BIO 221
Invertebrate Zoology I
Spring 2010

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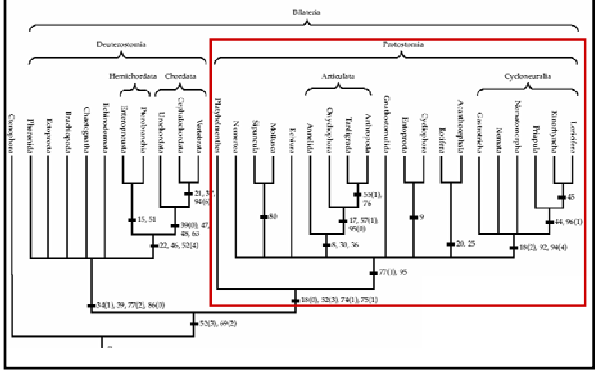
http://www4.nau.edu/isopod

Lecture 24

Protostomia



Protostomia

1. Synapomorphies

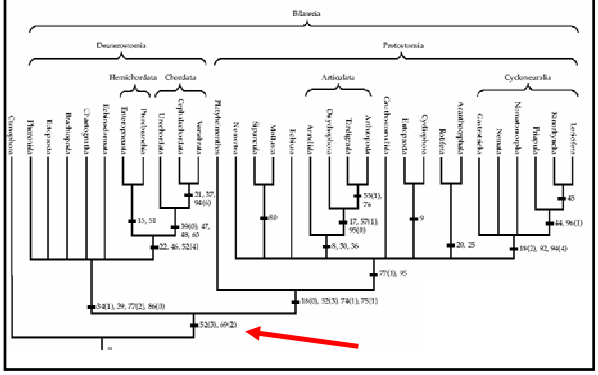
a. 18(0) – Cleavage pattern spiral.

b. 52(3) – Ventral or ventrolateral synaptic nervous system.

c. 74(1) – Entomesoderm derived from a single mesentoblast (4d) cell.

d. 75(1) – Subepidermal muscle in sheets, derived (at least in part) from 4d cell.

Rotation at the Proto-Deutero Node

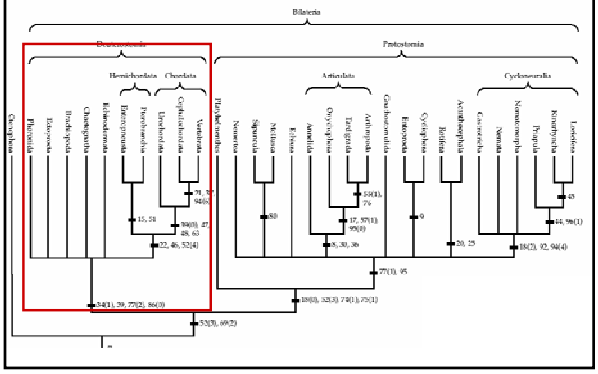


Synapomorphies Common to Bilateria

a. 52(3) -Ventrally located nervous system.

b. 69(2) - Primary symmetry bilateral with cephalization.

Deuterostomia



Deuterostomia

1. Synapomorphies

a. 34(1) – mesoderm derived from archenteron by enterocoelic pouching

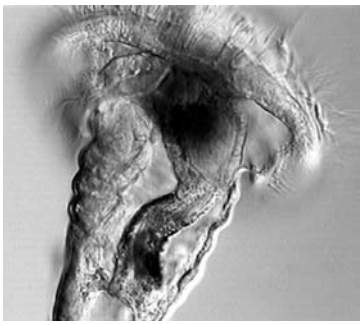
b. 39 – tri partite coelom (anterior, middle and posterior compartments)

c. 77(2) – internal body cavity lined by peritoneum (mesodermally derived).

d. 86(0) – anterior body cavity unmodified as a proboscis.

Invertebrate Classification

Note: we now have some additional characteristics that can be used to classify **Protostomes** and **Deuterostomes**.



Protostomes

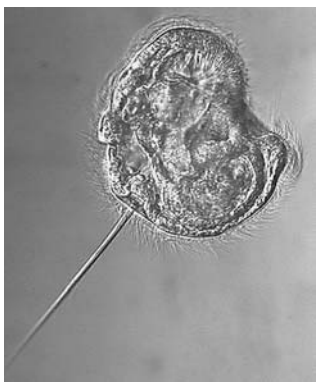
a. Usually spiral, determinate cleavage.

b. Name from "first mouth"; blastopore becomes mouth.

c. Coelom formation by schizocoely.

d. Represent a major evolutionary lineage.

