development of ova takes place; & hence it is an imperfect animal.

The Second locality in which the

B. Nodosus has been met with is in the intestines of the Aquatic rapacious Birds that feed on fish; such as the Divers, Guillemot, Heron, Grebe, Penguin & Tern. In these this entozoon is found in a state of perfection, for the segments are now filled with ova.

Abilgaard made a direct experiment by feeding two ducks for some time on the fish which most commonly contain this species; & on dissection found in one 63 individuals arrived at their full development.

It is further easy to see how the ova of the Bothriocephalus, expelled with the fæces of the aquatic birds, find their way into the bodies of other fish. But the B. Nodosus, or Sch. Dimorphus forms, according to Dujardin, the passage or connecting link between the Ligula & the Bothriocephala; & as we have found this to be a true Bothriocephalus, may not the Ligula be so also.

The Ligulæ are worms having the appearance of long white bands, without distinct articulations, with a very rudimentary head, & without reproductive organs. Such is the condition in which we find them in fishes, Cyprini, & called, by Rudolphi, Ligula Simplicissima. They are not found in the intestinal canal, but external to it in the peritoneal cavity. Creplin however has proved their identity with the Ligulæ found in the intestinal canals of the fish-eating birds.

In the Ligulæ of birds the head becomes more distinct. At first, according to Dujardin, it presents a slit resembling the head of the Schistocephalus; but as it becomes more developed the cephalic extremity becomes pointed & the two bothria are distinctly seen. In this condition the body presents a series of segments, containing a single or double row of ovaries with central generative pores; & hence it is to all intents a Bothriocephalus.

In the livers of certain fish, Gadidæ, cysts are found about the size of peas; each containing a long flattened entozoon, without segments; having a head without visible organs; in short, a Ligula; but Rudolphi calls it Cysticercus Gadi Lotæ, because the posterior extremity terminates in a caudal vesicle.

Another kind, called Cysticercus Salvelini, is found enclosed in cysts in the liver of the Salmo Salvelini. The head is furnished with two suckers, which Schrank declares to be in reality pits, or bothria, situated on the margins. The body is flat & smooth; but found when magnified to be composed of segments, & terminating in a caudal vesicle.

In fact the first condition of a Bothriocephalus appears to be a Cysticercus, inclosed in a capsule; which, according to Rudolphi, is sometimes ruptured, & the creature then exists free within the peritoneal cavity, in the form of a Ligula.

A transfer from one animal to another then takes place, & the Ligula is next met with within the intestinal canal, in which it sometimes arrives at maturity, but in other cases remains dormant.

Another transfer occurs, & the Ligula or Schistocephalus finds itself in the position best adapted for its perfect development. The characteristic bothria, & the central generative pores now become distinct; segments appear & ova are matured; the whole constituting a true Bothriocephalus.

This creature is peculiar to fish, & to those birds & animals which live on fish. Hence we must conclude that the species infesting man passes the first period of its development within the body of a fish embosomed in the ocean. In accordance with this supposition we find the Bothriocephalus Latus confined almost exclusively to Russia & some parts of Switzerland, where fish forms a large proportion of the food of the inhabitants. In Russia fish are preserved by packing in ice & are not salted; they are also said to be eaten raw in some parts of that empire. In this country the attention paid to the removal of the viscera, & the thorough cooking, renders the people much less liable to this the most dreaded of all the human entozoa.

III Genus Rhyncobothrius.

These are Cestoidea whose heads are furnished with two or more generally four retractile trunks armed with hooks. This genus has been lately investigated, & the whole development beautifully traced by an eminent Danish Helminthologist, Van Beneden: to a concise account of whose researches I am compelled to restrict myself.

The first state in which Van Beneden has observed the Rhyncobothrius is in the form hitherto called Scolex, inhabiting the pyloric cœca of fishes. It is a free entozoon, at first more or less vesicular, & afterwards becoming filiform. The head is furnished with four suckers & a trunk. The whole worm is extraordinarily contractile; & has two dark spots on the head, supposed by him to be eyes.

The Scolex after a time throws off from its surface a thick mucus; which, in concreting, forms a tenacious envelope composed of concentric layers. Within this envelope the Scolex, now become contracted, has some resemblance to a Distoma, & contains within itself another entozoon, a Tetrarhynchus. The Scolex therefore, according to Van Beneden, is a nurse; within which a Tetrarynchus is produced by gemmation.

The genus Anthocephalus of Rudolphi & Dujardin is in reality only this condition of the Scolex, or rather of the Rhynchobothrius; & is met with attached to the peritoneum of several varieties of fish.

The next, or third state, is that in which we find it free; inhabiting the intestinal canals, or embedded in the tissues, of the Sharks, Raies, & Skates, & passing by the names of Tetrarhynchus, & Gymnorhynchus. It is an elongated worm; having a head furnished with four retractile trunks, armed with spines, & elliptical bothria. The body however is cylindrical, with scarcely any trace of segments, & no appearance of reproductive organs.

The transverse lines begin next to appear across the body of the Tetrarhynchus, by which it is divided into segments; & thus the tæniaform entozoon is produced called a Rhynchobothrius. Reproductive organs are then developed, & ova for the first time produced; showing this to be the last or adult condition.

Van Beneden however is of opinion that the segments by separation constitute a species of Distoma, analogous to the Proglottis of Dujardin. But the Proglottis has been already proved not to be an animal; hence we cannot admit that the analogous segments of the Rhynchobothrius are transformed into Flukes to constitute the fourth condition of Van Beneden.

He states also that the ova of the Rhynchobothrius pass out with the excretions, & are swallowed by the smaller varieties of fish; in the intestinal canals of which they assume the form of Scolex. On arriving at perfection the Scolex pierces the walls of the intestine, & lodges itself beneath the peritoneum, where it secretes its mucous envelope, & becomes an

Anthocephalus; within which again a Tetra-
-rhynchus is developed by gemmation.

The Order Cestoidea may therefore be reduced to three Genera; of which all the other Genera are mere degrees in development.

Genus I. Taenia. comprising

Cysticercus	Rud.
Taenia	Rud.

Genus II Bothriocephalus.

Cysticercus	Rud.
Ligula	Bloch.
Schistocephalus	Creplin.
Bothriocephalus.	Rud.

Genus III Rhynchobothrius.

Scolex	Müller
Anthocephalus	Rud.
Tetrarhyncus	Rud.
Gymnorhynchus	Rud.
Rhynchobothrius.	Dujardin.

XIII. Order Acanthocephala

Genus Echinorhyncus. Müller

These are entozoa of flaccid, vesicular, or elongated bodies; with a retractile trunk, cylindrical, clavate, or globular in shape & armed with numerous minute spines. The sexes are separate, that is to say, in different individuals.

According to Steenstrup the Echinorhynchi appear to breed or are incubated between the skin & the viscera of the animals they infest. It is uncertain, he says, whether they spend part of their life externally to the organism which as full grown entozoa they inhabit; but it is very probable that they do so, since the embryo attain no real development in the ova so long as these remain in the Echinorhyncus. Though met with in the excrements by thousands they are still in the same condition; so that the development of the young within the ova, & their escape from thence, must occur long after the eggs have reached the water.

He found however in the mesentery & cellular tissue, surrounding the liver &

intestine of the Sole in the spring of the year, small bodies consisting of a thick membranous cyst, within which was enclosed a small much contracted Echinorhynchus. When extruded, by the rupture of the enveloping cyst, they measured from $\frac{1}{10}$ to $\frac{1}{20}$ of an inch in length. Their prehensile organ, with its hooks, was deeply retracted within the animal, & which after some time was protruded in the form of the armed proboscis characteristic of this order.

Eschricht's observations are also highly interesting. He found during the summer months in the flesh of the Copenhagen Haddocks numerous Echinorhynchi, which he could only regard as young ones, in the act of passing through the skin & flesh to the intestinal canal; in which situation alone they are met with in the adult state.

Siebold, probably examining only the intestinal canal, never met with individuals so young that the so-called "loose ovaries" were not developed within them; nor ever found any which he could call even small.

Putting these facts together Steenstrup came to the conclusion that the cystic state corresponds to the pupa condition; &, pursuant to his favorite idea, concludes that the "loose ovaries" are perfect individuals; whose entire existence is passed within the parent Echinorhynchus, which he in consequence looks upon as a nurse.

The young Echinorhynchi seen by Eschricht traversing the flesh of the haddock may either be a previous state to the cystic, described by Steenstrup, or, what I am inclined to think more likely, a later stage: for the observations of Steenstrup were made in the months of February, March, & April; whilst those of Eschricht were conducted through the summer; &, in all probability, had Steenstrup examined the muscular tissue he would have found similar cysts embedded in its substance.

