Biology of Invertebrates
BIOL 337

Dr. Bob Podolsky

Lecture 1

"Classification and phylogeny"
or
"*3 reasons* why our course title has problems"

Robert D. Podolsky: vertebrate

Evolutionary Ecology and Functional Biology of Marine Invertebrates

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Research | Teaching | Publications

Interests

- Life-history evolution and ecology of invertebrate larvae
- Fertilization ecology and evolution of spawned gametes
- Physiological ecology of development in variable environments
- Plasticity of form and function during ontogeny
- Mechanical vs. physiological effects of temperature
- Quantitative, phylogenetic, and comparative methods

Course websites

Biology 211: Biodiversity, Ecology, and Conservation Biology

Spiny C. Star *: "invertebrate"* #1!

Features
- unusual 5-part body symmetry
- no brain, but a nerve ring and radii
- exchanges gases through surface papulae
- uses hydraulic system for locomotion
- 1000s of appendages called tube feet
- everts stomach to feed
- uses an imbricating skeleton for body support
- can alter its own connective tissue(!)
- cannot function in fresh or even brackish water
- releases gametes to reproduce

"More than just the knowledge of its parts"

invertebrate diversity

Nematoda
C. elegans

Chaetognatha
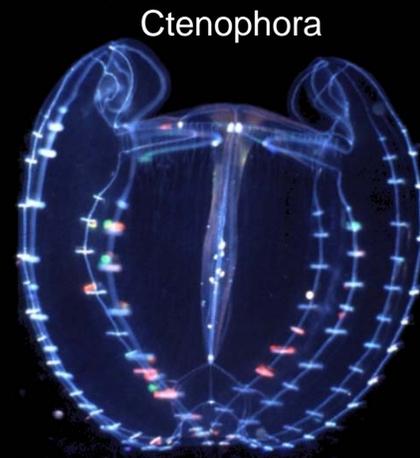
Ctenophora

Annelida

Brachiopoda

Hemichordata

pluteus

Nemertea
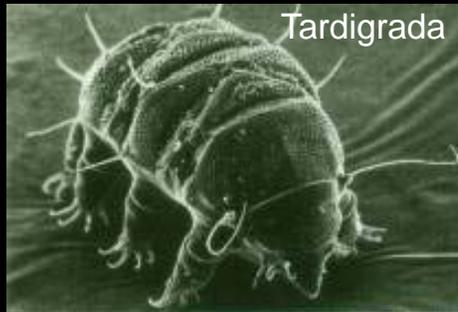
Tardigrada

Crustacea

Echinodermata

Porifera

Bryozoa

Priapulida

Cnidaria

CLASSIFICATION OF DIVERSITY: taxon size

PHYLUM	COMMON NAMES, DESCRIPTION	SPECIES
Ph. Placozoa	*Trichoplax*, discovered on aquarium walls	1
Ph. Porifera	Sponges	10,000
Ph. Cnidaria	sea anenomes, jellyfish, corals etc.	9500
Ph. Ctenophora	comb jellies	90
Ph. Platyhelminthes	flatworms	25,000
Ph. Mesozoa	mesozoans	50
Ph. Nemertea	ribbon worms	900
Ph. Gnathostomulida	tiny worms, interstitial in marine sand	80
Ph. Gastrotricha	"hairy-bellies," meifaunal worms	400
Ph. Rotifera	rotifers, microscopic primarily freshwater	2000
Ph. Nematoda	nematodes, worm shaped	80,000
Ph. Nematomorpha	horsehair worms	240
Ph. Kinorhyncha	spiny-crown worms, marine meiofauna	100
Ph. Loricifera	brush heads, marine meiofauna	10
Ph. Acanthocephala	spiny-headed worms, parasites	1000
Ph. Cycliophora	cycliophorans	1
Ph. Kamptozoans	entoprocts	150
Ph. Bryozoans	moss animals, ectoprocts	5000
Ph. Phoronida	phoronids, worm-shaped	10
Ph. Brachiopoda	lamp shells	335
Ph. Mollusca	chitons, snails, clams, squid etc.	110,000
Ph. Priapulida	phallus worms	16
Ph. Sipuncula	peanut worms	320
Ph. Echiura	spoon worms	140
Ph. Annelida	polychaetes, earthworms, echiurans	15000
Ph. Tardigrada	water bears, interstitial	700
Ph. Onychophora	velvet worms, terrestrial	80
Ph. Arthropoda		
Subph. Chelicerata	spiders, scorpions, horseshoe crabs, etc.	65,000
Subph. Crustacea	crabs, shrimp, barnacles, copepods, etc.	32,000
Subph. Tracheata	insects, centipedes, millipedes	860,000
Ph. Echinodermata	sea stars, brittlestars, sea urchins, etc.	6000
Ph. Chaetognatha	arrow worms	110
Ph. Hemichordata	acorn worms	90
Ph. Chordata		
Subph. Urochordata	tunicates	3000
Subph. Cephalochordata	amphioxus	23
Subph. Vertebrata	fish, amphibians, reptiles, birds, mammals	45,000

