BIS 1B
Lecture 8 (Winter 2008)
Animal Phylogeny

I. Phylogeny of animals: framework of evolutionary relationships, based on shared key characters

A. The intent

1. Establish the framework for animal phylogeny
2. Explore conservative developmental traits of animals
3. Develop the concept of an animal

B. Knowledge of animal phyla phylogeny extremely limited

1. Fossil record poor- missing in particular associations
    a. Animal groups first appear in fossil record ~680-500 mya
    b. The Cambrian explosion: 540 mya thought to be evolutionary origin of animal phyla
2. DNA sequence data suggest animals evolved much earlier: ~1.2 bya
    a. Why no fossils?
    b. First animals may have been tiny or soft or both
    c. Example: lived in ocean sands- numerous contemporary examples
3. Existing phyla often highly divergent or convergent

C. Phylogenies are hypotheses

1. New data causes animal phylogeny to change periodically
    a. Apear different depending on which groups of animals or characters are included
    b. Relationships of several enigmatic animal groups remain unclear (e.g. Protostome phyla)
    c. We shall consider a number of alternate hypotheses
2. Phylogeny constructed using cladistic approach, a cladogram

a. Our approach will be backwards- heuristic reasons

1) Draw cladogram with taxa

2) Introduce characters used to build cladogram

3) Show where different character states appear

C. Characters defining key subdivisions of animal phyla

1. Types-

a. Conventional morphological traits

b. Embryological- developmental features

c. DNA and RNA sequences ("molecular data")

2. Generally lead to same phylogenetic conclusions

D. Embryological characteristics somewhat special

1. Identify homologous characters

2. The problem: distinguish them from products of convergent evolution

3. Developmental characteristics highly conservative

a. Mutation altering early stages of development usually have radical effects on final adult phenotype

b. Much greater effects than mutations later in development

c. Cascading downstream effects generally profoundly deleterious

II. Distinguishing features of Animalia- conventional morphology

A. **Character #1- *Multicellularity with cellular division of labor***

1. Numerous cells living together

2. Some cells performing different life tasks essential to survival of the whole

a. Principal definition of metazoa or Kingdom Animalia

b. We hypothesize metazoa is monophyletic (competing theories)

B. **Character #2- *Collagen***

1. Cells need extracellular structure- a “skeleton”

2. Permits organization and association

3. Collagen is a common extra cellular structural proteoglycan

III. Traits in early development

A. Cleavage

1. Initial process of division of fertilized egg (zygote)

a. Products are cells called **Blastomeres**, maneuverable

b. No growth just division and development of a longitudinal axis (animal-vegetal axis)

c. Many types of cleavage patterns; two important types, radial and spiral

d. Define two major lineages in Kingdom Animalia

1) Spiral cleavage: some of the Protostomes

2) Radial cleavage: the Deuterostomes

2. **Character- #3a**- ***Radial cleavage***

a. First two divisions are the same in both types of cleavage

b. Subsequent divisions are either parallel or perpendicular to the axis of the first divisions and the cells stack at right angles-90 degrees, even symmetrical layers.

c. Each early stage blastomere (cell) has the ability to develop into a complete embryo - called regulative development.

3. **Character #3b**- ***Spiral cleavage***

a. The subsequent divisions are at angles different from 90, such that cells stack up in the furrows produced by previous divisions.

b. Modification of radial cleavage

c. Individual blastomeres lack capacity to become individual embryo and are highly specialized in early stages of division.

