

The Earth Worm
Lumbricus Terrestis - a genus of
 Annelida of the order Terricola -
 Fishing Worm. Angle Worm. Dew Worm.

This worm is found every where and
 is familiar to every body - Every plow
 Boy turns them up by the thousands Every
 Girl who has planted flower seeds has
 made its acquaintance - It is the
 all who walk out after the summer shower
 and then under their feet
 companion of our fishing parties - from
 early spring until the winter frost
 the Earth worm is constantly with us
 the friend of all the enemy of none is
 apparently unable to protect itself and
 has no protector for it seems that all

Slipping things have combined to
 The moles chase him in the ground and the birds
 pounce upon him if he comes to the surface
 make war upon it. They have

No eyes no feet - no claws no teeth

No organs of locomotion except a
 few stubby hairs to keep him from
 No means of attack or defence
 slipping. A more fearless animal
 than this cannot well be imagined

Yet in the struggle for existence it is
 regularly holding its own against the
 whole world

Why should man the lord of creation take
 up so lowly an animal as this for study
 What is to be gained Why should we
 care anything for these worms that we daily
 tread beneath our feet - It is not so
 much the earth worms that we propose to
 study but - the principles of life as
 illustrated in the earth worm and
 a comparison of these with the principles
 of life every where present around us
 What is life - do ~~we~~^{we} yet know - a something
 which pervades all nature ~~around us~~ - is ever
 present with us - a thing which we may destroy
 but may not reestablish. We may pull it down
 but we cannot build it up - we may see
 and know something of its phenomena but

of life itself we know almost-nothing.

It is the phenomena of life which we propose to study in the Earthworm. This study is one of the most-enticing that nature offers us, and the opportunities for its exercise is presented ~~to us~~ in the most-varied and interesting forms possible. While we are as yet-unable to understand life - the principles of life - we are able to gather some knowledge of the form elements in which it manifests itself, and to discern something of its phenomena. We find a wonderful similarity existing in the elementary forms composing the bodies of the most dissimilar animals, And we shall find something even in the Earthworm calculated to throw light upon and

increase our understanding of the more complex forms found in the make up of our own bodies. Every Histological form found in the earth worm is found also in man and with one single exception it is performing the same office in the one as in the other. And even this exception may be more apparent than real. On the other hand there are very many elementary forms found in man that are not found in the earth worm. The histology is more simple and therefore much more readily studied and comprehended than in man and the higher animals. We make a great mistake in putting our children at the study of the complexities of the four elements of man before they have gained

an idea of general principles by the study of some of these very low and much simpler forms. ~~Of all the life forms that I have yet studied there is none better adapted for the initiatory study of Histology and Hysto-physiology than the earth worm~~

The development of the form elements are begun in exactly the same manner and with precisely the same forms as in man the difference being that in man the diversification is carried very much farther (Charts)

All animals are developed from eggs as all plants are developed from seed

This development begins by the division of the egg into cells - called its segmentation

These cells first form one continuous mass

but very soon at a certain point - the germinal spot - they split into two membranes which separate from each other and a third membrane or layer of cells is formed between them making three layers - Now each of these layers are composed of cells differing slightly from each other even at this early period - They constitute the fundamental cell forms of the whole animal body and ever after have separate and distinct functions to perform. The one never performing the offices of the other in the future development of the body. Now it is by tracing these membranes through the history of their development that we will gain the clearest idea of the little creature that we are now to study and

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its differences from the higher forms

These three membranes are called ^{per-} the

Ectoderm - or External Blastodermic

Membrane - ~~the~~ ^{which} ~~and~~ forms the external
covering of the body ^{2nd} The Entoderm

or internal Blastodermic Membrane which
forms the digestive organs - ^{3rd} The Mesoderm

which forms the tissues of support and motion

Here we have three primary groups of cells

in the form of membranes with separate

and distinct offices to perform in the

formation of the animal and these are

precisely the same in the earth worm as

they are in man and the higher animals

The Ectoderm ~~the~~ forms the external covering

the outer skin and all its appendages

as the sweat-glands the hairs the nails
 the teeth &c by modifications of its cells
 The ~~Ecto~~ ^{Ecto}derm forms the tissues that
 minister to the nutrition - the alimentary
 the preparation of the food & and the ~~not~~
 introduction of it - into the system - it
 forms the alimentary tract and all the
 glands which minister to it - as the Liver
 Pancreas &c ^{The Lungs are also formed from}
 from the ~~Ecto~~ ^{Ecto}derm