Legend:
- ≥ 10,000 species
- ≤ 100 species
- "worm"

#2!

> 1,200,000 "Invertebrate" species

45,000 Vertebrate species

CLASSIFICATION OF DIVERSITY

**HABITAT**

pelagic

benthic

epifauna

complex life cycle

meiofauna

plankton

nekton

infauna
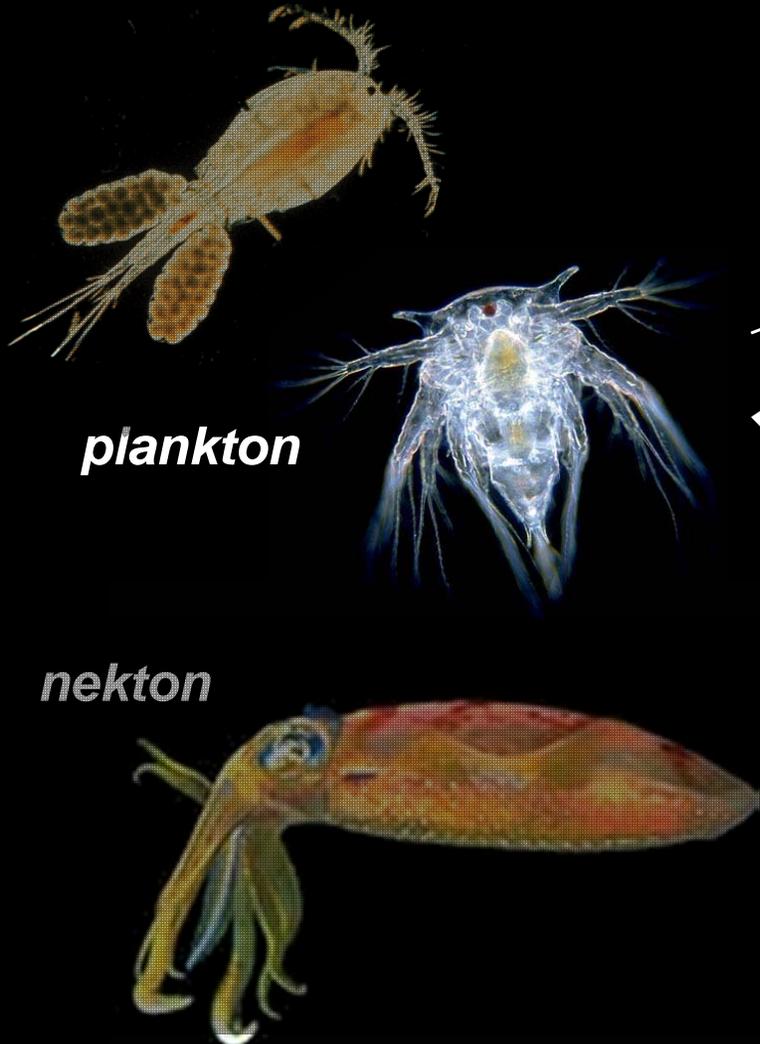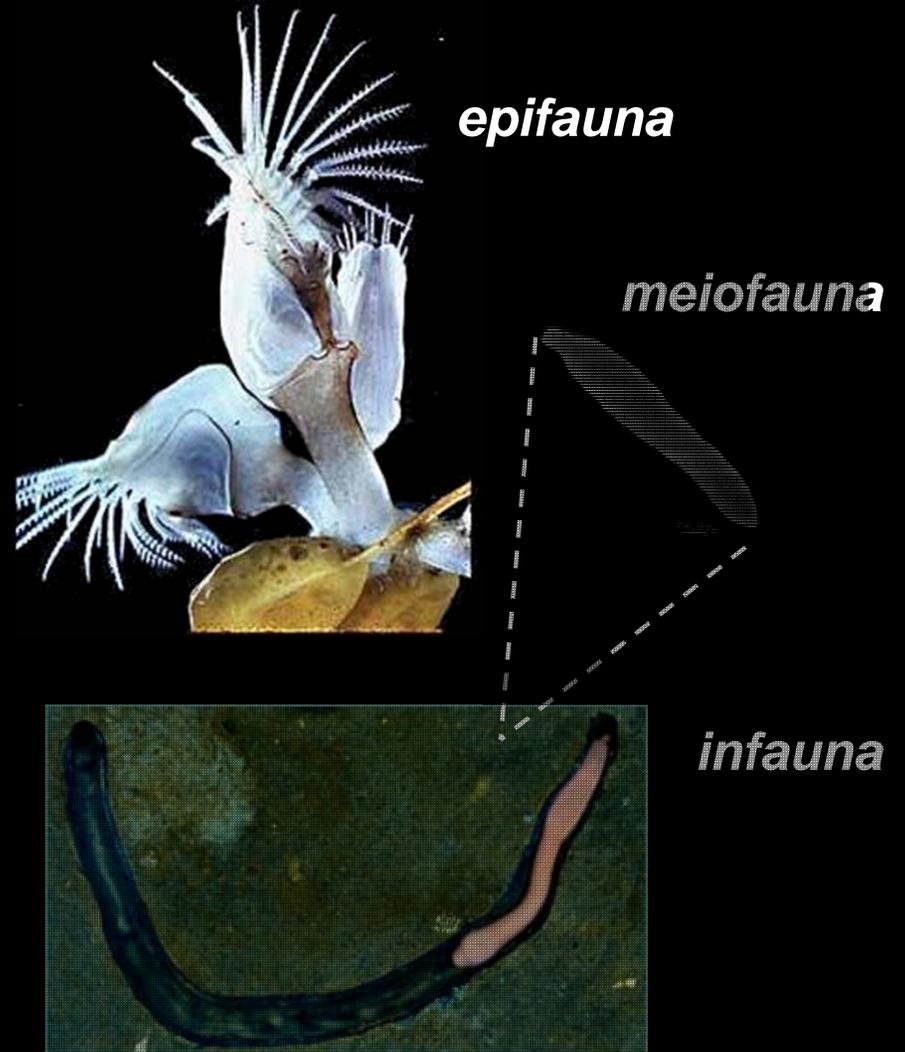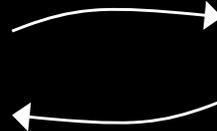
# CLASSIFICATION OF DIVERSITY