4. Ultimately produces mass of cells called a blastula

a) Many types; generally a layer of cells arranged in a hollow ball

b) Central fluid filled cavity called blastocoel

B. **Character #4**- ***Gastrulation***:

1. Origin of true germ layers, and diploblastic construction (Greek: gastrula- stomach)

   a. Development of the three embryonic tissue layers, central role in all further development

   b. Many forms of Gastrulation

2. Commonest form: **invagination**

   a. Part of the blastula wall grows inward as a chamber in the blastocoel

   b. Opening to outside called **blastopore** subject to further development

      1) **Character #5a- *Mouth usually arises from blastopore***

      2) **Character #5b- *Anus from blastopore***

   c. Chamber called the **archenteron** (Greek: arch = beginning; enteron = gut

   Generally becomes gut

3. Tissue development

   a. Character #6a- *Diploblastic*

      1) Invaginated archenteron wall cells become **endoderm**

         a) Becomes lining of digestive system

         b) Associated organs (Greek: endon = within)

      2) Remaining outer surface wall cells become **ectoderm**

         a) Forms outer skin and derivatives

         b) Nervous system (Greek: ektos = outside; derma = skin)

   b. Character #6b- *Triploblastic*

1) Development of third tissue- **mesoderm**

2) Becomes muscles, organs, circulatory system, internal body support system, musculature

3) Lining of body cavity (Greek: meso = middle)

c. Origin of mesoderm

1) **Character #7a-** ***Mesoderm arises from 4 d cell***

a) Sixth set of cell divisions

b) One of 64 becomes 4d cell (embryological coding system), aka mesentoblast

c) Mesentoblast gives rise to mesoderm and triploblastic development

3) **Character #7b-** ***Mesoderm derived from archenteron***

a. Mesoderm forms by invagination of the archenteron

b. Pouches of archenteron pinch off and enclose a space which becomes a body cavity

C. Development of body cavity or **coelom**

1. **Character #8a-** ***Coelom (if present) by Schizocoely***

a. A cavity forms inside band of mesodermal tissue (a subgroup of Protostomes called Eucoelomates)