From the ~~Ecto~~ ^{Ecto}derm the tissues of support
 and motion are formed - All of the great
 connective tissue groups - The Muscles
 The bones - Heart - arteries - and all their
 appendages - which receive the nutritive material
 from the alimentary tract and the lungs
 and distribute it to the system at large

The Brain and nervous system is formed by an invagination of the Ectoderm along the back of the fetus forming a closed tube for in which that peculiar tissue is developed and its organs are all formed by outgrowths from this primary cord.

The Epidermal layer The Ectoderm of the earth worm is composed of a ~~long~~ single layer of cells. There is ~~not a single~~ ^{but two} modification of the original Ectoderm to ~~one of these is~~ ^{one of these is} be found except the short stubby hairs which occur ^{eight} ~~four~~ upon each segment ~~of the~~ the other is the Clitellum. ~~There is no invagination for the formation of any glands whatever while in the higher animals these modifications are very numerous~~

Ectoderm //

There is but two modifications of the original cells of the Ectoderm one is for the formation hairs - the other the Clitellum

The hairs occur - eight - upon each segment - except the 1st - and the last - They occur in pairs as it were on the four corners of the body - that is two on each side below and two on each side above they are short - stiff - and nearly the shape of the old fashioned long S they extend deeply into the tissues and to the inner ends muscles seem to be attached by which they may be used as levers

The Clitellum is a very curious object in a histological sense. it consists of a band of immensely elongated epithelium which extends about two thirds around the body ceasing abruptly at the lower part of the body on either side. This seems to be shed off pretty often so that we will occasionally find worms without ~~them~~^{it} or with the elongation so slight as to be scarcely noticeable. It seems to be a sexual organ and is used in clasping its mate.

There is no molting ^{of the Ectoderm} for the formation of any gland whatever while in the higher animals these modifications are very numerous.

The sweat glands - the sebaceous glands
the Mouth - Lungs - Salivary glands Glands
Kee ~~are~~ ^{result from} all modifications of this layer of cells

The Epidermal layer is also modified within
itself - That is in man and the higher animals
it is composed of many layers making a very
appreciable thickness It is very curious
to note the development of the Epiderm as
we pass from the lower to the higher forms
of animal life From this alone we might
judge tolerably well of the position of the
animal in the scale Thus in the earth worm
we have but one layer - in the Frog we have
three to four - while in man they are numerous
The number of cells superimposed upon
each other gradually increase as we ascend

to the higher forms. There are some special modifications however belonging to the individual classes of animals. The Earth worm has one which is peculiar to this class of animals and has it - to a wonderful degree. The worm lives in the earth through which it - burrows in search of its food and it - must - force the earth aside by the power of its muscles. The Epidermic layer must protect the tissues beneath. They therefore require a considerable degree of firmness - otherwise they would be destroyed. Now there is another element in the make up of this little fellow that is directly antagonistic to this - he is capable of very greatly changing his form - he can draw himself up until he is very short or stretch himself out

to ~~five~~ ^{eight} or ~~ten~~ times his shortest length - Now you will see that this is very decidedly opposed to rigidity of the epithelial covering. ~~It~~ We find however that nature has been equal to the emergency and the epithelial covering and the muscles beneath it are so arranged that the epidermis is thrown into a series of folds as shown in the diagram when the worm shortens his body and these are straitened out - when ^{he} lengthens out his body - by this very simple arrangement both objects are gained rigidity and flexibility -

Entoderm 16

In all the higher animals the ~~the~~ cells of the Ectoderm are continued into the Mouth-Throat and down to the Stomach. But in the earth worm the cells of the Entoderm are continued directly to the mouth. In the higher animals also the Lungs and air passages are formed by the Entoderm and these are continued to the nostrils and are ciliated - which seems to be the primary condition of the Entodermic cell. In all the higher forms of animal life the cells of the Alimentary tube have lost their cilia, In the lower forms however we find the cells of the entire alimentary tract ciliated almost exactly as they are

in the air passages of man

The histology of this layer of cells presents but few modifications

It has one large gland which is the analogue probably of the pancreas but serves the ^{same} purposes ^{as} the salivary glands in the higher animals - and discharges its contents into a large dilation of the canal just below the mouth which is probably more like the crop of the birds than the stomach of the higher animals - back of this we find the canal very narrow for about one third the length of the worm when it suddenly expands - and throughout the rest of the length of the animal

it - is a large straight annulated cavity - The Epithelial cells lining this cavity do not vary much from in its different parts - The variation that occurs is mostly in the length of the cells they being much shorter in the narrow part of the canal ~~in the its first third~~