The idea that the loose ovaries are adult individuals, whose life is to be passed within the body of the nurse, is very problematical. I may say that it is at variance with fact: for, admitting Steenstrup's theory to be the true one, we find the sexes developed only among the nurses; they are not even united in the same nurse, but exist in distinct & separate individuals.

If therefore we regard any as nurses it must be the ovaries. These however merely throw off fertile ova under the influence of fecundation in the parent. But viewed in this light all ovaries must be accounted nurses, whether loose or otherwise; the mere fact of their being loose not destroying the possibility of their being ovaries.

Hence all that we at present know with regard to the development of the Acanthocephala is that at first they occur as ova. Secondly, they are met with as young Echinorhynchi, either enclosed within cysts, or in a state of freedom; but without reproductive organs. Thirdly, the adult form, or that in which the Echinorhynchus has reproductive organs of a high order. The ova are expelled with the fæces. The young are situated either in folds of the peritonæum, or are embedded in the tissues. Lastly, the adult form is found within the intestinal canal of the infected being.

IV Order Trematoda.

The Trematoda, or Flukes, have been the subjects of much research. Many have investigated their nature; & well have their labours been rewarded.

To Steenstrup is due the merit of having first drawn the attention of naturalists to the metamorphoses through which the animals forming this Order pass before arriving at their full degree of development. These consist of the successive evolution of a series of "Nurses", or "Germ Sacs"; from the last of which germs are thrown off, to pass through the pupa state previous to their final acquirement of the perfect form. I shall however confine myself to the changes he describes as occurring in the Monostomum Mutabile, & the Cercaria Echinata.

The Monostomum Mutabile infests the cranial cavities of certain water birds; & the embryo is frequently hatched just as the ova are expelled. The newly hatched young are oval in form, furnished at the anterior extremity with short retractile lobes, while the rest of the body is covered with vibratile cilia, by which it moves through the water. On the anterior part of the body are two eyes; while the posterior two thirds of it are slightly transparent.

The contained being after vigorous efforts ruptures the body of its parent, & presents itself as an animal of an entirely different appearance. The young of the Monostomum resemble very closely the embryos of another Distoma, the Cercaria Echinata, found in several species of fresh water snails; & which have been called by Steenstrup "Parent Nurses", from their producing other Nurses like themselves.

The "parent nurse" of the Cercaria Echinata is formed of an elongated body; a head, furnished with a muscular oval cavity, central mouth, & a collar; at the root of the tail are two pointed projections. The bodies of these parent nurses are filled with a progeny much resembling themselves in outward appearance; & originating from spherical germs.

These germs elongate, & by degrees assume nearly the form of the parent nurse, though not quite so long. They are the "Nurses" of Steenstrup, & are found adhering to the walls of the cavity containing the viscera of the snail. The body of the Nurse is cylindrical, furnished with a spherical head containing a muscular oval cavity, & a small circular mouth. Below the head is a sort of collar, while at the posterior extremity are three projections, the central one being longer than the other two & constituting the tail. The œsophagus opens into a small stomach situated below the collar, while the whole of the rest of the body is filled with Cercariæ in all stages of development.

These at first present the appearance of spherical germs. They then elongate at one end, the head remaining globular, while the other becomes attenuated to form the tail. The body assumes an oval form with its two suckers; & last of all appears the collar. As the tail increases in development the more lively are the motions of the embryo within; till at length they pass out of the body of the nurse by two apertures placed behind the collar.

The body of the Cercaria itself is more or less elongated, with an oral aperture at one end, surrounded by a suctorial disc; beyond which are two concentric circles of minute spines, separated from the trunk by a fleshy collar. A little behind the middle of the body, is the abdominal sucker, & there is a tail of about the same length.

The Cercaria now swims about freely in the water, or attaches itself by means of its abdominal sucker to the surface of a fresh water snail. The little animal then by means of its spines inserts itself into the integument, & after strenuous efforts throws off the tail.

As soon as this has been effected

the Cercaria, by turning itself round on the same spot, forms for itself a circular cavity within the mucus, which by gradually hardening over it forms a tough but transparent case. Here the Cercaria undergoes its pupa state, in which it appears to remain till the following spring.

They then leave their cases, having the same form, provided still with the suckers, spines, & collar, by means of which they penetrate by degrees through the integument into the deeper organs of the snail. On entering the liver they lose their spines; the collar disappears, & the suckers diminish much in size. The entozoon becomes sluggish in its movements, & constitutes a perfect Distoma or Fluke.

Thus, admitting the analogy between the Monostoma Mutabile & the Cercaria Echinata to be correct, & commencing at the ovum, we have Eight different forms necessarily assumed by the Distoma.

First, The Ovum.
Second, The Ciliated Embryo.
Third, The Parent Nurse.
Fourth, The Nurse.
Fifth, The Cercaria.

Sixth, The Pupa.
Seventh, The Imperfect or Armed Fluke.
Eighth, The Perfect Distoma.

One fact in connexion with these remarkable changes is the multiplication which takes place in the third & fourth stages. At a moderate computation each Parent Nurse produces ten Nurses; & each Nurse again gives birth to ten Cercaria, each of which is transformed into a Fluke. Thus One hundred Distomata are developed from a single ovum.

V Order Acanthotheca.

Genus. Pentastoma, or Linguatula.

The genus which forms this Order is composed of round annulated worms; with a straight intestinal canal; a mouth nearly terminal, & placed on the ventral surface, accompanied by two pairs of single or double hooks, which are retractile each into a distinct cavity. When the hooks are retracted there appear to be five rounded orifices. Hence the name Pentastoma, which however ought to be rejected as based on an illusion. The nervous system approaches closely to that of an insect. The sexes are separate; & the body is made up of rings.

They occur in the frontal sinuses & the lungs; they are also met with enclosed in cysts on the surface of the peritoneum, liver, mesentery, & abdominal viscera.

Van Beneden says the Linguatulæ are not entozoa, but most allied to the Lerneidæ. He describes the embryo as found within the egg before it is expelled from the oviduct. When hatched it is oval, round in front, flat below, & terminating behind in two points. On the ventral flat surface is placed the mouth, likewise two pairs of feet, each composed of three articles. The first is basilary, & is articulated to the body; the second joins & moves upon the first, supporting in its turn the third portion, which consists of a solid bifurcating hook.

This appears to be all that is known of the development of the Linguatulæ; at first an ovum; then a four footed embryo; thirdly an encysted pupa; & lastly, a free entozoon, armed with four retractile hooks.

VI Order Nematoidea

This order contains all the round worms which have a terminal mouth, a straight intestine, the body covered by a resisting cuticle, ending in a pointed tail with an almost terminal anus, & the sexes in separate individuals.

Some idea of the extent of this Order may be formed from the fact that Dujardin has divided it into 52 Genera; of which 43 are well established, & 9 doubtful. I must however confine myself to the description of a single Species of the Genus Ascaris: a genus of peculiar interest to the Physician; being one of the very few kinds of entozoa commonly met with in man. It is also that with which the valuable researches of a number of distinguished authors have made us better acquainted than perhaps any other.

Genus 19 Ascaris Dujardin

Species Ascaris Mystax. Zeder.

The Ascaris Mystax is found in the intestinal canal of the domestic Cat.

So common is it that out of about 25 examined for the purpose I have not failed to find them in more than 3 or 4 cases. The part preferred by them is apparently the duodenum, between the pylorus & the point where the bile-duct enters. When the cat has fasted for some hours the Ascarides pass the pylorus into the stomach, perhaps in search of food. But this is never the case during digestion. On the contrary they then appear to be swept farther down the intestine than usual.

The male Ascaris Mystax is about an inch & a quarter in length, Pl VII Fig 83: whilst the female is from 2 to 3 inches, occasionally even 4 inches long; Fig 84. The males are easily distinguishable by their size, & the peculiar curve of their tails, 83.a; which are coiled round on the ventral surface. The tails of the females increase slightly in thickness to within a short distance from their termination, & are perfectly straight, without any curvature of the point. 84.a.

This creature derives its specific name from two lateral projections on either side of the head resembling moustaches, VII. 85.a. These projections are flat, transparent & striated;

being covered by the horny cuticle which envelopes the whole body. In front is the mouth with its three lobes, 85.b; opening directly into the intestinal canal; 85.c. The entire body is covered with cartilagenous rings, placed side by side & exactly of the same breadth; the whole forming one continuous cuticular envelope, appearing to be regularly striated when viewed externally; 85.d.