1. Some exceptions are now known; e.g. Lophophorates.



Deuterostomes

a. Usually with radial, indeterminate cleavage

b. Name from "second mouth" blastopore becomes anus, mouth forms later.

c. coelom formation by enterocoely

d. also represnt a major evolutionary lineage

1. again with some exceptions.

Invertebrate Evolution

Sources of Coelom

a. Gonocoel theory

1. internal cavities of acoels containing gametes persisted and became body cavities.

2. Gametes and coelom often *are* associated

3. But: cavity usually appears to precede deposition of gametes into it.

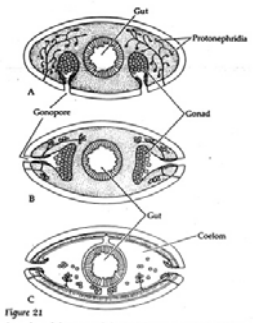


Figure 21

A version of the gonocoel theory (schematic cross sections). A, The condition in flatworms, which have mesodermally derived gonads leading to ventral gonopores. B, The condition in nemerteans, which have serially arranged gonadal masses leading to laterally placed gonopores. C, The condition in polychaetes, in which the linings of the gonads have expanded to produce coelomic spaces with coelomoducts to the outside. (After Goodrich 1946.)

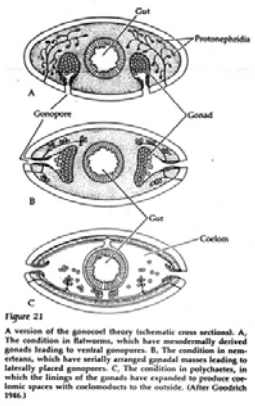


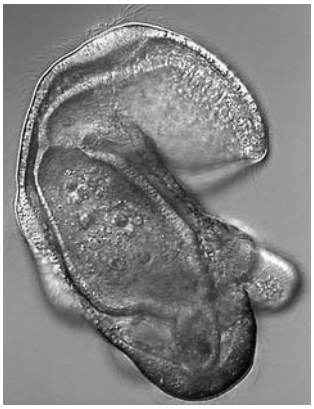
Figure 21

A version of the gonocoel theory (schematic cross sections). A, The condition in flatworms, which have mesodermally derived gonads leading to ventral gonopores. B, The condition in nemerteans, which have serially arranged gonadal masses leading to laterally placed gonopores. C, The condition in polychaetes, in which the linings of the gonads have expanded to produce coelomic spaces with coelomoducts to the outside. (After Goodrich 1946.)

Sources of Coelom

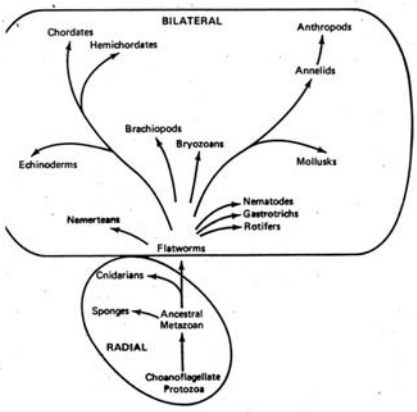
Nephrocoel Theory

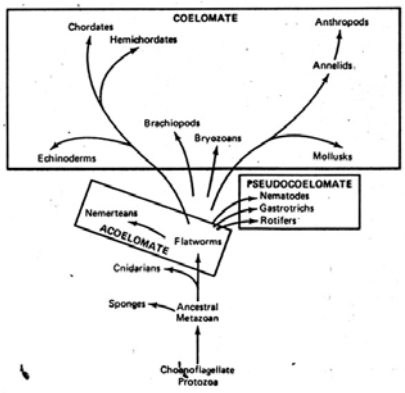
1. Excretory openings of acoels became modified to form body cavities
2. Same arguments as for gonocoel model.
3. Also require monophlyletic origin for all coelomate phyla
   a. As we will see this is unlikely.