The liver is also a product of the Entoderm and in the worm it has taken a very singular form - we will speak of it in connection with the Blood vascular system

In the higher animals as you all know the Mucous membrane of the alimentary canal ~~is~~ below the stomach is studded with a perfect forest of villi - little prolongations of the membrane into

into the canal which immensely
 increase the amount of its surface
 Not only this, ^{but} in every part, the epithelial
 layer of cells dips down into the tissues
 beneath forming little tubular glands,
 which may be reckoned by the million -
 No such thing as this is found in the
 earth worm. All these forms are developments
 of the higher orders of life. This letter worm
 has no such advantages in the digestion of
 its food. The only modification of its
 straight alimentary canal is the sacculated
 arrangement of its posterior two thirds
 and so far as we are able to discern the
 same cells must secrete the juices that are
 to dissolve the food and again take

up the dissolved portions and convey
it into the system. So far as digestion
is concerned each cell seems to be a
cell of all work ~~so far as~~ while in
the higher forms those cells that dip
down to form the tubal ~~canal~~ glands
secrete the juices to perform the solution
of the food
and those on the villi take up the
dissolved product. It strongly
reminds us of the different states of
society. In the very early forms of
society - each family took the raw
material and made their own clothing
&c but - as society is more developed
there is a division of labor
just so in the different forms of

animal life - just as the creature
attains a higher development there
is a greater division of labor among
its constituent parts

Mesoderm 22

Now we come to speak of the mesoderm
or middle layer. It is the office of
this layer to form the tissues of support
the bones - and of motion - the muscles
the blood vascular system
and all the areolar and connective
tissues which serve to support ^{the vessels} the glands
and the epithelium generally.

Here we find the earth worm poor
indeed he has ^{but - very little areolar tissue} ~~no~~ no bones, but one
of the forms of muscular tissue - the
smooth muscular fibers which in
this instance form both the voluntary
and involuntary muscles alike.

here again we find one form of tissue doing
double duty for in the higher animals the
voluntary and involuntary muscles are

Sharply distinguished from each other
 by their form - No such distinction is
 to be found here - this is not a striped
 muscle in the whole animal - Then shall
 we conclude that the worm has no voluntary
 motions - if we should jump to such a
 conclusion a few minutes unprejudiced
 observation would ~~greatly~~ convince
 us of our error - he clearly exhibits
 choice in many ways - but we will speak
 of this when we come to consider the nervous
 system - The Muscular walls of the
 intestinal canal does not materially
 differ from that found in the higher animals
 either in form or function

The Muscular system of voluntary

Motion also smooth fibers - is composed of two systems of fibers one ~~the~~ encircling the worm lying immediately beneath the epithelium and mostly contained within the epithelial folds when the animal is contracted - There is then distinct bundles of fibers in each segment of the worm corresponding with the Epithelial folds - There is this difference between these voluntary muscles and the involuntary muscles. The involuntary muscles of the intestinal tube are not arranged in bundles while the voluntary muscles are generally arranged in tolerably distinct bundles though they are rather small. The other system is longitudinal

fibers the bundles running the
 whole length of the animal. They
 are arranged in Eight divisions
 which are maintained from the
 fourth segment ~~from the~~ to the next
 to the last - in the same form. There
 are four broad ^{divisions} ~~belts~~ and four narrow
 ones. The broad ^{divisions} ~~belts~~ run one along
 the ^{dorsal surface} back - one along the ^{ventral surface} ~~abdomen~~
 and the other two along each side
 of the animal. These four are about
 equal in size and each occupies about
 one fifth of the circumference of the worm.
 The four smaller divisions occupy the
 space between the broader ones.