The posterior extremity of the female becomes suddenly narrowed to a blunt point, 84.a. A short distance from this is the anus, a round aperture. The tail of the male, as I have said before, is abruptly curved on itself, so that its dorsum is convex, 86.a, & its ventral aspect concave, 86.b. Near the conical apex & on the ventral surface in front of the anus, 86, 87.c, is the genital orifice, 86, 87.d. On either side of the concave surface in the male is a projecting ridge, 86.f; consisting of a number of conical tubercles placed in a row, & supporting a horny membrane stretching between them. This membrane is finely serrated, the teeth looking towards the tail, & no doubt serve an important part in giving it a secure hold while clasping the body of the female.

The intestinal canal, 85.c, 87.i, is a

straight tube, passing from the mouth to the anus, situate in the axis of the body, & surrounded by loose cellular tissue. It usually contains undigested particles, & portions of intestinal villi.

I pass now to the consideration of the reproductive organs, & commence with the generative apparatus of the male as being most simple. By squeezing the tail carefully between plates of glass two spiculæ, Pl. VII. 86, 87, g, are forced out of the genital orifice already mentioned. These spiculæ are slightly curved, the curvature looking towards the body; & in the ordinary state of the parts are entirely retracted within the trunk. They are placed one before the other, & are about $\frac{1}{20}$ of an inch in length, & $\frac{1}{1600}$ in breadth. Their consistence is horny & their structure tubular, 89. a, b. That part which always remains within the body 87. f, 89. c, is furnished with tooth like projections for the attachments of muscular fibres; 89. d.

Of the way in which copulation takes place I can speak with certainty; having in my possession a specimen in which the tail of the male, 88. a, is wound round so as to embrace that portion of the trunk of the female where the orifice of the vagina is situated, 88 b, by which means the spiculæ are directed into its cavity.

The internal organs of generation in the male consist of a single tube, variously dilated & contracted, but without any branching, Pl. IX. 118. This tube is placed between the integument & the intestinal canal; & originates in a very fine cœcal extremity; 118. a. As it gradually enlarges it becomes much contorted, doubled backwards & forwards, surrounding the intestinal canal, & occupying the lower half of the body. 118. b.

Commencing at the narrow extremity is a very long tubular portion, 118. b, c; answering to the testicle. Joined to this is the seminal vesicle, 118 d; which is dilated & several times the diameter of the testicular tube. Lastly, the seminal vesicle contracts slightly, 118 f, & forms the mouth of the spicules, within which in the ordinary state they are contained, VII. 87. h. The membrane forming the cœcal extremity, VIII. 90. a, is very thick; but it soon becomes thin, so that the upper portion of the testicle is perfectly transparent, & at the same time homogeneous. 90, 91. b.

On examining the membranous wall of the generative tube lower down, Fig 92, it is found to present longitudinal striæ, & a finely granular structure. A little above the seminal vesicle, IX. 118. c, the tube becomes muscular, presenting transverse rugæ, VIII. 93, intended no doubt to force forward the contents. The vesicle itself, IX. 118. d, is covered by reticulations of long muscular fibrillæ; giving it the appearance of being enclosed in a net. The contraction of these fibres must be attended with considerable power of propulsion. The spiculæ are provided with special muscles for protrusion & retraction; but I pass to the more important investigation of the mode in which the seminal particles are developed.

I have already described the cœcal extremity as composed of a very thick membrane, VIII. 90. a; but this membrane, although perfectly well defined on the exterior, is not so within. Externally homogeneous, it becomes more & more granular till the inner surface appears almost entirely composed of very minute granules. This is the true secreting organ, for the granules 90 c, 94 a, when thrown off, begin immediately to enlarge & form nucleated cells, 90 d, 94 b.

The homogeneous portion of the testicle is filled with little else than these cells of various sizes, floating in a transparent fluid, 90 d; but as it gradually becomes striated, the cells are obscured by an immense number of minute opake granules, 91. a. The nucleated cells & granules are at first intermixed without any order, 94. a. b; but after a time the granules group themselves round the cells, forming envelopes for each individually, 95. a. b.

On rupturing the testicular tube about the middle of its length, 92, these granular masses are protruded, 95; irregular in form. Within them the nucleated spermatic cell may be distinctly seen, 95 b. They are however so delicate that the slightest pressure destroys them altogether. 95. c.

Passing as far down as the muscular portion of the testicle, 93, we find the masses much smaller in size, as well as more regular in shape, 96. a. The granular envelope is globular, with a well defined margin; & perfectly opake, so as to render invisible the included cell, except on applying a gentle pressure. 96. b. c.

This, 96. a, is the utmost development the semen undergoes as long as it remains in the male organs. A spermatic cell may indeed sometimes be seen which has escaped from its granular envelope, & increased to twice or three times its former diameter; but this is very rare. 96.d. The granular envelope appears to perform the important function of preventing the enlargement of the spermatic cells, 96.c; the occurrence of which would prevent their passage through the spiculæ, whose calibre is capable of admitting only a single granular mass at a time.

Although the further changes, which the spermatic cells undergo, take place within the female, & consequently are unconnected with the generative apparatus of the male, I shall, to avoid confusion, treat of them here.

On examining the uterine contents of a freshly impregnated Ascaris Mystax a granular fluid is observed in which a number of nucleated cells are floating, Fig 97. 98; but I have never observed the granular masses already described in the male. The disappearance then of the granular envelope is the first visible change in the constitution of the semen, & can be accounted for in many ways.

The loose granules are the debris of the cell cases; while the nucleated cells, 97. 98, are simply the spermatic cells, 96.c, much enlarged.

By this enlargement a most beautifully trans=parent spherical cell, 97.98.a, is produced, $\frac{1}{900}$ of an inch in diameter, enclosing, or rather having attached to its inner side, a round discoidal nucleus, 97.b; within this again there is a nucleolus, 97.c, & sometimes two.

Before I describe however the transformation of these nuclei into spermatic particles it will be useful to examine cursorily the statements of others on the subject. Wagner & Leuckardt in their article on Semen in Todd's Cyclopedia, speaking of the Ascaris Acuminata, say, "the nucleus has at first a roundish shape Pl IX. Fig. 119 a; but gradually stretches itself more & more, & projects more or less outwards with its point, 120.121.122.a; thus metamorphosing itself into the peduncle-like appendix of the sper=matozoon; the body of which is formed from the persisting membrane of the seminal cell. 119 to 122.b.

Kolliker states that these cells are formed, four at a time, 123 a, within other larger cells, 123 b; & that the elongated nuclei, of Siebold & Wagner, are mere bundles of undeveloped spermatozoa, whose form he supposes, but has never seen, to be capillary.

Reichert, in his researches on the development of the Spermatozoa of the Ascaris Acuminata, indicates a spermatic cell containing a nucleus & nucleolus. The cell increases in size as does the nucleolus; but the nucleus becomes less definite, & retains its former size, 124. This, according to him, is the fully formed spermatozoon, consisting of a spherical cell, 124.a; a nucleolus, 124 c; & indistinct nucleus, 124 b.

This is the substance of what has been done with regard to the investigation of the development of the Spermatic particles in the Ascaris Acuminata. I now proceed to state my observations as to their formation in the Ascaris Mystax; the phenomena of which will be found to differ materially from those just described.

I have previously said that in the more developed condition of the spermatic cells these bodies present the form of a transparent vesicle, Pl. VIII Fig. 97. 98 a, free from its granular envelope, & containing a nucleus & nucleolus, 97. 98. b & c. The nucleus appears discoidal when seen from above, 97 b; but lenticular when viewed in profile, 98 b; apparently enclosed between two portions of the membranous cell wall, 98 a.d.

The internal margin of the nucleus, 98.d, soon loses its clear & defined outline, 99. The granular mass constituting the nucleus undergoes a marked increase in volume, projecting more or less in a conical form towards the centre of the cell. 99 to 102.105. A membrane is then produced over the whole of that part of the nucleus which is in contact with the wall of the spermatic cell, 99.100.102f. This membrane is very distinctly seen to separate the granular matter of the nucleus from the external cell, with which it is in accurate contact. The margin is not in apposition with the cell wall, but has a tendency to surround & enclose the nucleus; giving the membrane the form of a watch glass whose convexity is in contact with the spermatic cell, while its concavity is filled with the granules of the nucleus from which it was formed.

The watch glass form however is soon lost. The membrance, acquiring a tendency to become more convex at its centre, assumes first the appearance of a cup filled to overflowing, 102, 103.105; then that of a rounded cone, whose margin is everted to enclose the granular substance, 103. 104. 108. 109; but occasionally the nuclear matter surrounds & hides it from view. 110.

When this convexity takes place exactly in the middle the external cell wall is projected in the form of a papilla, 101 to 104; but this is probably only an accidental occurrence, & not the general rule. Although at variance with the statements of Wagner I speak with the more confidence as Dr Allen Thomson, with whom I had an opportunity of examining these changes most fully coincides in the view I have here taken.