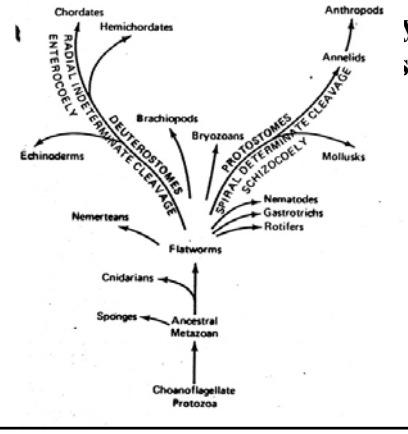


Other Developmental Characters

1. Egg characters
2. Cleavage characters
3. Blastula
4. Gastrula
5. Coelom characters
6. Note various evolutionary relationships that seem to fit, not fit.




COELOMATE
Chordates
Hemichordates
Anthropods
Annelids
Brachiopods
Bryozoans
Echinoderms
Mollusks
PSEUDOCOELOMATE
Nematodes
Gastrotrichs
Rotifers
Nemerteans
ACOELOMATE
Flatworms
Cnidarians
Sponges
Ancestral Metazoan
Choanoflagellate Protozoa


Chordates
Hemichordates
Anthropods
Annelids
RADIAL, INDETERMINATE CLEAVAGE
ENTEROCOELY
DEUTEROSTOMES
Brachiopods
Bryozoans
PROTOSTOMES
SPIRAL, DETERMINATE CLEAVAGE
SCHIZOCOELY
Echinoderms
Mollusks
Nematodes
Gastrotrichs
Rotifers
Nemerteans
Flatworms
Cnidarians
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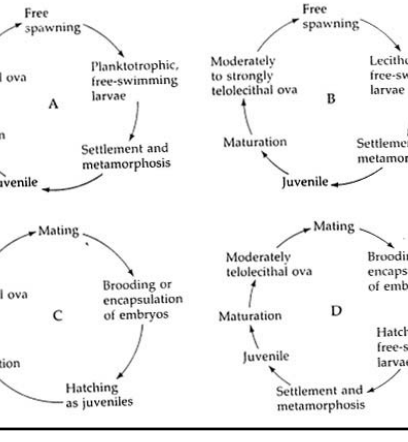

Free spawning
Weakly isolecithal ova
Planktotrophic, free-swimming larvae
A
Maturation
Settlement and metamorphosis
Juvenile
Free spawning
Moderately to strongly telolecithal ova
Lecithotrophic free-swimming larvae
B
Maturation
Settlement and metamorphosis
Juvenile
Mating
Strongly telolecithal ova
Brooding or encapsulation of embryos
C
Maturation
Hatching as juveniles
Mating
Moderately telolecithal ova
Brooding or encapsulation of embryos
D
Maturation
Hatching as free-swimming larvae
Juvenile
Settlement and metamorphosis

Life History Characters

Isolecithal ovum	Radial holoblastic cleavage	Coeloblastula	Invagination	Coelogastrula	Enterocoely
Weakly telolecithal ovum	Spiral holoblastic cleavage	Stereoblastula	Epiboly	Stereogastrula	Schizocoely
Isolecithal ovum	Radial holoblastic cleavage	Coeloblastula	Ingression	Diploblastic condition	
Moderately telolecithal ovum	Modified spiral cleavage	Coeloblastula	Ingression	Pseudocoelomate condition	
Strongly telolecithal ovum	Meroblastic cleavage	Discoblastula	Involution	Discogastrula	

Metazoan Evolution

Ernst Haeckel (1834-1919)

Colonial Theory

1. First proposed by Ernst Haeckel (1874)

a. Source of "ontogeny recapitulates phylogeny"

1. Much philosophical debate about this

2. Has leaked into human development as well.

The Colonial Theory

b. Haeckel noticed that certain "lower" organisms resembled developmental stages of "higher" organisms.

The Colonial Theory

a. *Blastea* - simple multicellular organism.

1. A hollow sphere of flagellated cells.

2. Simple specializations

a. Locomotion

b. Reproduction

c. Transport, absorption via cell membranes.

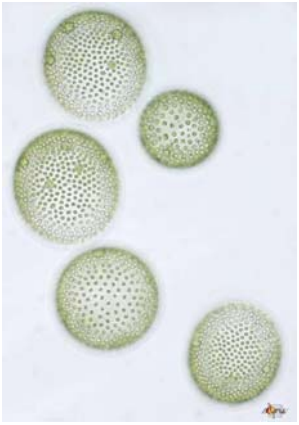
3. Living example: *Volvox.*

The Colonial Theory

a. Has led to assumption that *Volvox* WAS the ancestral example

b. Not likely, but possible that similar example actually existed.

c. Rapid reproduction can cause cells with chloroplasts to lose them.



