Cambrian Explosion:
The Evolution of Animal Body Plans

I. What is a body plan?

II. Cambrian Explosion

III. Why have no new plans evolved?
What is a body plan? (bauplan)

At the upper levels of the taxonomic hierarchy, phyla- or class-level clades are characterized by their possession of particular assemblages of homologous architectural and structural features…

-J. W. Valentine (1986)
Characteristics of Body Plans

- Symmetry
- Skeleton
- Body Cavity
- Segmentation
- Appendages
Traditional Phylogeny

Four Major Splits:

1) Parazoa-Eumetazoa
2) Radiata-Bilateria
3) Acoelomates-Coelomates
4) Protostomes-Deuterostomes
Split 1: Several characters define Eumetazoa.

- Tissues separated by basement membranes
- Special Cell Junctions (other than septate junctions)
- Neurons and Synapses
- Muscle
Split 2: Body symmetry defines Bilateria.
Two Phyla compose the Radiata.

Cnidaria

Ctenophora
Bilateria are worms.
Split 3:
The presence of a body cavity defines Coelomates.
Split 4: Developmental characters define Deuterostomes.
Traditional Phylogeny

Four Major Splits:

1) Parazoa-Eumetazoa

2) Radiata-Bilateria

3) Acoelomates-Coelomates

4) Protostomes-Deuterostomes
Burgess Shale
540 mya
Cambrian Sponges
Cambrian Annelids
Cambrian Arthropods
Cambrian Brachiopod
Cambrian Chordate
Traditional Phylogeny

Four Major Splits:

1) Parazoa-Eumetazoa
2) Radiata-Bilateria
3) Acoelomates-Coelomates
4) Protostomes-Deuterostomes
1. What selective factors caused the Cambrian Explosion?

2. Why have no new body plans evolved since?
What was so special about the Cambrian?

- abiotic environment
Atmospheric oxygen was fairly stable during the Cambrian.

Morris (1995)
At the beginning of the Cambrian period, sea level was very similar to that of present day.

However, sea level rose steadily throughout the Cambrian period.

Hallam (1992)
What was so special about the Cambrian?

• abiotic environment
• biotic environment
Life during the Late Cambrian Period
What was so special about the Cambrian?

- abiotic environment
- biotic environment
- internal environment
The internal environment can impose natural selection.

Recent

Developmental co-ordination

Functional co-ordination

Selective agents

Recent

External

Abiotic

climate
substrate
others

Biotic

predation
competition
parasitism
others

Traditional

Arthur (1997)
During development, genes turn on other genes.

A mutation that stopped this indirect effect would decrease the product of gene C.

A mutation that added a direct effect would increase the product of gene D.

Arthur (1997)
Mutation of Developmental Genes

Arthur (1997)
What was so special about the Cambrian?

• **internal environment**
  – developmental functions of genes were not yet tightly connected
  – mutant genotypes were more likely to survive development.

• **biotic environment**
  – the lack of biodiversity probably provided lots of empty niches

• **abiotic environment**
Advantages of a Body Cavity

- Locomotion
- Circulation
- Protection of Organs
- Reduced Movement of the Body Wall
- Storage
Advantages of Segmentation

- Development
- Locomotion
- Exoskeleton
- Specialization