A slight projection of the external cell wall is common indeed at one period; but in no instance have I observed a greater amount of protrusion than that figured in 104. The elongation of the nucleus into a tail to the spermatic cell must be regarded as doubtful in Ascaris Acuminata as it is certainly not the case in the A— Mystax. How then are the spermatic particles formed?

I have described the tendency of the nuclear membrane to become more & more convex. As this convexity increases the apex impinges more or less obliquely against the cell wall, 105. 109. 110, protruding it slightly, at the same time that it is itself diverted from the straight course to form a curve. 106. 107. By this time the granular portion of the nucleus has become much diminished in volume, still presenting however the nucleolus; while the nuclear membrane has passed from the conical to a cylindrical shape, 106. 107. During these changes in form the nuclear membrane also increases in thickness; & presents a double outline. 106 to 110.

The now cylindrical membrane being prevented from passing directly outwards is curved along the concavity of the spermatic cell. By further contraction in its transverse diameter, & elongation in the other, it assumes the appearance of a bent tube, forming often the quarter of a circle. 111 to 114.

From the period at which a double outline is first visible the granules begin to disappear; till at last the nucleus becomes entirely transformed into an elongated cæcal tube with very thick sides; its interior occupied by a dark homogeneous substance. At its mouth is found the nucleolus & a few granules that have not yet disappeared. The whole is enclosed within a spherical cell. 113. 114. The blind extremity next becomes enlarged, the enveloping cell is dissolved, & a flask shaped body the true spermatic particle is thus set free. 116. 117.

Although the disappearance of the spermatic cell occurs normally at this period it often happens much sooner; & thus we find the spermatic particles set free in all their stages of development, from the primitive nucleus, 115. a, to the perfect condition. 116. 117. In many of these spermatic particles the nucleolus still remains 116 a; but it also in course of time disappears, leaving the mouths of these hollow bodies open, 116. b.

Originally the nucleated cells in the caecal extremity of the testicle are not more than $\frac{1}{10000}$ of an inch in diameter. Pl. VIII. 94. As they descend they become enveloped by granules: at first forming irregular masses about $\frac{1}{1000}$ of an inch, 95; but these gradually contract & become round opake bodies measuring $\frac{1}{1700}$ of an inch, 96. a, each of which contains a single spermatic cell, now however increased to $\frac{1}{2500}$ of an inch. 96 b. c.

After the spermatic cells are introduced into the female uterus they enlarge rapidly, & are met with measuring from $\frac{1}{1000}$ to $\frac{1}{700}$. I have however represented them of the average size of $\frac{1}{900}$ of an inch. 97 to 114. The nucleus, 97. 98 b, is about one third the diameter of the cell, or $\frac{1}{2700}$; while the breadth of the spermatic particles differs from $\frac{1}{5000}$ to $\frac{1}{3600}$, & their length from $\frac{1}{1600}$ to $\frac{1}{700}$; 115 to 117.

The spermatic particles have long been known, but their nature has not hitherto been fully determined. Cloquet in his elaborate works on the Ascaris Lumbricoides, mistook them for undeveloped ova. More lately Kolliker imagined them to be bundles of capillary spermatic filaments. Wagner believes them to form the tail only of the Spermatozoon, 122. a. Reichart evidently did not recognise their function, for he makes a nucleated cell his "reifes Saamen körperchen". Lastly, Siebold conjectured these corpuscles to be Spermatozoa, having seen them in contact with the ova; but he appears to have gone no further into the investigation.

That these flask shaped bodies, VIII 117, are mature spermatic particles cannot now be doubted, since we meet with them the highest in the oviduct, while, nearer the external orifice of the vagina, none but nucleated cells or cup shaped nuclei are seen.

As I have said before I have never observed a spermatic particle forcing out the cell wall except at a very early period of its development, 101 to 105. But when perfectly formed it is set free by the total disappearance of the cell; nothing remaining except a few of the untransformed granules surrounding the nucleolus, & although the cell wall is very frequently lost much earlier, 115, yet the development of the spermatic particles seems to go on as long as any of the nuclear granules remain, 116.a.

Wagner therefore is not correct in supposing these bodies to be mere tails, because they never project as such from the spermatic cells. Also when they become free it is by the total disappearance of the cell wall; and, lastly, because they alone are found highest in the oviduct. Again, speaking relatively, what immense Spermatozoa these cells, 97 to 114, would form, if the opinions of Wagner & Reichert were true, from $\frac{1}{1000}$ to $\frac{1}{700}$ of an inch in diameter, or one third that of the egg in the same animal, a circumstance altogether unparalleled.

Neither do I see any reason to believe Kolliker's statement, that the spermatic cells are formed four at a time within a mother cell, Pl. IX. 123.b; never having observed such an occurrence.

The whole of the changes I have described may easily be traced by examining the uteri of the larger individuals, as in these impregnation has in all probability not occurred till very recently; their size apparently depending on the non evolution of fecundated ova. However from the delicacy & transparent nature of the spermatic cell when at its greatest development, it is perfectly useless to employ any but the very best microscopes.

Having now fully traced the formation of the spermatic particles from the nucleated granule thrown off by the cœcal extremity of the testicular tube in the male, VIII. 90, to the flask shaped body met with in the oviduct, 117; I now pass to the description of the female organism, previous to entering on the development of the ovum.

The Female Ascaris Mystax, VII. 84, as I have already said is larger than the male, 83. Its tail also is straight, 84.a, & not curled up. The orifice of the vagina, ~~IX~~ 126.a, is placed about one third the length of the animal from the head. It is a simple circular opening; so small that it is seen with the greatest difficulty.

On squeezing gently between glass plates, & magnifying at the same time, the convolutions of the ovarium tubes, 125.b, are observed; filling the body from the tail to within a short distance of the head. This reproductive apparatus is not fixed firmly in one position, but moves backwards & forwards with considerable facility; the tubes, 125.b, being coiled round the intestinal canal, 125.c; lying between it & the integument, 125.d.

The following is the method I employ for the extraction of these generative tubes. Cut off the head & neck a little above the convolutions, & seizing the tail with forceps, by gradually increased pressure commencing at the tail & passed along the body towards the cut extremity, squeeze out the whole visceral contents; leaving nothing but skin behind. To prevent entanglement of the different parts it is best to effect this expression under water. When this has been accomplished, unravel with needles the convolutions, & remove the intestinal canal; which is easily recognised by its straightness, & great relative diameter. If carefully performed we thus obtain two very long, almost capillary tubes, 127. a.b.c.d; which after enlarging, 127.f, become united into one canal, 127.g; whose termination has already been described as the generative orifice. 126.a.

On examining this apparatus we observe it to be composed of several portions, differing in appearance as well as structure. The tubes commence near the tail in two cæcal extremities, 125, 127.a, gradually increase in size as well as in opacity, & after performing various convolutions backwards & forwards throughout the greater part of the body, 125.127.b, they suddenly become constricted; 127.c. These are the ovaries, or more properly ovarium tubes, as the cæcal extremities alone appear capable of throwing off germinal vesicles.

This opake portion, 127.a.c, is from four to six inches long; while the second part, 127.c.d, is only about half an inch in length, nearly transparent, & separated in like manner from the next by another constriction. 127.d. Each tube now becomes greatly dilated, so as to be several times the diameter of the former portion, & form what are termed the uteri. 127.f. The Uteri are also about half an inch long; parallel to each other, & unite together to form the vagina, of about the same length, 127.g.

The opacity of the ovaries, uteri, and vagina, 127.b,f,g, is dependent on the eggs with which they are distended; the transparent part, 127.c.d, contains hardly any. This portion has not received any definite name, nor have its limits been pointed out; but, as it is here that the all important process of fecundation takes place, a name becomes indispensable. To this therefore I shall apply the term Oviduct.

The upper extremity of the ovary is formed of a membranous, & perfectly transparent tube, Pl. X. 131. The membrane however is much thicker at the very end, Pl XI. 132.a, where it presents a finely granular structure. This is the only part from which germinal vesicles are thrown off, & is consequently the true ovary. X

A short distance from the extremity one or more apparent invaginations occur, 132.b; as if other cœcal tubes were contained within the first. These appearances are caused by granular casts of the internal surface of the upper end of the ovary, 132. a, which are probably thrown off at intervals.