The divisions between these are always

complete - and correspond with the position of the hairs which we have already mentioned as being placed eight in each segment. These hairs extend almost through the muscular wall -

These longitudinal fibers are not arranged in straight bundles but - they are plated together in a very curious and indescribable way when the worm is contracted -

Cross sections of them often show very pretty patterns something like fern leaves extending from the periphery inwards. The bundles as we have said are continuous from end to

of the worm but the fibers themselves
 -as is the case with all smooth muscular
 fibers are short and connected together
 in something of a pinnate fashion yet
 without anything that can be called
 a tendon - there seems to be no such
 thing as a tendon in the worm
 About the head of the worm this
 arrangement of the muscular fibers
 is lost - giving place to an arrangement
 as we suppose better suited to the
 purposes of the animal but too intricate
 to be at all easily made out or
 described. The fibers seem to run
 in every conceivable direction
 When the worm is very much contracted

the longitudinal fibers are very much
folded upon themselves especially the
inner portions of them next the peritoneal
cavity - a few fibers laying against the
circular bands still remain straight or
nearly so

The peritoneal cavity or ^{more properly} ~~peritoneum~~
~~chylagous~~ the Chylagous cavity -
extends from the fourth segment
to continuously to the last - entirely
surrounding the alimentary canal
Within it - are found the principal
blood vessels - the liver cells - the
salivary gland the Chylagous fluid
and folds of the peritoneum connecting
the alimentary canal to the muscular
walls In the posterior two thirds of
the worm there are four folds to each
segment extending from the intestine
to the muscular wall which prevent
the intestine becoming much displaced
either backward or forward and yet

allowing

& very considerable liberty of motion
In the anterior third there seems to
be nothing of this kind

This cavity - we call the Chyliferous cavity -
because of the peculiar use to which it is
put - in this little creature and most other
creatures in a similar stage of development

In man and the higher animals the
Chylopoetic system is very complex
The Mesentary suspending the intestinal
tube and including in its complex
foldings the bloodvessels and an
extensive series Chyliferous vessels
and Lymphatic glands. These are
entirely absent in the worm. The
& slight-folds of the peritoneum which

some as stays to the intestinal tube have only a few blood vessels passing to and from ~~they have no chyliferous vessels or glands~~
~~No vessels nor glands~~ The plan

of the chyliferous system is entirely different. The Chyle or the product of intestinal digestion instead of being received by a system of blood and chyliferous vessels simply exudes through the intestinal wall into the Peritoneal cavity - hence we call this cavity - the Chyliferous Cavity for the reason that the chyle it contains is a very thin watery fluid - but otherwise resembles the chyle of the higher animals - It is ^{about} ~~nearly~~ as white as ordinary skinned milk and resembles it very much in its microscopic characters; the difference

that its oil globules are more uniform in size - These globules ~~often~~ become aggregated to ^{as white masses} larger more or less and can readily be seen, with the microscope floating backward and forward as the fluid vibrates in its cavity.

This fluid has a perfectly free motion in its cavity - throughout - the length of the worm and comes in direct contact with all parts of the web like peritoneal membrane clothing the muscular walls. The principal blood vessels float freely in this fluid. They consist of two great branches the principal vein and artery. ~~The~~ ^{The} Portal Arches, the Cardiac arches - ^{floating free in the cavity} - Esophageal plexus

and branches of distribution within the tissues

The principal vein runs from the posterior extremity of the worm forward to the cardiac arches which are situated just in front of the clitellum. It receives in its course the Portal arches. ^{these arches} ~~these~~ arise from either side of the intestinal tube - one arch for each segment behind the clitellum - and arching up over it - join the principal vein at the center. These arches are of considerable size but open into the principal vein by a narrow valve like orifice - ^{which prevents} ~~these will~~ the blood from regurgitating into them ~~be noticed again when we speak of the~~ ~~when~~ during the contractions of the vein

They receive the blood which has
~~Liver~~ x circulated through the walls of the
 intestinal tube and convey it to the
 principle vein (Chords)

The Cardiac arches and the

Oesophageal plexus is an exceedingly
 intricate congeries of vessels surrounding
 the Oesophagus occupying a considerable
 part of the space between the Cistellum and
 the salivary gland. The Arches are double
 that is to say there is first looped or arch
 shaped expansions of this portion of the
 principle veins, and at the termination
 of each of these - at its contracted portion -
 a lateral arch is given of which encircles
 the Oesophagus - and as it does so each
 breaks up into a most intricate network
 of capillaries which pervades the entire
 structure of this portion of the Oesophageal

Oesophageal Plexus 35-

tube This is a most-singular anatomical arrangement which I have studied with much interest but-as yet-am at-a total loss as to its physiolog. The Oesophagus through the part-is very narrow-a mere slit-and does not seem capable of any considerable dilation-The plexus is confined to its walls

The number of arches is five-and here we find the very singular feature of the anatomy. They represent-the same five arches that are present at-some time in the life history of every vertebrate animal all the way up to man-Whatever may be

added to or taken away from the
 make up of the animal. These five
 arches are never absent if that
 animal is to be a vertebrate.