The Colonial Theory

Gastraea

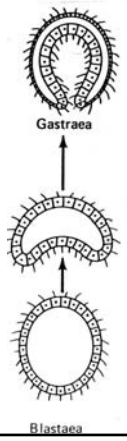
1. Bilayered organisms that arose when blastaea-like ancestor.

Underwent invagination.

a. Produced two-layers of cells.

b. Potential for further specialization.

c. With "blastopore" like opening (mouth).



The Colonial Theory

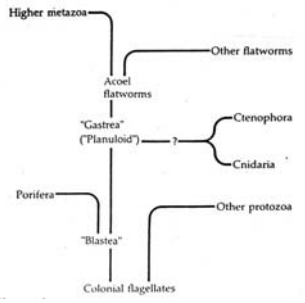
Gastraea

2. Two lineages proposed to have arisen:

a. Radiate phyla

b. Bilateral phyla.

3. Both of these apparent lineages recapitulate these stages in their development.



Evidence For:

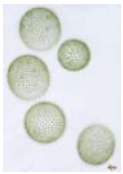
a. Many living examples of colonial aggregations of flagellated cells

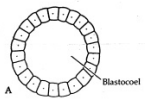
1. Algae

2. Choanomastigotes

3. Porifera - multicellular, flagellated cells.

b. Developmental evidence.





Evidence Against:

a. Problems with ontogeny-phylogeny analogy

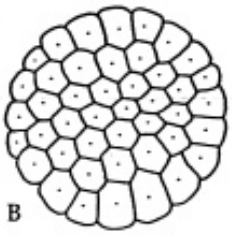
1. Examples used resemble embryonic stages, not adults.

2. But later same argument used to show that developmental programs are conservative.

Evidence Against:

b. Cnidaria

1. gastrulas are *solid* not *hollow*.



Revision by Metschnikoff (1887)

a. Suggested that blastea didn't invaginate, it underwent *ingression*.

b. Generated the solid gastrula characteristic of cnidarians.

1. called ancestor a *Planuloid*

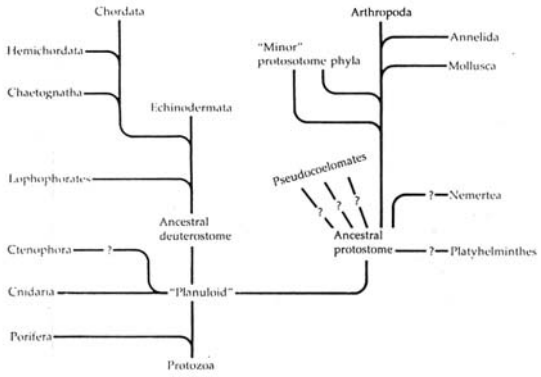
ELIE METCHNIKOFF, 1845-1916

The Planuloid Theory

a. An ovoid, solid mass of cells with exterior flagella, radial symmetry.

b. No mouth, exterior phagocytosis, materials shunted inward.

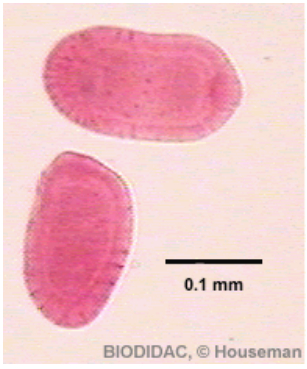
2. Very similar to cnidarian planula larva.



Evidence For:

a.Accounts for solid gastrula of Cnidaria.

b. Is structurally similar to cnidarian planula.



Evidence Against:

a. No living representatives other than the planuloid life stage of cnidaria.

The Plakula Theory

1. Otto Butschli (1883) suggested that no model explains why a digestive layer should evolve in the first place.

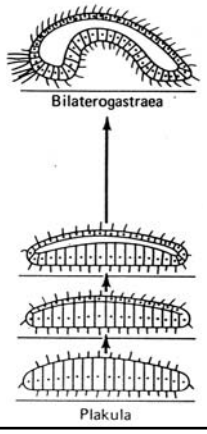
a. Why should an interior cavity be any more likely to be associated with absorption than external?