On examining a portion of the ovarium tube where it begins to become opake, 133, we observe it marked with very faint lines, & minute granules, which gradually increase in distinctness, 133. a. The sides also become thicker, so that about midway the tube is formed of a homogeneous membrane outside, 134. a, & a number of longitudinal ridges or striae internally. Each of these striae contain a number of granules embedded in them, causing them to project into the interstices of the tube, & giving it somewhat the appearance of a rifle barrel. +

This is the structure presented by the ovarium tube for the greater part of its length X. 130; commencing as soon as granules are seen to surround the germinal vesicles, XI. 133, b, & becoming gradually more distinct to within a short distance of the oviduct. Here the striae disappear, & the external membrane alone remains, to form the lower portion of the ovary. 129 a; 135; 136, a.

The spot where the ovary terminates & the oviduct begins, 129 c, 136 b, is marked as already stated by a constriction, 129 b, 136 d, causing the tube to become so much narrower as only to admit the passage of one ovule at a time, 136 c.

The whole length of the oviduct, 129 c, is characterised by transverse markings evidently of a muscular or contractile nature, but most developed at the ends where the constrictions occur, 129 b.d. While the exterior of the oviduct is transversely ribbed, 136. 137. b, its inner surface is covered with large cells distended with a dark granular fluid having the appearance of secreting cells, & projecting strongly into the cavity of the tube.

That these cells secrete some sort of fluid is proved by the fact of their becoming turgid when the Ascaris has been feeding, & on the contrary so flaccid as to be almost invisible when fasting. Again, while the ovary, 129. a, is filled with an almost solid mass of ovules, the oviduct, 129. c, contains a transparent finely granular fluid with only an ovule here & there. It is probable also that a peristaltic action is set up by these fibres, by which means the closely packed ovules are detached & forced forwards singly into the uterus.

As already stated another constriction, 129 d, 137, but not so well marked as the first, indicates the termination of the oviduct; immediately beyond which the tube becomes suddenly dilated into the uterus, 129 f; which is several times the diameter of the preceding portions.

The uterus commences by a rounded extremity, the fundus, 129 f, into which the oviduct, 129 c, opens; & becomes gradually narrower, 128 f, until it unites with its fellow to form one tapering vagina. 128 g. The uteri are formed of an external membrane lined with broad flat quadrangular cells, 138 a. Each of these presents an oval or round nucleus, 138 b, & central nucleolus, 138 c; the whole forming a very beautiful microscopic object.

Lastly, the vagina, 128 g, presents some transverse rugæ externally, 139; & flattened cells internally; completing thus the view of the complex structure of the female reproductive apparatus.

The cœcal extremity of the ovary, 132 a, throws off as I have said small rounded granules, 132 c; which enlarge rapidly, & form the germinal vesicles, 132 d. These granules are formed by the thickened apex giving its substance a semitransparent structure. A fluid likewise fills the upper part of the ovarian tube, by which it is secreted, appearing to be of an albumenous nature.

The germinal particles, when first thrown off by the internal membrane of the cœcal apex are only $\frac{1}{10000}$ of an inch in size, 132 c; but begin almost immediately to increase to several times their original bulk; become vesicular, 132 d; & present a nucleus within each cell 132 f. These are the germinal vesicles caused by the swelling up of the primitive granules. Kolliker mistakes the invaginated appearance of the upper end of the ovary, 132 a b, for large cells whose nuclei are the germinal spots, set free by the successive opening up of the large cells. See Müllers Archives for 1843. He further states that the germinal spot is first formed; & around it the germinal vesicle is developed, like a primitive cell round its nucleus. My own observations however lead me to believe that a germinal particle is first formed. 132 c, 140 c.

This appears to be semi-opake & solid. By the imbibition of the surrounding fluid the external membrane of this germinal particle becomes distended, & thus forms the germinal vesicle XI 132 d, XII 140 d; leaving the solid contents to form a central nucleus or germinal spot, 132 f, 140 f. The germinal vesicles are now $\frac{1}{3500}$ of an inch in size, 132 d; As they pass down the ovary they disappear from view, becoming envel-oped by opake granules, 133 b.

At first, that is to say in the upper part of the ovarian tubes; these granules are perfectly free, floating loosely in the fluid, & lying in contact with though not adhering to the germinal vesicles, 132 g.

A little further down we observe the whole contents of the tubes to become almost solid, at least gelatinous, & to consist apparently of nothing but granules, 133 b. On rupturing this portion of the tube, & applying gentle pressure, the granular contents are easily forced out, & may be seen to break up into a number of semitransparent masses, 141, 142. Each mass constitutes an ovule, small & imperfect, but containing all the parts essential to an ovule. In the centre of each we find a germinal spot, 142 a; enclosed in its germinal vesicle, 142 b; & this again surrounded by a few granules, 142 c, imbedded in a transparent jelly, & contained within a very delicate membrane, the vitelline membrane, 142 d. These granules are the first appearance of the yolk. They are opake, separated from each other, & surrounded by the gelatinous fluid.

The ovule in this stage of its existence is very irregular in form; sometimes caudate, 141. 142; sometimes triangular, 143; & at others round, 144. They are all more or less flattened & transparent, so that the contained germinal vesicle & spot may be distinctly recognised. When of a triangular or caudate form the vitelline membrane is often imperfect at the apex, 145 d; which seems to be the part last formed, & is invariably placed nearest the centre of the ovarian tube. Whence the vitelline granules are formed is problematical. They may be either thrown off by the caecal extremity along with the germinal particles, or separate spontaneously from the surrounding fluid, or lastly be formed by the striated wall of the ovary.

I believe that the large granules, 142 c, first of all seen surrounding the germinal vesicle, 142 b, are thrown off by the blind extremity, & become attached to the vesicle previous to the formation of a vitelline membrane, 142 d. But when the ovule arrives at the striated portion, 134, the number of yolk granules is greatly increased, 143 to 145; leading to the supposition that the granules contained within the striæ are thrown off & become embedded in the ovule.

The possibility of such an occurrence might be doubted from the existence of a vitelline membrane. But this membrane is only the external limit of the gelatinous mass, 142 c, consolidated a little, & so delicate as to offer no resistance to the entrance of the oily particles, which constitute the globules obscuring the germinal vesicle at this period, 145.

The germinal vesicles maintain all along a very uniform size, but becoming gradually larger. They are globular in shape & contain a highly refractive fluid, which makes them easily distinguishable, 144. The Ovula appear to increase in size by the accumulation of granules from the walls of the ovary, 145. The reasons for supposing so are, first, that the granules become more & more numerous as the ovulum passes down the tube. Secondly, The granules exactly resemble in size, colour & form those produced by the internal wall of the ovary. Thirdly, The striae cease just where the ovule ceases to become larger. Lastly, That these granules are not produced by the germinal vesicle is evident from its remaining of the same size.

As the ovule descends we find it increasing in diameter from $\frac{1}{1000}$ to $\frac{1}{280}$ of an inch: becoming more & more opake, as well as thicker.

The fact that the ovula are packed edge wise in this part of the tube, 147 a, was first pointed out to me by Dr Allen Thomson; also that three or four occupied the same plane, 146. This I have found to be perfectly correct; & it at once explains the reason why the triangular form is the only one met with at this part, 143, 145.

The ovary is about $\frac{1}{120}$ of an inch broad at its widest part; & here it is that we find the ovula packed generally four on a plane, 146, with their edges presenting externally, 147 a; appearing long & narrow when viewed in profile, but broad & triangular in front, 147 b; entirely filling the transverse section of the tube, XI. 135 a.

The belt of clear substance that separates the vitelline membrane from the granules surrounding the germinal vesicle, XII. 144, becomes less & less as these granules increase in number; so that at last the whole ovule appears to be entirely composed of yolk globules; immediately encircling which is the yolk membrane, 145, 146.

This is the state in which the ovula are met with close to the entrance of the oviduct, XI. 136 c. They now become separated; detached singly from the mass, X 129 a; lose their triangular form; &, passing through the first constriction, 129 b, XI 136 d, enter the glandular portion of the reproductive apparatus, 129 c, 136 b.

When the Ascaris has been impregnated the ovule first meets with the spermatic particles in this part; but I think it may be best to trace the further changes it undergoes in the unimpregnated state of the female, as they enable us to explain, or what is of more importance to contrast, the appearances presented by the fecundated ovum with those of the non-vivified egg.

As soon as the ovule enters the glandular portion, X 129 c, it floats free in a clear liquid secreted by the cells lining the oviduct. The ovule becomes thicker & more rounded. Losing the flatter form it assumes that of an oblong sphere XII 150. A granular chorion, 152 a, begins to form external to the vitelline membrane, 151 b; & gradually constitutes an elastic shell, 155 a. While this external chorion is forming, the internal contents are undergoing change. The yolk granules become much smaller, 150; the germinal vesicle & spot disappear; but in their place we find a number of large transparent globules, 151 to 154 c, having much more the appearance of oil than of being formed by cells.