FORM: growth

unitary   modular
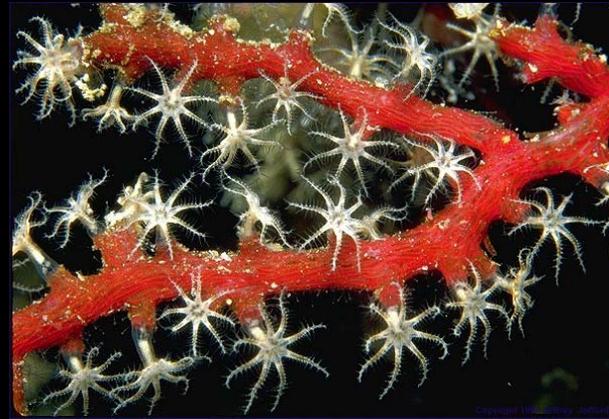
FORM: skeletal support

endo-   exo-   hydrostatic

CLASSIFICATION OF DIVERSITY

FUNCTION: feeding

deposit feeding

*surface*

subsurface

suspension feeding

tentacles, cilia

mucus net, muscular pump
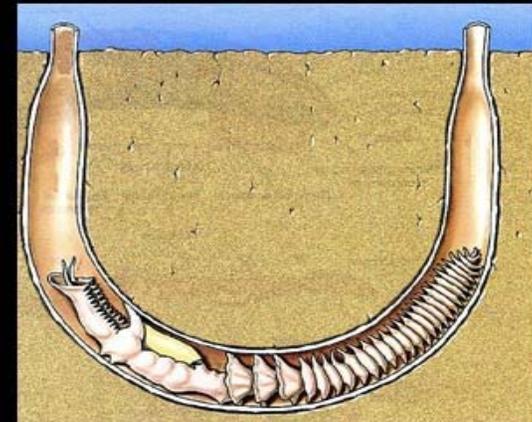
CLASSIFICATION OF DIVERSITY