b. Mesoderm becomes pressed against inner surface of the ectoderm

2. **Character #8b-** ***Coelom derived by Enterocoely***

a. Cavity in mesoderm pouches becomes body cavity

b. Organisms with in the Deuterostome lineage

c. Process called enterocoely

IV. Symmetry

A Animal's overall shape- fundamental structure

1. Predicated on number of planes can we pass through the animal, dividing the animal into "mirror image" parts

2. A number of types and variations

B. **Character #9a- *Radial symmetry***

1. Cylindrical body shape one main axis about which body arranged

2. Infinite number of planes through axis divide animal equally

3. Example: phylum Cnidaria: jellyfish, sea anemones

4. Radial animal ecology- sessile or drifting, environment is encountered from any direction

C. **Character #9b- *Bilateral symmetry***

1. One plane of symmetry, divides animal anterior to posterior: left and right sides

2. *Homo sapiens* is bilaterally symmetrical

3. Bilaterally symmetrical animals move through environment with an anterior end forward

4. Corollary outcome of bilateral symmetry: Cephalization (G: Kephale = head)

   a. Development of a head- locomotor anterior

   b. Concentration of sensory, feeding organs at anterior end of animal

D. **Character #9c- *Secondary pentaradial symmetry***

1. Radial, but only 5 planes of symmetry

2. Secondary because derived from bilateral ancestor

3. Characteristic of phylum Echinodermata: starfish, sea urchins, sea cucumbers, etc

V. Larvae and larval development

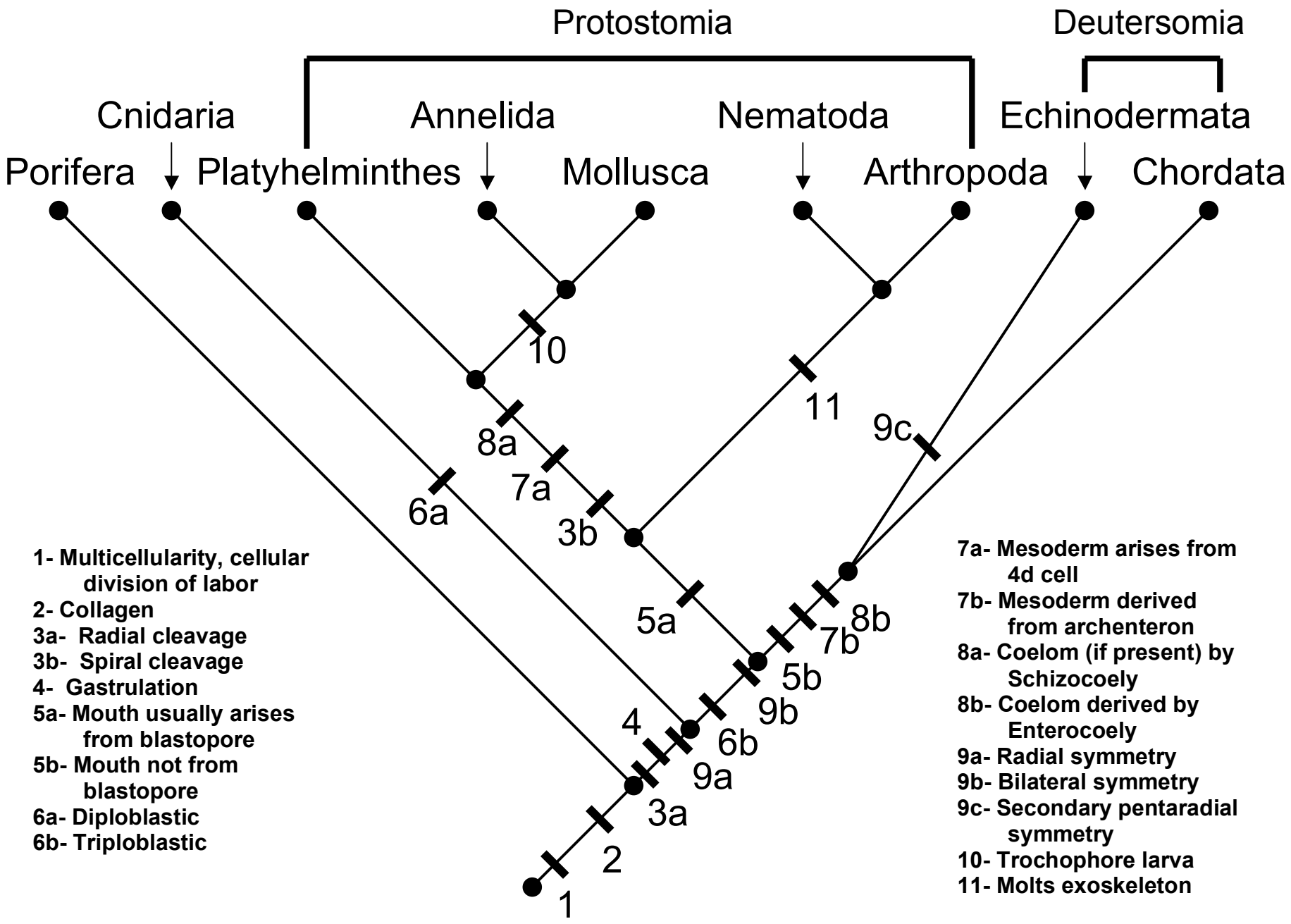
A. **Character #10- *Trochophore larva***

1. Free swimming ciliated marine larvae

2. Diverse but generally ovoid with circlets of cilia

B. **Character #11- *Molts exoskeleton***

1. Growth and development requires periodic shedding of cutical
2. Permits rapid changes in morphology



1- Multicellularity, cellular division of labor
2- Collagen
3a- Radial cleavage
3b- Spiral cleavage
4- Gastrulation
5a- Mouth usually arises from blastopore
5b- Mouth not from blastopore
6a- Diploblastic
6b- Triploblastic

7a- Mesoderm arises from 4d cell
7b- Mesoderm derived from archenteron
8a- Coelom (if present) by Schizocoely
8b- Coelom derived by Enterocoely
9a- Radial symmetry
9b- Bilateral symmetry
9c- Secondary pentaradial symmetry
10- Trochophore larva
11- Molts exoskeleton