Origin of Animals and Diversification of Body Plans

Animalia is hypothesized to be monophyletic based on shared derived characters including:

- rRNA
- cell junctions
- matrix proteins
Animals are generally characterized by the organization and specialization of cells into tissues and organs, which derives from a unique developmental program that includes "gastrulation".
Body Plan are Basic Structural Designs

Virtually each animal phylum represents a fundamentally distinct body plan.

Body plan refers to major characteristics of an organism's structural and functional design; its basic architecture and the integrated functioning of its components.

General trend towards increased complexity in body plans.

Aspects of body plan include:
- body symmetry
- presence of embryonic tissue layers are resultant tissues and organs
- organization of nervous tissue - eg cephalization
- skeletal support - eg hydrostatic skeleton
- presence/nature of a body cavity
Animals originated some 580 mya. Over the relatively short course of 60-70 million years, virtually all phyla and major body plans arose.

Source: Freeman (2002)

Asymmetrical body plan: brown volcano sponge (Branchiostoma sp.), Roatan, Honduras. Copyright David J. Wrobel/BPS.
Phylogeny of Animals based on rRNA sequences

Phylogeny of Animals based on morphology

blue branches differ from morphology-based phylogeny
Phylogeny of animals based on morphology

Porifera  Cnidaria  Ctenophora  Platyhelminthes  Nematoda  Arthropoda  Annelida  Mollusca  Echinodermata  Chordata

Phylogeny of animals based on rRNA sequences

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Phylogeny of Animals based on morphology

Lophotrochozoans; includes phyla with lophophore feeding structure or a trochophore larva stage in life cycle

Ecdysozoans; includes animals that molt, via a molting hormone called “Ecdysone”
Bryozoaons are colonial lophophorates
Annelids are spiralians

Lophotrochozoans
- grow by increasing size of skeletal elements
- use cilia for locomotion
- many have a free-living larva called a “trochophore”

Ecdysozoans
- increase body size by molting (molt hormone is called “ecdysone”)
- don’t use cilia for locomotion
- share a common set of homeobox genes

Most of the basic body plans of animals derive from variations in a relatively few design and construction features
- Embryonic tissues
- Symmetry
- Body cavity
- Early development

Source: Freeman (2002)
Embryonic tissue layers

Tissue
Group of similar cells organized into a functional unit and usually integrated with other tissues to form part of an organ.

Characterization of Phyla by presence or absence of tissue layers

Diploblasts Two embryonic tissue layers; endoderm and ectoderm.

Triploblasts Three layers -- above two and an intervening mesoderm.

Functional and structural significance; tissues and organs derived from embryonic tissue layers in triploblasts

Endoderm digestive tract (gut)

Mesoderm connective tissue (muscle, bone)

Ectoderm outer covering, nervous system
Body Symmetry

Symmetry refers to the number of imaginary planes that would divide an organism into identical sections:
- Asymmetry
- Spherical symmetry
- Radial symmetry (spoke-like)
- Bilateral symmetry (identical halves)

Relating function to radial symmetry

Most radially symmetric animals are aquatic and live either planktonic or sessile (or both) lifestyles. Lack directed (unidirectional) movement; have ability to react to predators or prey approaching for any direction.

Free-swimming ephyra of Aurelia aurita.

Relating function to Bilateral symmetry

All bilaterally symmetric animals are triploblastic.

Bilateral symmetry is wide-spread, so assumed to be highly adaptive; efficient unidirectional movement for finding and securing food, and avoiding predators, driven by well-differentiated head and tail (trunk) region.

Cephalization; nervous system development; anterior concentration of brain and sensory structures.

Trunk or tail region largely involved in movement, which derives from musculature and skeleton.

Evolution of third tissue layer -- mesoderm, allowed for evolutionary innovations not only in musculature and mesodermal tissues and organs, but in differentiation and specialization of ectoderm - nervous system.

A triploblastic, bilaterally symmetrical body has great potential for evolution of efficient and effective lifestyles.
Body Cavity (coelom)

Fluid-filled body cavity has great evolutionary potential
- creates medium for circulation
- creates space and protected environment for internal organs
- gives rise to potential for operation of hydrostatic skeleton

Diploblasts lack fluid-filled cavity other than central canal
All triploblasts, except flatworms have fluid-filled body cavity

Of all lineages with fluid-filled cavities, in all except the nematodes and rotifers (pseudocoelomates) the cavity lies entirely within mesoderm (coelomates)
Coelomates bear a more "advanced" design in that muscles, blood, etc can form on either side of the body cavity
Hydrostatic skeleton of a nematode

Coordinated muscle contractions result in locomotion

When muscles on one side contract, fluid-filled chamber does not compress - instead, the animal bends

Patterns of early development in Coelomates

Coelomates are triploblastic and, except for echinoerms, bilaterally symmetrical.

The great coelomate lineage includes two groups that differ based on early embryonic events and processes; protostome and deuterostome lineages.

A very large proportion of all animals are protostomes including arthropods, molluscs and annelids; chordates and echinoerms are deuterostomes.