FUNCTION: reproduction

broadcast spawning
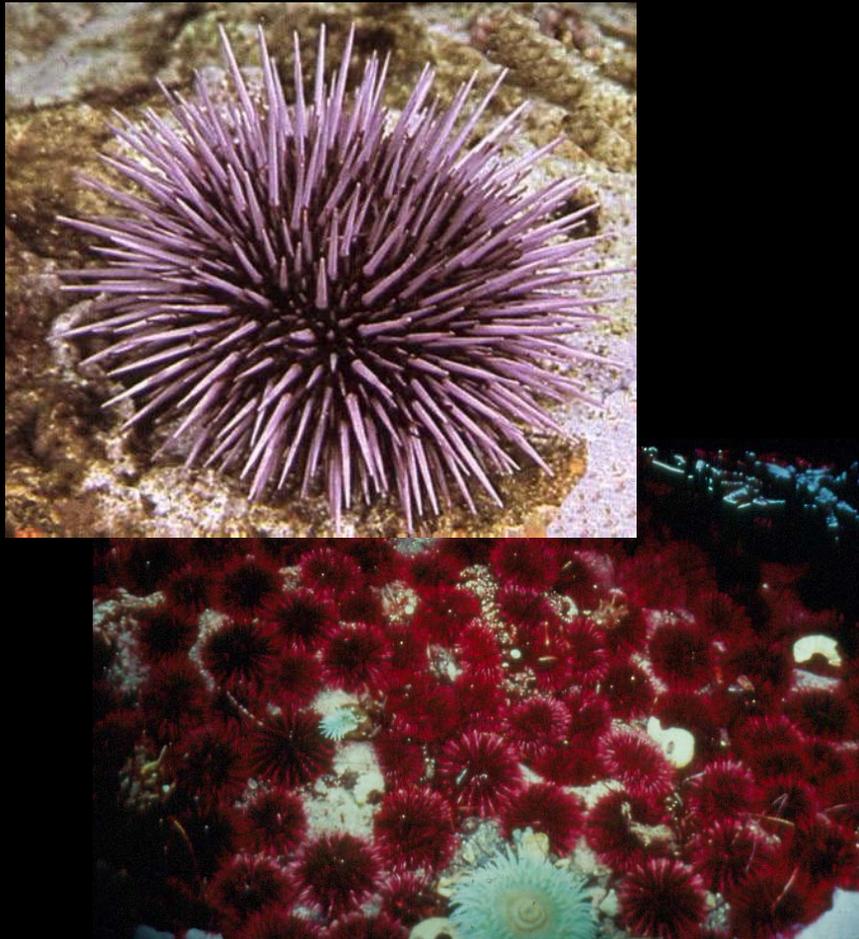
internal fertilization
copulation

"sessile"

"mobile"

spermcast spawning

CLASSIFICATION OF DIVERSITY

TAXON SIZE

HABITAT

FORM
- growth
- skeletal support

FUNCTION
- feeding
- reproduction
- locomotion
- protection/defense
- gas exchange
- circulation
- excretion
- nervous control and sensory systems

CLASSIFICATION OF DIVERSITY: taxonomy using traditional features

Multicellular

Number of cells
(many)

No layers   Diploblast   Triploblast

Number of embryonic germ layers
(0, 2, 3)

skin
(from ectoderm)

gut
(from endoderm)

muscles, organs
(from mesoderm)
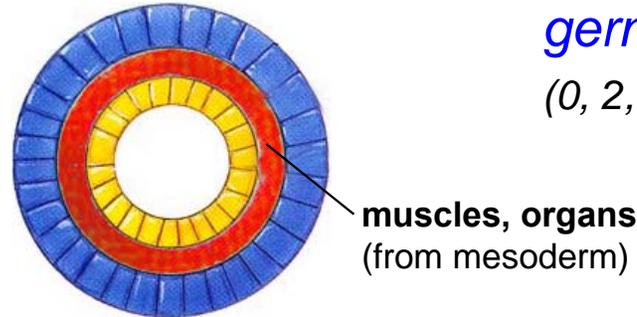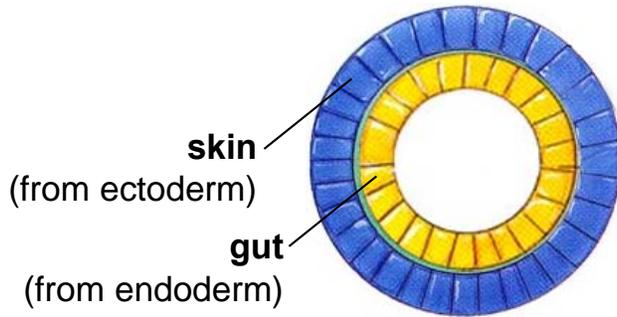
Acoelomate   Pseudocoelomate   Coelomate