These globules appear to be formed partly by the disappearance of the germinal vesicle, & partly by the separation of the oily matter from the granular vitellus, 154 d. After a time these oily globules approach the periphery, while the now much more minute as well as opake particles pass towards the centre.

By some process, perhaps of

exosmose, the oily globules disappear; & at the same time a membrane, 154, 155 b, separates from the internal surface of the chorion, 154, 155 a, & contracts on the particles contained within it, forming one, spherical, perfectly opake, molecular mass, 155 f.

This false ovum, 155, if I may be allowed to call it so, is surrounded externally by a peculiar granulated chorion, or shell, of an irregularly ovoid form, 155 a; within which, but separated by a clear fluid, is the opake spherical mass already described, 155 f, with its delicate membrane, 155 b; probably the vitelline membrane of the ovule, 142 d. 41

No further change takes place, but that of decomposition. The false ovum is expelled in this state from the unimpregnated female, & finally decays & disappears. In some cases I have observed spermatic particles to exist in the lower part of the uterus, which had not yet ascended to the oviduct; yet all the eggs were imperfect, having the characters of the false ova just described, & like them incapable of further change.

From this we may infer that after

the formation of the chorion impregnation is impossible; & since it is formed while the egg is yet within the oviduct, fertilization must take place there before the appearance of the external enveloping membrane. Let us return to the fertile condition of the female, & trace the development of the ovum as it threads its way along the oviduct.

The ovula are here surrounded by the spermatic animalcules. Here therefore it is that fecundation takes place: that all important process; as wonderful as it is unknown; but by which alone fertile ova can be produced. I shall endeavour to describe the conversion of the ovulum into the fertile ovum, according to my own repeated observations.

Immediately that the ovulum passes the constriction, which terminates the ovary, & enters the oviduct it comes in contact with the semen XI. 136. It has an irregularly oblong shape, XII. 148, 149, & is thickly studded with opake granules, rather lighter towards the margin. The edge is uniform, that is to say, not ragged; being limited by the vitelline membrane. Sometimes a faint trace of the germinal vesicle, XIII. 156, 157 a, may be perceived; but the ovule is so opake that things on the other side can never be seen through it. 148, 149.

At first the margin of the ovule is entire, that is to say, the vitelline membrane is imperforate; but a little further we perceive the spermatic particles to be closely applied against this membrane, depressing it slightly in some places, 158, 159, 161 b.

Another step, & all the ovula present a rupture in some part of their periphery, 156 to 161, 164; generally at one point, but frequently in several places at the same time, 168, 169. At these places some of the yolk granules are seen protruding through the opening in the vitelline membrane, 156, 158, 159, 164 c. That these appearances do not arise from pressure applied during the examination I am now perfectly satisfied; having repeated my observations above a hundred times, & varied them so as to remove all possibility of such an occurrence.

The effect of pressure on the ovule is also very different from that just described; as I have repeatedly seen. If an entire ovule is squeezed between glasses, the vitelline granules coalesce; the yolk membrane dilates; &, at last, the whole disappears into a yellowish fluid.

From the immense number of ovula in which I have seen this partial imperfection of the vitelline membrane, & the want of success in my endeavours to cause a similar protrusion of the yolk granules by compression, I am irresistably led to the conclusion that it is a vital phenomenon, consequent upon some natural cause, & not the result of accidental violence

Further, by Dr Thomson's suggestion, I divided the oviduct at both ends, washed away all loose ovules by a gentle stream of water, & then superimposed as carefully as possible a piece of the thinnest glass. No other force than the weight of the piece of glass was applied; yet every one of the ovula, as they slowly found their way out of the oviduct, presented in some part or other this want of continuity of the membrane.

The reason why all the granules do not escape is that they lie not in a fluid but in a sort of gelatinous substance, easily broken up it is true, yet sufficiently coherent to retain the granules in their places. To what are these appearances owing, & how are they produced

I have already noticed that the Spermatic particles are applied at first to the periphery of the ovula, 158, 159 b. Either by the contraction of the oviduct, or, more probably, by some property inherent in these particles, they are next seen to indent the vitelline membrane. A little lower we find the spermatic particles not only in contact but partially embedded in the ovule, 159, 164 b; surrounded by loose granules set free by the rupture of the vitelline membrane.

Sometimes only one is seen to be thus embedded, 164, 168 b; but more commonly several spermatic particles are applied at the same place, with their closed ends directed generally towards the centre. 167, 170 b. Penetration next takes place; the particles passing into the substance of the ovule, among the vitelline granules, 167, 169 to 173 d.

I have seen the spermatic particles in all stages of penetration; from mere contact, 167, 168 b, to perfect involvement within the ovule 170 d. In their course they appear to effect very little displacement, passing readily in all directions among the granules. Their transparency & high refractive power renders them easily distinguishable when near the surface, 169 to 173 d.

I cannot here enter upon the consideration of the changes which occur in the manniferous ovum, as I intended to have done, from the length my Essay has already attained as well as from want of time. I confine myself therefore to a few remarks.

Dr Barry says, "on one occasion in an ovum of $5\frac{1}{4}$ hours, I saw in the orifice of the membrane," (the external membrane of " the ovum) "an object very much resembling " a Spermatozoon which had increased in size. " I am not prepared to say that this was certainly " a Spermatozoon, but it seems proper to record " the observation". Whether we believe Dr Barry to have really seen the penetration of the spermatozoon into the Manniferous ovum; or whether we, agreeing with Bischoff & most other distinguished authors, deny the correctness of Dr B's observation, as well as the possibility of any such occurrence, the present investigations appear to be the first by which the fact has clearly been made out; by which the entrance of the spermatic particles into the ovule has been first established, in one of the most highly organised of all Entozoa, the Ascaris Mystax.

Of the possibility of penetration no one who has seen an ovule of this Ascaris can have any doubt. 148, 149. The only protective envelope it possesses is the vitelline membrane, which is so delicate, 142 d, that, as I have already remarked, there is great reason to believe the very granules it encloses, 142 c, have passed through its walls.

Secondly, with regard to the probability of such an occurrence there is the breaking up of the vitelline membrane, 156, 158, 159, 164 c, in certain places; rendering it still easier for the entrance of the spermatic particles.

Thirdly, The application of the seminal particles to the broken edge, 159, 161, 164, 167, 168, 170 b.

Lastly, I have repeatedly seen the spermatic particles within the ovule, embedded in its substance, 167, 169 to 173 d, & surrounded on all sides by the vitelline granules & membrane.

Having shown the possibility & the probability, it remains for me to prove the accuracy of my observations. That the spermatic particles seen by me might possibly have been external to the ovule will naturally occur to every microscopic observer. Several considerations will establish that there is no room for such a doubt. 1st The particles could not have been lying upon the ovule, because vitelline granules were visible above them. By distancing the Object glass slightly the spermatic particles became indistinct & a layer of granules came into focus entirely covering the space they occupied.

2nd They could not have been below; for the ovules are much too opake to admit of being seen through. 3rd The seminal particles observed within the vitelline membrane were only in focus when the margin of the ovule was in focus, & must therefore have been on the same plane with it. As the ovule is a more or less spherical body, the focus of its margin corresponds with that of its centre; hence the particles already mentioned could only have existed in the substance of the ovule.

Another objection might be raised. Admitting the particles to have been situated in the substance of the ovule, might they not have been oil globules, like those seen in the non-fecundated egg XII 151 to 154c? The reply to this is most satisfactory; for not only were the particles elongated, & cylindrical, XIII 167, 172 d; but the one extremity was closed, & the other open, 169 to 171, 173 d; Hence they could only have been the spermatic particles of the male VIII. 116. 117.

The accuracy of my observations being I trust satisfactorily proved, we must admit that the flask shaped spermatic particles do penetrate into the ovule.

54

The accompanying drawings present these appearances as exactly as possible, being taken from actual specimens by means of a Camera Lucida. In some we find the broken margin of small extent, 156 to 159, 164: in others it embraces nearly one half of the circumference 168 to 171. Some give a faint indication of the contained germinal vesicle, 156, 157 a; but in most the granules are too opake to admit of its being seen at all, 158 to 164. Occasionally we meet with an ovule here & there that appears destroyed, nearly transparent; in which the yolk granules seem to have coalesced, the germinal vesicle having disappeared. 160.

Sometimes, when they have lately entered, the spermatic particles present their ordinary flask shaped appearance, 169 to 173 d, but in others they seem to have undergone a change, & to have swollen up into transparent rounded masses. 156 to 159, 162 g. I infer that these are transformed seminal particles because they are met with in all stages of the change, both within & outside of the ovule, 156 to 159, 162 h.