In man they appear only in the
 fetal stage and very early in that
 the form having almost entirely
 disappeared at birth. The arch
 of the aorta is the only portion of
 it - remaining complete in the adult.
 Another arch is represented by the
 lungs another by the subclavian artery
 the upper extremity - another and so
 on. While the arches disappear
 as to the arch form - and what
 is ~~especially~~ especially singular

one half of ³⁷ Esophageal Plexus
is that, these arches ~~first~~
disappear by obliteration during
the development of the human fetus.
They are formed and again blotted
out - and the first one formed is
~~blotted~~ obliterated before the last-
one is formed or at about the same
time.

In the human one of these arches
supplies the lungs.
In the ~~frog~~ tadpole three of them
are occupied solely with the
respiration and in the fish all
of them contribute to the aeration
of the blood in the Branchiae.
It is from this history of the

arches that they are called Branchial
arches even in those animals
which never breathe with gills

~~The type is persistent throughout~~
~~the vertebrate animals none of~~
~~them are without it~~ - we give
specimens of ~~dogs~~ in diagram
of them in Man the Chick
Frog and earth worm -

The Lungs have long ago been
regarded as a great gland - This
notion was arrived at from the study
of its development - In the earth worm
these arches and the plexus they form are
undoubtedly the analogue of the Lungs
of the gills of the Fish - of this there

is no room for doubt - Here we find
 a most-wonderful persistence of a
 similar form in the different species
 of animals - But of this it might
 be said that the ultimate object - ~~was~~
 in all is the aeration of the blood
 before its distribution to the general
 system - But now we have passed
 that point in the earth worm - for
 in this little fellow these branches
 are not for the aeration of the blood
~~enter the tissues of the~~
 They ^{and} do not leave the tissues of the
 Oesophagus ~~which they enter until~~
 they ^{are} ~~emerged~~ into the arteries which
 distribute the blood to the tissues
 at large - and it is well known

that the aeration of the blood is carried on entirely through the skin. And now comes the very novel feature. This plexus in the earth worm is in fact - a gland.

It is a gland of very unusual character. Although we do not yet know its office we can make out its histology. This is entirely new to me - and though many instances of it may be found to occur in low forms of animal life I have as yet seen no allusion to it.

The wonderful feature of this gland is this. The blood vessels constitute the framework of the gland and the gland cells are ~~are~~ placed in

columnar form around the vessels with the long axis perpendicular to them. The interstices ~~of the~~ to receive the secretion are formed by the spaces left between these. These interspaces have two or more ducts opening into the Oesophagus - we therefore find that this plexus forms a gland secreting a fluid which it ~~passes~~ discharges into the alimentary canal but we know nothing of its nature or function.

tube. This is a most singular anatomical arrangement and I am at a total loss as to its physiology. This part of Oesophagus is very narrow indeed it is a mere slit in a Perpendicular direction through this mass of blood vessels and its size and form are maintained throughout the length of the plexus - Cuts between the arches shows that the plexus continues from the one to the other.

The principal vein throughout its length when seen in the living wound is found to be in a continuous state of contraction and expansion - This is hardly to be called a pulsation - it is more like a vermicular motion beginning behind and running forward.

gaining in power as it advances and
culminating in the Cardiac arches where
the greatest contractions are seen
(All its blood seems to come from the Portal arches)

The Blood - if it may be so called
has ^{no form elements} ~~no~~ ~~morphological forms~~. There
are no globules. No particles. Nothing
whatever that can be recognized with
the Microscope. The color is a bright
Crimson - and it is thick and viscid
about of the consistence of ordinary syrup.
If a large vessel be cut very little of the
fluid will escape - It coagulates very
firmly and sometimes assumes a slightly
fibrous character - It may be preserved
in color in Millers fluid - but will
coagulate and become brittle

The ventral surface. All the blood vessels converge to the esophageal plexus in the earth worm as they converge to the heart - in the higher animals - They are also very minutely distributed to the tissues of the body - A good dissection of the mouth and lips of the earth worm will show as rich a capillary system as the lips of man

Arterial system H4

After being coagulated in Mullers fluid it may be tolerably preserved in balsam thus giving us specimens with a natural injection some of which are very beautiful.