Type of body cavity
(none, pseudocoelom, coelom)

pseudocoeloem   coelom
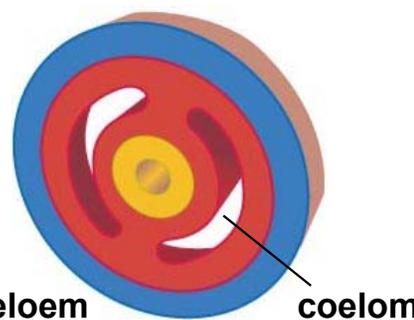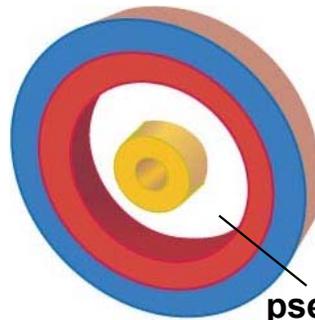
Protostome   Deuterostome   *Early development*

Early development: six features that go together

protostomes *vs.* deuterostomes

1. *Pattern of early cell cleavage*
2. *Fate of early cleaved cells*

3. *Origin of the mouth*

"D" mouth opens secondarily

"P" Blastopore → mouth

Blastula

Gastrulation in progress

Gastrula

"P"   "D"

top view

side view

spiral, determinate   *radial, indeterminate*

4. *Origin of mesoderm*
5. *Formation of coelom*

"P"   "D"

ectoderm

endoderm

mesoderm

coelomic cavity

"schizo -coely"   "entero -coely"   blastopore

6. *Cilia per cell*

"D"   *monociliate*

"P"   *multiciliate*
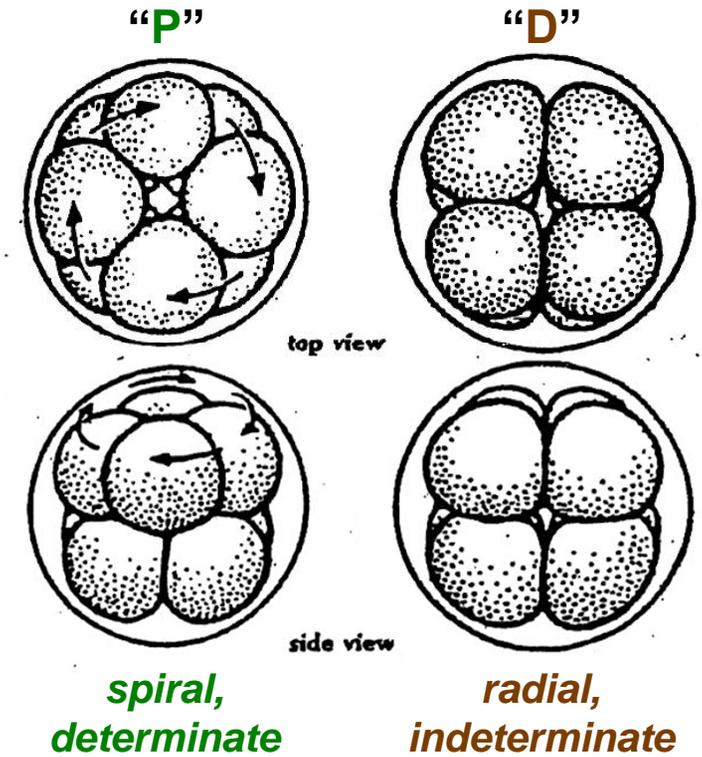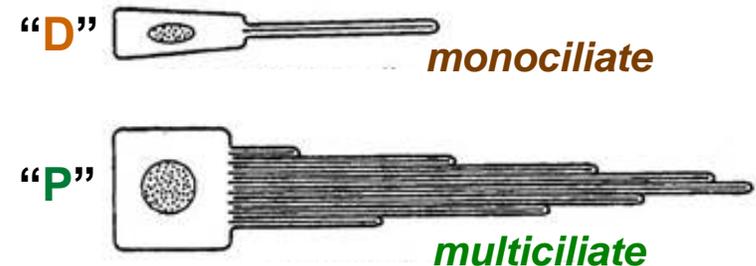
CLASSIFICATION should reflect degree of RELATEDNESS
(taxonomy)
(phylogeny)

TAXONOMY...