Let us pass now to the examination of the changes which take place in the ovule after the entrance of the spermatic particles.

Immediately after the passage inwards of the flask shaped bodies, the ovum begins to acquire a chorion, XIV 174 a. The formation of this does not appear to be at all dependant on the penetration, but to the ovum reaching that part of the oviduct by which the membrane is secreted; for we find it occurring even in the unfecundated egg. This chorion differs however from the granular shell of the false ovum, 152 to 155 a, in being perfectly smooth, membranous, & transparent, 175 to 181 a. It first shows itself on those portions of the vitelline membrane that remain entire, forming with it a single dark line, 174 a. This dark line sometimes only partially encircles the ovule, 174 a, being imperfect at those places where there is a protrusion of the granules, 174 b; at other times it surrounds the yolk entirely, 175 to 181 a.

The apparently single envelope thus formed consists really of two membranes, though from the great tenuity of the vitelline membrane within it cannot be seen. At first the chorion is flaccid, & the ovum appears of an irregular shape, 174, 175, 178; but by the imbibition of fluid it swells up, becoming tense, & spherical, 176, 177, 180, 181.

Very shortly after entering the ovule the spermatic particles disappear, probably by becoming dissolved, for occasionally transparent irregularly roundish bodies, 179 i, are perceived within the chorion, 179 a; which seem to be undergoing the process of solution.

The vitelline granules that previously to the impregnation of the ovum formed one uniformly opake mass, 148, 149, now become broken up, excavated in some places & dissolved in others, 174 to 181 b. This seems to be owing to some direct influence of the seminal particles on the yolk; for many of the granules disappear entirely, 174 to 186 b; while others, 182 to 186 m, are changed both as regards colour & size: a transformation quite different to that which I have described as taking place in the false ovum. 176, 177, 180 a.

The ovum at this period presents a very peculiar mottled appearance from the breaking up of the yolk into masses of opake granules, 175 to 182 b; separated by interspaces of transparent fluid, 175 to 182 c. Sometimes the whole yolk is thus, 180 b, broken up; but more commonly it is only the surface that is thus first affected; the process of disintegration gradually passing towards the centre. This mottled, 180, appearance has been previously noticed in the egg of a Strongylus, & ascribed to the formation of cells within the yolk; which is certainly not the case in the ova of the Ascaris Mystax.

When there is much disintegration the germinal vesicle may be seen, 177, 180, 181, 183 d, with its nucleus, 177, 180, 181, 183 f; & occasionally within this again one or two nucleoli, 177, 180 g. But in by far the greater number of ova the breaking down of the vitelline mass commences on the surface; first eroding it, & then passing gradually more & more towards the centre; from which cause the germinal vesicle, being covered by a layer of opake granules, cannot be seen.

As the solution of the yolk goes on the opake granular mass in the centre becomes less & less, leaving a clear margin of fluid surrounding it on all sides, 183 to 186 c. Some granules however escape, & are seen floating in the fluid; but they are larger & more transparent than the original yolk granules, 182, 186 m.

About this period the ovum acquires another envelope, consisting of two membranes, as is distinctly seen in those cases in which endosmose has occurred. 186. h. l.

When the granular mass has become much reduced in size, 185, 186 b, it suddenly loses its opacity, & thus the whole vitellus is transformed into a few large, nearly transparent granules, 187, 188 m; among which we look in vain for a germinal vesicle, 188 m; & only now & then are we able to distinguish one granule to be larger than its fellows, 187 f; & to contain within it a dark spot. 187 g. In short the germinal vesicle, 177, 180, 181, 183 d, ruptures when disintegration has proceeded a certain length. Its disappearance is followed immediately by the transformation of the remaining vitelline granules.

I propose to call these transformed or altered vitelline particles by the name of Embryonic granules, 187 to 189 m; since they appear about the same time as the embryonic vesicle, & in connexion with it, help to form the embryo.

After the rupture of the germinal vesicle the interior of the egg is filled with the embryonic granules; not however packed close like the vitelline, but scattered loosely. About the centre of these granules, one a little larger than the rest, 187 f, may sometimes be seen having in it an opake spot, 187 g. On comparing these with the nucleus & nucleolus, 177 f, g, of the germinal vesicle, 177 d, before its rupture I found them to resemble each other completely; having the same size, shape, & appearance; the same degree of refraction; & the same situation.

The germinal vesicle immediately before its rupture is $\frac{1}{1000}$ of an inch in diameter. Its nucleus, or, as it is commonly called, the germinal spot, 177 f, is $\frac{1}{4000}$; & the contained nucleolus $\frac{1}{8000}$ of an inch. After rupture the nucleus & nucleolus are of exactly the same sizes respectively. But soon the nucleus, which is at first solid, begins to enlarge, swells up, & constitutes a transparent cell, 189 f; while the nucleolus remains of the same size, 189 g; forming in short an embryonic vesicle & spot.

As soon as the embryonic vesicle begins to form, a membrane separates from the internal surface of the egg envelopes, 190 k; & gradually, 191, 192 k, contracts on the embryonic granules, till a perfect sphere is formed, whose breadth is equal to the lesser internal diameter of the ovum, 193 k.

This membrane is perhaps the vitelline membrane of the ovule, 142 d; but on this point I cannot speak with certainty; for the present therefore we must rest satisfied with the fact that the innermost layer of the shell separates & contracts on the granules contained within it; forming another, an embryonic yolk, 193 k, in contradistinction to the first or ovular, 148, vitellus.

When the membrane of the embryonic yolk first separates from the inner surface of the egg, it encloses not only the embryonic granules, vesicle, & spot; but likewise the clear fluid in which they float. But as contraction goes on this fluid passes through the membrane, 193 c; & occupies the space between it & the external envelopes. The membrane therefore acts as a sieve; allowing the fluid to pass but retaining the granules, 193 m, & bringing them within the influence of the embryonic vesicle.

The embryonic yolk is at first large & irregular, 190 to 192 m; but it soon becomes perfectly spherical, 193 m; $\frac{1}{600}$ of an inch in diameter; enclosing an embryonic vesicle & spot, whose sizes are $\frac{1}{2000}$ & $\frac{1}{6000}$ of an inch respectively; 193 f. g.

At this period the egg, 193, is oval; its longer diameter being $\frac{1}{310}$, & its shorter $\frac{1}{350}$ in. Its membranes are firm & resisting; & with this amount of organization it is expelled from the body of the mother. The perfect ovum therefore consists of two or three homogeneous membranes, united to form an oval shell, 193 h; some limpid fluid, 193 c; a spherical embryonic yolk membrane, 193 k; embryonic granules, 193 m; an embryonic vesicle, 193 f; & its nucleus, the embryonic spot, 193 g.

Compare the true XIV. 193, with the false ovum XII 155. One is immediately struck with the immense difference that exists between them. In the false egg there is no embryonic vesicle; no embryonic spot. The substance that does exist is apparently the colouring matter of the vitelline granules, collected into a structureless yolk; & surrounded by a membrane, 155 b. The whole is enclosed in a granular chorion, 155 a; instead of a laminated shell XIV 193 h.

The formation of the embryonic yolk membranes is not the effect of fecundation, for we see one produced in the false ovum, 155 b. But after the entrance & solution of the spermatic particles, certain other changes are effected which in the ovule which do not otherwise occur. The spermatic particles by penetrating exert over the ovule an influence of three distinct & somewhat opposed kinds.

First, A preservative effect; preventing the decay, disappearance, & blending together of the vitelline granules, the germinal vesicle, & spot.

Secondly, A destructive, or solvent influence; by which the vitelline granules, & germinal vesicle are, after a time gradually dissolved.

Thirdly, A power of transformation by which the vitelline are changed into embryonic granules

The Preservative, Destructive, & Transformative Influences commence, as we have seen, with the union of the spermatic particles & ovule. They are conferred by the spermatic particles on the ovule; which continues to exist, while the sperm is destroyed by the act. And, lastly, they appear all three to be of a purely chemical nature.

These properties once acquired continue not only throughout the whole life of the creature, but remain even after the death of the individual. To one or other of these influences may be ascribed all the changes that take place in the living body, with the exception of those that are referrible to vitality alone.

But before entering on the consi=
=deration where life commences, & in what part it resides, it is essentially necessary that we

make ourselves fully acquainted with the changes it occasions in the ovum; by which the egg is transformed into an embryo in all respects like the parent; like it capable of voluntary motion, assimilation, & the power to produce other ova.

These are most beautifully seen in the egg of the Ascaris Mystax. As they have been already described by far abler authors I shall confine myself to a very brief outline of the changes as they occurred under my own observation.