The Arterial system is composed of three principle arteries the largest of which lies within the chyliferous cavity but is closely attached by peritoneal folds to the spinal cord throughout its length. ~~The vessel~~

This vessel sends off numerous branches to the tissues and through the peritoneal folds to the alimentary canal. This vessel arises from the esophageal plexus and has an anterior and posterior portion. Another small vessel accompanies the spinal cord throughout its length. While the third runs along

Nervous system 46

The Nervous system consisted as in most other animals of a Brain - spinal cord. and nerves - It has however but one brain - no division into anterior and posterior brain - it consists of a single mass of Brain substance - A very considerable enlargement of the anterior portion of the spinal cord which is fissured into two lateral halves much as our brains are

From this which occupies several segments of the worm the spinal cord or nervous cord passes backward to the last segment and has a modular swelling corresponding with each segment of the animal

From the anterior portion of the brain two bundles of nerves pass forward and

distributed to the parts about the mouth. From each side Nerves are given of - two of which, one on either side, are gathered together into a nodule which are probably rudimentary eyes. Along the spinal cord there are nerves given of corresponding with each segment throughout its length which are distributed to the tissues of that segment.

The earth worm you will see is not especially poor in nerves - His brain also is large when we consider the ~~pos~~ lowly position of the animal in the scale of life. Of the five senses he has certainly but - two, the sense of

tuck and the sense of taste, we do not certainly know that he has the latter but it is fair to presume that he has - that the rich plexus of nerves about the mouth supply this sense -

As to the sense of touch there can be no question - every part of his body is endowed with this sense and it seems to be very acute - in a word he is a very sensitive little creature. This sense must serve him instead of eyes to guide him when he comes out of his burrow at night in quest of his mate - and must show him his way back again ~~also~~. It must also serve him instead of ears - instead of smell

What use has this little creature for
 brain. Suppose one of us bereft-
 of arms, legs, hands, feet - of sight-
 of hearing of the sense of smell, what-
 could we do with our great-cerebral
 masses - Not much certainly. I doubt-
 if we could so use it - as to gain a
 living for ourselves - we certainly
 could not unless we had some special
 gifts as to the structure of our bodies
 fitting us for some particular mode
 of life and of gaining a livelihood
 but even then I think we could not
 make much progress in the sciences
 Well we must not expect any very
 great manifestations of brain power

from the earthworm, he is very
 poor in the means of expressing his
 thoughts - and unless we observe him
 very closely we will not discover that
 he thinks at all - His principal
 enemies are the ~~poor~~ Birds above
 ground and the mole below the
 ground - where the Moles are
 — ^{So Dr Wood of London says} —
 plentiful the Worms learn to avoid
 them by running out of the ground
 when they feel the earth shake - and
 this may be taken advantage of when we
 want to catch them for bait - just -
 stick down the garden fork and
 shake it - gently and the worms thinking
 the mole is after him comes to the

surface in haste - but if the mules
 are not plentiful and he has this not
 become acquainted with this enemy
 in the earth - you will shake your
 fork in vain - in that case the
 enemies he knows are all above
 ground and he will either lay very
 still or he will go deeper

Many instances might be brought
 forward to show that he exhibits
 the power of choice ~~and~~ if space
 would allow -

The Liver 52

We will now speak of the liver Our chief object in studying the earth worm was the examination of this organ ~~Our~~ Our notions of the liver are not as yet - very certainly fixed - ~~a good deal~~ there is considerable uncertainty as to its exact - physiological office or offices for it - seems to have more than one - it - seems to be a compound organ It secretes gall and delivers it into the intestine evidently to serve some purpose in connection with digestion and assimilation -