Kingdom	Animalia
Phylum	Echinodermata
Class	Asteroidea
■ **Order**	Forcipulatida
Family	Asteriidae
Genus	Pisaster
Species	*Pisaster ochraceous*

...PHYLOGENY

A B C D E F G H I J K L M N O P

clade

time

*mono*phyly

A B C D E F G H I J K L M N O P

time

*poly*phyly

A B C D E F G H I J K L M N O P

time
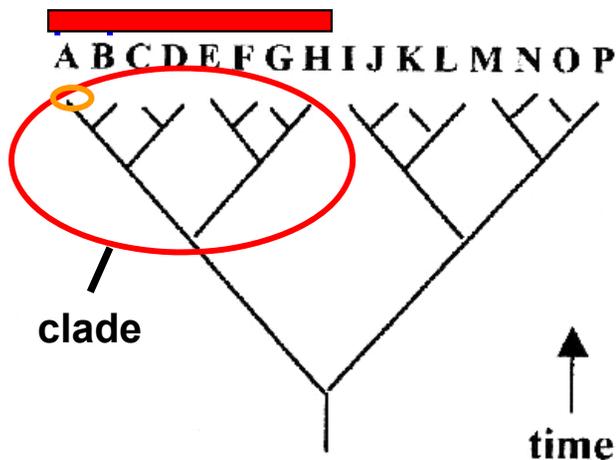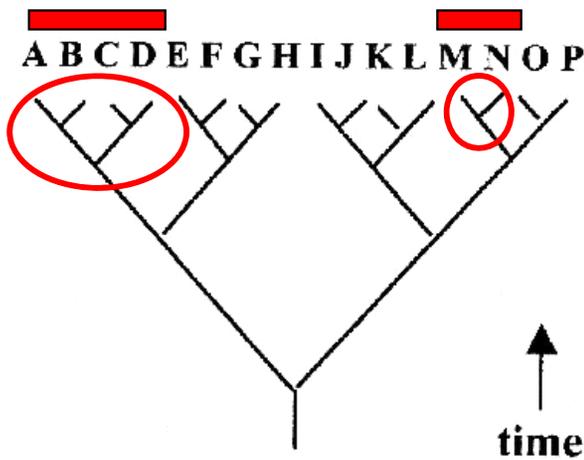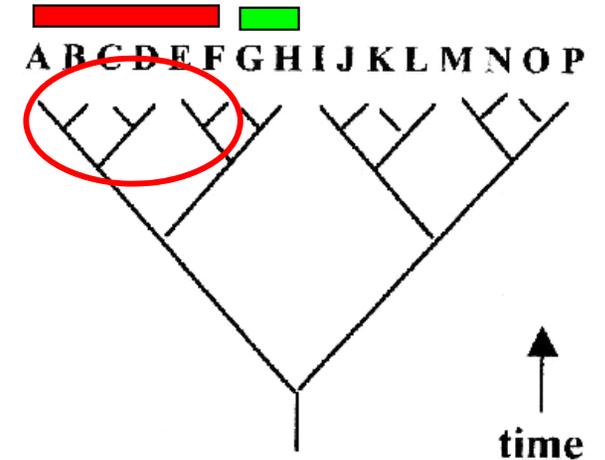
*para*phyly