Otto Butschli (1848-1920)

The Plakula Theory

b. Why if cnidarians have solid planula should gastrulation occur?

c. Proposed a multicellular ancestor called a *plakula*.



The Plakula Theory

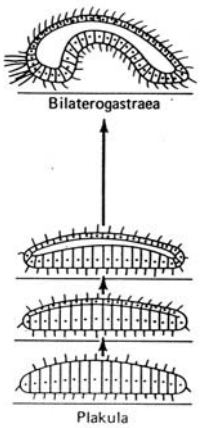
2. Characterisics

a. A flat, mass of cells, two cell layers thick.

b. Creeps on substrate, ventral surface modified for absorption.

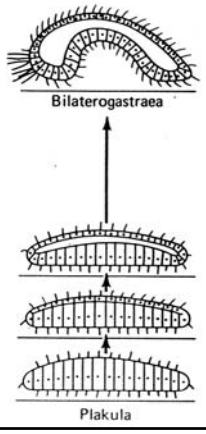
c. Hunches up to capture, digest food.

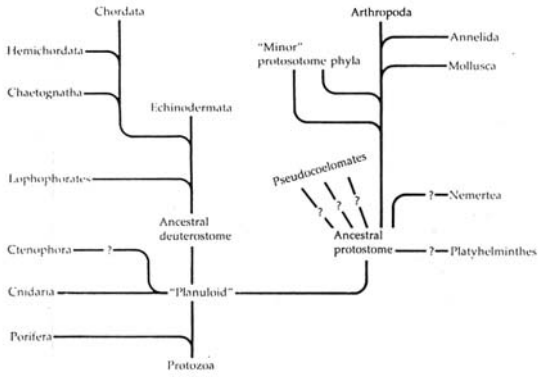
d. could give rise to other forms with more permanent cavity.



The Plakula Theory

e. Proposed progression: creeping existence -> bilateral symmetry -> *bilaterogastrea*





Evidence For:

a. *Trichoplax adhaerens* discovered soon after Butschli's hypothesis was articulated.

b. Similar appearance, habits, feeding behavior.

c. Hypothesis later revised by Grell (1969, 1985).

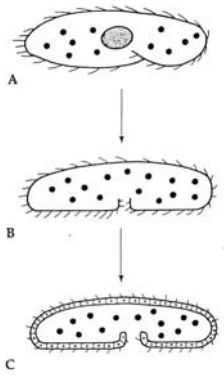
Evidence Against:

a. Still must account for appearance of radial symmetry in Cnidaria.

b. The jury is still out, but presence of extant example lends credence to idea of plakula ancestor -> bilaterogastrea.

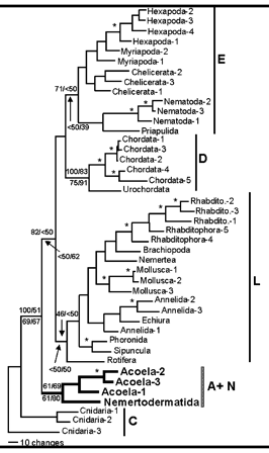
The Syncitial Theory

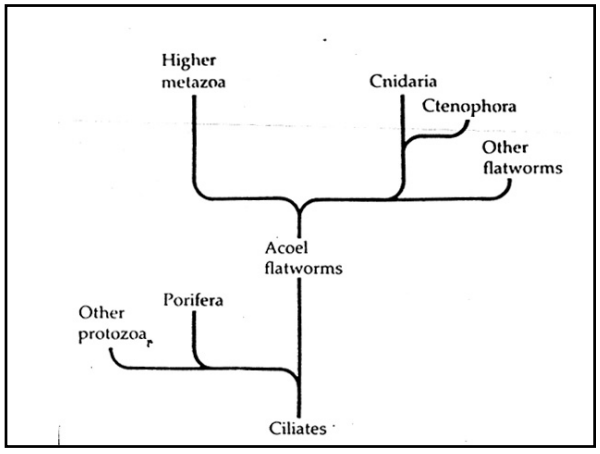
1. Previously popular, but recently discredited by molecular evidence suggesting that ciliates are only distantly related to Metazoa.



The Syncitial Theory

2. However, other evidence suggests that Acoel flatworms belong at the base of the Metazoan tree.





The Syncitial Theory

a. This need not suggest a link to ciliates, only that Acoels are simple in construction.