Again it is proven that ~~the~~ sugar is one of its products and that this sugar is not - discharged from the

ducts of the gland but is delivered
 directly to the blood circulating
 through it - It also seems to
 have something to do with ^{the} collection
 of and the maintenance of the fats
 of the body ^{Especially in the lower animals} - The liver of many of
 the lower animals contains a very
 considerable amount of Oil - sometimes
 of peculiar quality - we all know
 something of this oil from the Cod fish
 We had been inclined to regard the
 Liver as the great organ of the Blood-
 vascular system but Koeliker has
 in his recent great work on embryology
 proven conclusively that it belongs
 to the Alimentary system - That

it is the product of the ~~entoderm~~
 Entoderm - of the alimentary
 Canal - It seems that the liver
 arises from a bud or diverticulum
 given off from the duodenum at -
 a very early period of fetal life
 This grows in toward and its cells
 very soon surround the Vena
 Omphalo Mesenterica around
 which its development proceeds
 This marking its very early and
 entical connection with the blood
 It is the only gland in the system that is formed round
 about ~~adherent~~ ^{about adjacent blood vessel} blood vessel
 vascular system - It also becomes
 so placed in reference to the circulation
 and the alimentary Canal that
 the blood circulating in the

walls of the intestinal tube
and taking from it the products
of digestion must first be passed
through the capillary circulation
of the liver before being passed
on to the general circulation

This is called the portal circulation

This is briefly the position in
which the liver stands in relation
to alimentation and the circulation
in ~~the~~ man and the higher animals

We will presently speak more particularly
of the lacteal system

Now let us see in what relation we find the liver to these in the little worm we are studying.

It is certainly a perfect curiosity. Its cells are scattered almost from end to end of the worm. They are nowhere aggregated into the form of a gland but each individual cell is a gland in itself acting independently for itself ^{in its ministrations to the animal}. All along the ~~the~~ alimentary canal from the ^{Oesophageal Pylorus} ~~stomach~~ to its posterior extremity they stud its entire outer surface. ^{They} They are not within the wall

of the intestine but - they
 are attached to the wall
 each cell by a little ^{pedicle which forms a} duct
 of its ~~own~~ own and the cell
 hangs out freely from the wall
 and floats in the chylaceous
 fluid - Did any of you ever
 dissect out the fresh duodenum
 from man or any of the higher
 animals and expose its inner
 surface ~~with its long villi~~
 under water and examine
 it - with a low power and
 see ~~the~~ ^{to and fro} that forest of
 villi swaying ^{the} with motions
 of the water like a field

of growing wheat before
 a breeze? If you will do
 the same with ~~the~~ ^{of the intestine} the outer
 wall, of the earth worn you
 will see a very similar thing
 but instead of villi it will
 be the liver cells floating
 and ^{with every motion of the fluid} swaying, ~~before your~~
 eyes - With a low power they ~~tot~~
 form a yellowish swaying velvety
 flock ^{etely} ~~completely~~ covering the
 muscular wall and hiding it
 from view This is composed

When we search this out with the
 higher powers we find ^{this flock composed} ~~these~~ a flock
 each one
 shaped cells, seemingly included in

a membrane which continues ^{and} ~~at~~
~~the attachment of the~~ in the form
 of a duct attaching the cells to the
 intestinal wall and - as we suppose
 continues through ~~the~~ ^{its} several coats
 discharging its secretion into the
 intestinal cavity.

Now if we turn our attention to
 the portal arches and the principal
 vein we find ~~them also that~~ the
 lateral sides of the veins and the
 posterior and anterior sides of the
 portal arches fringed with the same
 cells which discharge their secretion
 directly into the blood vessels
~~Upon the portal~~ These you

will notice are all placed in such position that they will not be crushed against the muscular walls when the intestine is very full.

Upon the portal arches there are occasional Ceca hanging off from the vessels on which these cells cluster like a bunch of grapes upon a stem. These are present from the posterior extremity of the worms forward to the cardiac arches occurring on almost every one of the portal arches - sometimes two or three on one arch.

This is apparently widely different from the liver in man and the higher animals - ~~The~~ In form we

find no such thing as the great gland with its lobes ~~and~~ gall bladder and duct.