Anya K. Podolsky: *vertebrate, mammal, primate...*


Homo sapiens

animal

Hs

time
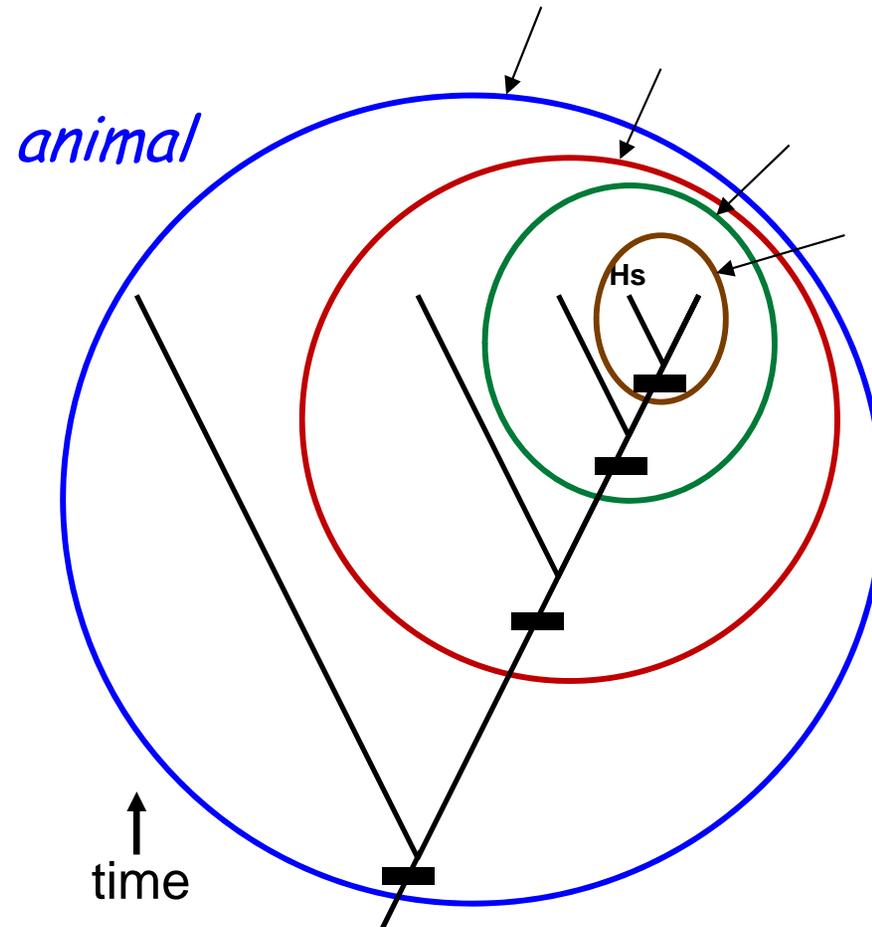
Evolutionary classification based on cladistic methods

<u>Cladistics:</u> a method for inferring the true
pattern of evolutionary relationships based on
"shared, derived characters" (synapomorphies)

Ex 1. **Event A: head** (short vs. long)
Event B: eyes (small vs. large)
Event C: mouth (narrow vs. wide)
Event D: ears (absent vs. present)