The first alteration that the ovum undergoes is the division of the embryonic spot, XV 195 a, & elongation of the embryonic vesicle, 195 b. This division is sometimes seen even before the germinal vesicle has disappeared, XIV 181 g; but it usually does not take place till after the formation of the true or embryonic yolk, 195 c.

The division of the nucleus is immediately followed by that of its cell, the embryonic vesicle, 195 b; & thus two embryonic vesicles are formed, 196 b, each containing a nucleus or spot, 196 a.

As soon as this has occurred the two cells are seen to separate, & approach the opposite sides of the yolk, 196. A portion of the yolk membrane, 196 d, is protruded outwards by the application of one of the embryonic cells against it. At first this protrusion is very slight, 196 d; but, by the continued movements of the vesicle, it becomes more & more increased, till at length the yolk assumes an oblong shape, with a constriction about the middle, 198 c. This constriction gradually deepens, 199; & finally two yolks are formed, 200 c, by the division of the investing membrane, 200 d.

I have repeatedly watched this process as it occurred under the microscope. The division of an embryonic vesicle, 196 b, takes from 5 to 10 hours; but as soon as this is effected the division of the yolk does not take more than half an hour. The separation of the yolk into two parts is, I think, entirely mechanical; & not produced by vitality inherent either in the yolk granules or membrane.

I have observed during the progress of division that, beside the rapidity of its accomplishment, the embryonic vesicles continue to revolve round & round in circles; the one moulding the newly projected portion of the yolk membrane into a spherical form; while the other prevents the original part from collapsing. Sometimes, when the formation of a yolk has been prevented by immersion in preservative fluids, the division of the embryonic vesicle still takes place, 194 b; & they are seen occupying opposite sides of the egg; but without any membranous or granular investment.

As soon as the yolk has divided into two a pause occurs. The two embryonic vesicles, 200 b, remain stationary; their nuclei, 200 a, subdivide. They themselves elongate, & ultimately separate into two each, 201 b. Thus four embryonic vesicles are formed; two within each yolk mass, 201 c, which by the repetition of the same process is redivided into four, 203 c.

Occasionally, when one embryonic vesicle divides more rapidly than its fellow, three yolk masses are produced, 202 c; but this is rare, & not normally the case.

By a third series of divisions, commencing like the former with the nuclei & embryonic vesicle, the yolk is parted into eight more or less globular masses, 204. As this process is repeated from time to time the number of yolk masses increases from eight to sixteen, 204 to 209; & so on to 32; 64; 128; 256 &c, till they become so minute as to appear like granules. Yet each such granule is composed of a nucleus, an embryonic cell, yolk substance, & yolk membrane. From the minute subdivision, & the number of interspaces, arising from the spherical form of the globules, the whole of the egg is filled with them, giving it a dark, opake appearance. 209.

A membrane, 210 f, appears to form on the external surface of this mass, 210 g, the production of which is attended with the loss of some of the more superficial granules.

Next a depression, 211 f, of the membrane occurs, corresponding usually with one of the sides. This depression is at first slight, 211 f; but it gradually increases, 212 f, forcing some of the granules before it, while others disappear into a limpid fluid, which passing through the membrane, occupies the space between it & the shell.

A hemispherical mass is thus, 212 g, produced; but the central portion continues to advance till it touches & unites with the membrane covering the opposite or convex surface, 213. By this means a thick circular ring is formed, 213 g; which soon presents a constriction at one part, 214 g. This constriction by deepening divides the ring, which is thus transformed into a cylindrical body, bent round so that the two ends are in apposition, 215 g; covered externally with the membrane now become thick, while internally we still see nothing but granules.

As the body elongates the two ends overlap, & are seen to be pointed, 216. At first this overlapping is slight, but it gradually increases, 217, 218; till at length the little worm forms nearly two turns of a spiral, 219, 220 g; surrounded on all sides by a fluid, & the shell or egg envelope.

By rupturing the egg the embryo worm is set free, 221; & is seen to possess the three lobed mouth, 221 h, peculiar to this genus; & a very thick cuticle, 221 f; enclosing a number of untransformed granules, 221 g.

The development of the embryo is best observed by placing the females entire in Spirits of Turpentine, for a fortnight or three weeks; at the end of which I have found the ovaries distended with ova, all of which contained young worms. These were not only fully developed but alive, doing their utmost to rupture their shells; by rolling themselves up into a tight spiral, 220 g, & then suddenly reversing the coil.

Let us now consider shortly which of these changes are vital & which physical. The most remarkable as well as most apparent alteration that takes place in the ovum is the division of the yolk; which, though singular, seems to be entirely mechanical. For the yolk membrane when at rest, as seen before the division, assumes the spherical form by its own molecular attraction; but, when drawn out by the embryonic vesicles, acquires first a cylindrical shape; then that of an hour glass, because that part of the membrane occupying the centre of the cylinder having nothing to distend it collapses; the two ends being prevented from doing the same by the continued movements of the embryonic vesicles. When the hour glass form has been attained, the molecular attraction of the membrane tends no longer to draw it into a single sphere, but into two globules, & thus the division of the yolk is completed.

This view is further confirmed by the fact that, while the first steps of this process take comparatively a long time, as soon as the hourglass form has been once acquired, complete division is effected with the greatest rapidity.

But, on the contrary, the division & movements of the embryonic vesicle can only be ascribed to vitality. That they are not produced by the action of the spermatic particles is evident from the fact that, the division does not take place from without inwards, but from within outwards. The embryonic spot divides first, & this is seen to take place even before the germinal vesicle has been ruptured, while it is still entire; & consequently long before the seminal fluid could possibly exert any influence over its nucleoli, embedded, as they are, in the substance of the yet solid nucleus, surrounded by fluid the product of the ovule, & protected by the germinal vesicle.

The fissiparous growth of the embryonic spot proves beyond a doubt that its division is caused by its inherent vitality. The embryonic vesicle, though it owes its division to the nuclei it encloses, is likewise alive; because it grows in size; & moves when divided, not by electric repulsion alone, as some suppose, for I have most distinctly seen it continue to revolve in different directions, & in circles of various diameters.

But the embryonic vesicle & spot are nothing else than the nucleus & nucleolus of the germinal vesicle. Is this then alive? Yes; because when first thrown off by the ovary as a germinal particle it is solid. The external layer of it by growth forms a vesicle, while the interior remains solid some time longer & constitutes its nucleus.

This nucleus has already been shewn to possess vitality, & as it exists in the germinal particle it must also be alive. The growth of the germinal vesicle therefore from the germinal particle is as vital as the growth of the embryonic vesicle from its nucleus the germinal spot.

We have seen that life does not originate at fecundation. We have traced the vitality possessed by the ovum as far back as the very commencement of the ovule. We must therefore admit that it is derived from the mother.

For as the germinal particle is living when thrown off by the ovary; & as the ovary being part of the female shares its life; the vitality possessed by the germinal particle can only be derived from that of the mother.

From this it appears that the embryo or young Ascaris obtains its vitality from the mother; but, that certain conditions are necessary for the continuance & development of that life, & that these conditions are furnished by the changes effected by the product of the males on the substance immediately surrounding the living cell.

When the male secretion is not present, when the above conditions are not fulfilled, life ceases; the vital point dies; &, although the surrounding substance does not immediately perish, it no longer encloses a germinal vesicle, nor even a germinal spot.

Finally, I would desire to draw attention to the beautiful analogy that exists between the products of the ovarian & testicular tubes. The cœcal extremities of both the male & female reproductive systems throw off solid particles of the same, size, shape, & appearance. Both kinds soon present spots in their centres

& both swell up into nucleated cells. Yet the one is a seminal & the other a germinal vesicle.

Granules are now accumulated round both. Both might with equal propriety be called ovules. So analogous are they in structure that size alone distinguishes them. But the one is an ovule; & the other a granular seminal mass.

The granular matter of the ovule dissolves, the germinal vesicle enlarges, & disappears, setting free its nucleus. The seminal mass likewise loses its granular covering, the seminal vesicle enlarges, & disappearing, its nucleus also is set free.

Thus far the analogy is complete, but here it ceases. The transformed nucleus of the male cell enters the granular vitelline substance of the female ovule, perishing by solution. On the other hand the nucleus of the germinal vesicle enlarges, divides, subdivides, redivides, till a mass of granules are formed, each possessed of an individual existence; & together capable of producing a living whole: a worm, in every respect like its parent; endowed like it with the powers of assimilation, locomotion, and reproduction.

A new life therefore is not generated during the development of a new being by the happy combination of physical forces: but the same life, bestowed by God at the Creation, continues without intermission, & is transmitted from mother to offspring; pervading & redeveloping itself in each individual member.

Index.