Yet - when we come to study its function we find but little difference - for here all along the alimentary canal we find the cells with their ducts opening into the intestinal tube - instead of one duct which carries the collected secretion from the whole number of cells - each cell has its own duct. And then upon the bloodvessels we find the cells again discharging the product of their functional activity.

directly to the blood - Instead of the circulation of the blood bringing the product of digestion from the intestine to the liver direct - and spreading it through its capillaries to be acted upon by its cells - here we find the liver cells continually bathed in the product of digestion - the chyle which has passed into the chyle agnous cavity - Here you see we have the complete identity of function though the form assumed is entirely different. The Liver is still placed between the act of digestion and the delivery

of the product of digestion to
the general circulation and performing
practically the same office in the one
as in the other

Mesentary 64

Several years ago in writing of the Mesenteric glands we made the remark that they seemed to be so many little livers which performed a similar office toward the fats taken up from the alimentary tract, ^{by the lactals} as the liver proper performed toward the albuminous and starchy foods which ~~were passed through~~ are taken up by the blood and passed through the ~~large~~ great organ - As the product taken up by the blood must pass the capillary circulation of the liver so must the product taken up by the lactals be passed through the mesenteric glands ~~But in our little~~

Here is a division of labor again
 which belongs to highly developed
 society - The society of cells forming
 our earthworm are not so much
 developed and have not this division
 of labor - There is no lacteal
 glands and therefore the liver cells
 must administer the fats as
 well as the other products of digestion
 Hence we find the liver cells of the
 worm loaded with fat - and this
 is especially true of all those lower
 animal forms in which no mesenteric
 glands exist - We throw this in
 as a simple line marking the
 course of organic development

Theory of Secretion 66

from the lower to the higher forms

In these cells of the liver we have a most-concise disproof of certain ideas that have prevailed in regard to the manner of the performance of the act of secretion.

It has been held that the gland cells grow from the ~~per~~membrana propria or from a certain point in the lobule of the gland and as they come to maturity they ~~p~~ burst and dissolve in their own fluid and thus form the secretion.

This is a mistaken notion conceived long ago when the investigation of the cell and its manner of the

performance of its function was
 yet - in its infancy and has been
 continued as affording a thoughtful
 explanation of a subject that
 presented great difficulty of
 solution. We do not believe this
 to be demonstrably true of any
 gland whatever in the entire
 detail of ^{the secretory} ~~its~~ function - it is however
 true in part of one class of glands
 the sexual glands - in these the
 cells seem to form and grow in
 the manner described - but they
 are discharged from the gland as
 cells (mingled with a fluid
 formed ~~then~~ in part within

the gland itself but mostly by the cells of the ducts of the gland or by supplemental glands upon which this function devolves) and the cells so formed have their function to perform as cells after they leave the gland which formed them.

This function is in every case something ~~so~~ very different from the function of ordinary secretions.

We have critically examined the liver cells of the earth worm - and many of the low forms of animals and we are certain that Dr. Carpenter was mistaken when he said that what we call cells - are "flask-shaped".

Ceca filled with developing cells
 which burst - on maturity and
 form the secretion - the granules called
 cells in this case are nothing more
 nor less than globules of oil collected
 within the body of the cell and they are
 discharged from the cell through its
 duct - as oil globules and enter the
 blood vessels as oil globules and
 are quickly lost - sight of - but in the
 little Ceca of which we have spoken
 they may be distinctly seen - we have
 by manipulating the cells under high
 powers seen these oil globules
 pass out and through the ducts
 and have in the same cells ~~and~~

distinctly seen the nucleus of ~~the~~
~~the~~ studied about with these oil
globules - and also clearly demonstrated
the nucleus strongly
by staining with hematoxylin

Section is not brought about
by the destruction of the cell performing
the act - but is the result of a choice
of materials by the sarcode of the
cell body which after being acted
upon by the life principle residing
in that sarcode is again discharged
from a certain part of the cell
as a new product differing essentially
in its properties from the material as
taken into the cell - This is the

The functional office of gland cells
That gland cells are continually dying
and being discharged with the secretion
of the gland is of course true and
can at any time be demonstrated
all epithelium is continually being shed
and renewed

Urinary and sexual systems

72

distinct

The earth worm has no urinary apparatus - This function is performed probably by the cells of the alimentary canal

We have not time in this paper to speak at any length of the sexual organs of the earth worm - both sexes are included in the same individual But - the mutual congress of two individuals is necessary for fecundation as they are not capable of self fecundation

The sexual pores open ~~just~~ a little way in front of the clitellum on either side of the lower part of the body - while the oviducts

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stretch backward from them
on either side. The Testicles
are situated beneath the back
part of the esophageal plexus