Ex 2. **Event E: nose** (absent vs. present)
Event F: hair (absent vs. present)
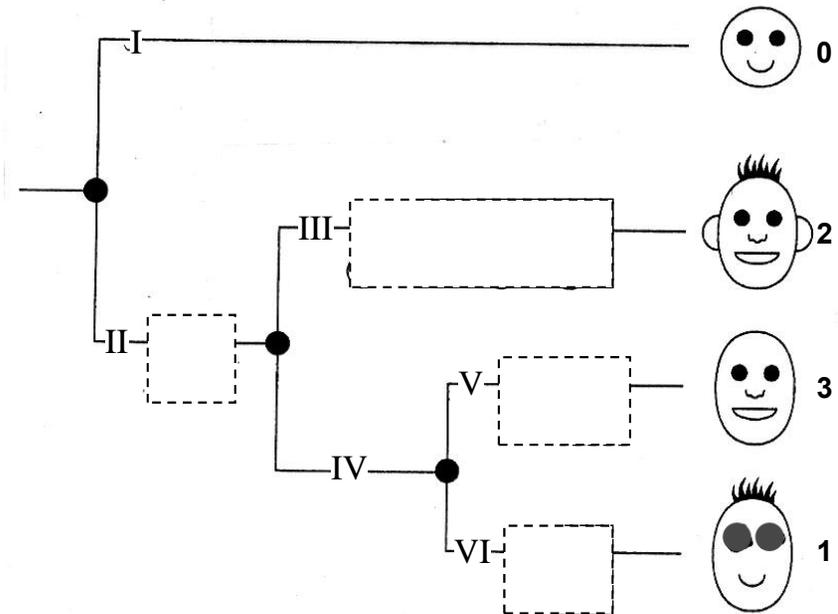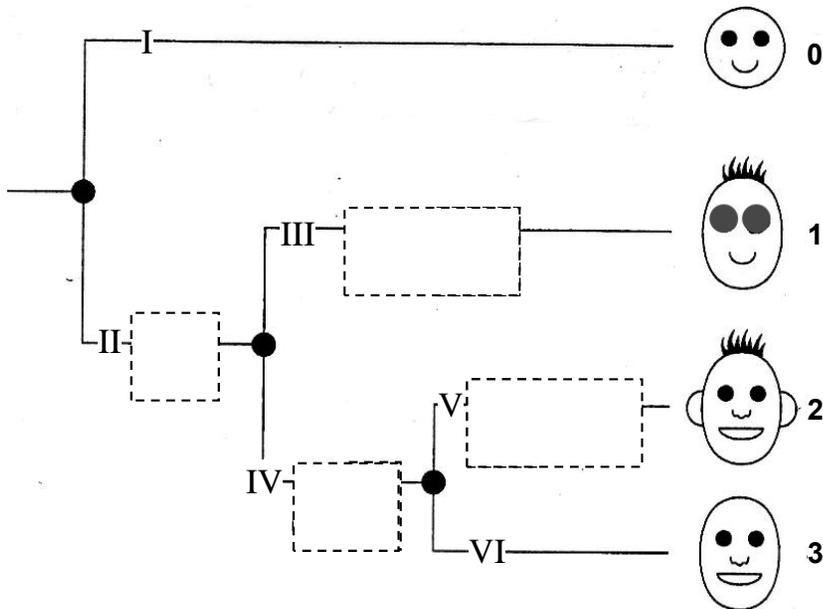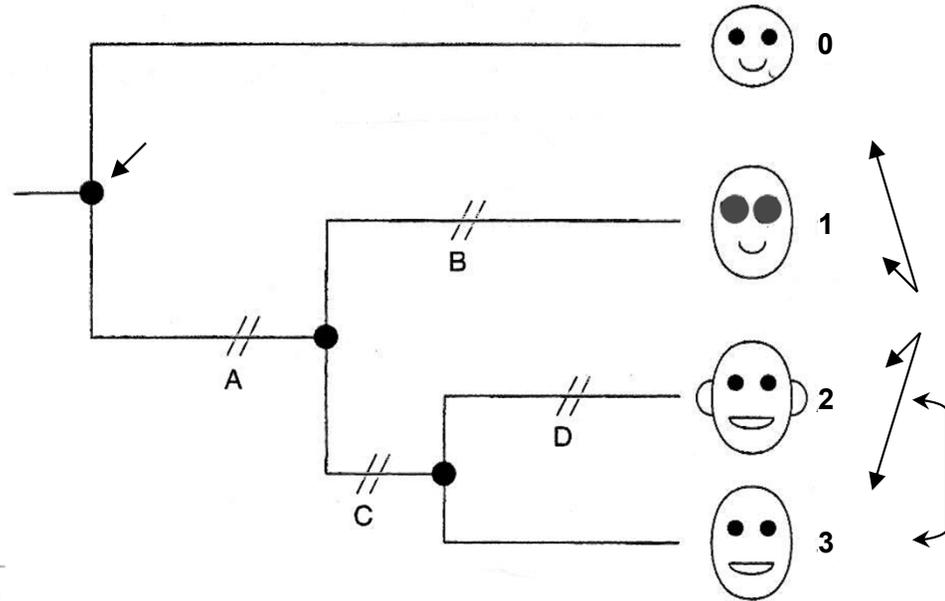
Q1: Which phylogenetic hypothesis has better support?
Q2: What is the third phylogenetic hypothesis?

K. Animalia = "Metazoa"

Porifera
Placozoa
Cnidaria
Myxozoa
Ctenophora
Acoela
Chaetognatha
Platyhelminthes
Mollusca
Annelida
Sipuncula
Nemertea
Phoronida
Brachiopoda
Bryozoa
Gnathostomulida
Cycliophora
Kamptozoa
Acanthocephala
Rotifera
Arthropoda
Onychophora
Tardigrada
Gastrotricha
Nematomorpha
Nematoda
Priapula
Kinorhyncha
Loricifera
Echinodermata
Hemichordata
[vertebrates]
Urochordata

?

Lophotrochozoa

Ecdysozoa

"protostomes"

"deuterostomes"

"coelomates"

Bilateria