A short history of life
and introduction to metazoan phyla

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Objectives

1. Phylogeny and classification
2. Origin and early history of life
3. Metazoan radiation and phyla
4. Diversity and mass extinctions
Terminology

Species – a population lineage that evolves independently of other lineages (a reproductively isolated population through time). Species names consist of two words, Genus and species (e.g., Homo sapiens). In paleontology the genus is often the focus of attention. The genus name is always capitalized and the species in lower case, and the full name is italicized.

Phylogenetics – the study of evolutionary relationships.

Clade – another name for a group whose members are related to one another (this is the standard kind of group). Clades are defined as all the descendants of a particular ancestral species.

Phylogenetic tree (or cladogram) – a branching diagram showing the relationships of taxa.

Taxon (plural: taxa) – a formally named group of organisms, at species level or higher. Clades are taxa if they are named.

Classification - the names given to taxonomic groups. Usually named groups are monophyletic, consisting of all taxa descended from a particular node on a cladogram.

Nomenclature - the rules for applying names to taxonomic groups, especially at the species, genus, and family level.
Phylogeny: the ‘family tree’ of organisms

from Tree of Life project
(http://tolweb.org)
Metazoa (Animalia): classification and phylogeny

Classification

Metazoa (=Animalia)

Porifera (sponges)

Bilateria

Chordata (including vertebrates)
Echinodermata (urchins, crinoids, sea stars)
Arthropoda (insects, crustaceans)
Bryozoa (coral-like filter feeders)
Mollusca (bivalves, cephalopods, snails)
Brachiopoda (bivalve-like filter feeders)

Cnidaria (jellyfish, corals, anemones)

Ctenophora (comb-jellies)

Phylogeny

[Diagram showing phylogenetic relationships among phyla, including Deuterostomia, Ecdysozoa, Porifera, Cnidaria, Ctenophora, Bilateria, with Myxozoa, Chordata, and other phyla.]
Origin of Life: some definitions

Amino acids – molecules that make up proteins (tryptophan, glycine, arginine, etc.)

Nucleic acids – molecules that make up DNA and RNA (adenine, cytosine, guanine, uracil, thymine, etc.)

Protein – a compound made of amino acids and synthesized from RNA.

RNA – a compound made of nucleic acids, normally synthesized from DNA.

DNA – a compound made of nucleic acids that forms the heritable genetic material passed from parent to offspring.

Virus – an ‘organism’ consisting of DNA or RNA surrounded by a protein capsule. Requires the apparatus of a host cell to transcribe the DNA or RNA into new viruses.

Bacteria (prokaryotes) – unicellular microorganisms without a cell nucleus or other organelles.

Eukaryotes – unicellular or multicellular organisms with cell nucleus and other organelles.
Surviving Archaean crust
Greenstone belts

Archaean evidence of earliest continental accretions
Archaean Greenstone Belts
Pilbara Craton, Western Australia
First tentative evidences of life

Fossils consisting of filaments, spheroids, and films.

Warrawoona Chert, Australia (3.5 bya)
Apex Chart, Australia (3.5 bya)
Overwacht Group, South Africa (3.3-3.3 bya)
Fig Tree Group, South Africa (3.2 bya)

These are consistent in many ways with organisms similar to prokaryote cyanobacteria (though may not literally be the same group) but some may have resulted from inorganic processes.
First strong evidence of life

Stromatolites

Layered structures built up by photosynthetic organisms ("cyanobacterial mats")

Found in shallow marine environments that lack "grazing" animals

Common in Archaean and early Proterozoic, rare today (due to evolution of grazers)

First stromatolites 3.4-2.4 bya

These indicate "communities" of life
Fossil stromatolites
Banded Iron Formations (BIFs)

Sedimentary rocks composed of shale or cherts interbedded with iron oxides.

The oxidation (‘rusting’) indicates the presence of oxygen in the atmosphere, which was produced by the earliest cyanobacteria.

Banded iron formations are evidence of the increasing abundance of life and changes in the atmosphere.
Proterozoic life

Rodinia
First supercontinent
(formed ca. 1 billion years ago)

Grenville mountains

Vendian (or Ediacaran)
- Snowball earth?
- Rodinia formed
  - Greenville Orogeny
- Stromatolite Partytime
- Redbeds common
  (lots of $O_2$)
- Wopmay Orogeny
  (first real orogeny)
Snowball earth: 600-700 mya

Distribution of glacial deposits (tills, etc.) in the Neoproterozoic
Vendian Metazoans
Also known as the Ediacaran fauna

Soft-bodied multicellular organisms whose relation to modern phyla is controversial. May include primitive cnidarians, annelids, etc.

These soft-bodied organisms were diverse, presaging the Cambrian explosion of animals with shells and skeletons.
The Cambrian Explosion

Evolution and diversification of animals (metazoa) with hard skeletons, often composed of calcium carbonate.

Animals with skeletons first become common in the fossil record at the beginning of the Cambrian.

Skeletons evolved independently in many groups that already had Proterozoic histories.
Diversity in the Phanerozoic

Sepkoski’s Three Evolutionary Faunas

- CAMB.
- PALEOZOIC FAUNA
- MODERN FAUNA
Major “phyla” of Metazoans in the Paleozoic

Porifera
Sponges. Simple metazoans with only a few tissue types. Some had skeletons and were reef builders (Stromatoporoids). Most preserved as “spicules”. “Colonial”

Cnidaria
The corals, hydras, anemones, and jellyfish. Corals are common Paleozoic organisms. Radial symmetry, sometimes colonial.

Brachiopoda
Shelled filter-feeders (unrelated to mollusk bivalves). Bottom-dwelling or “benthic” organisms. Bilateral symmetry.

Bryozoa
Colonial marine organisms similar in some way to corals, but with quite different structure. Bryozoans were common members of many Paleozoic faunas. Colonial.

Mollusca
Chitons, snails, bivalves, and cephalopods. Snails (gastropods) and straight cephalopods (nautiloids) were important Paleozoic fossils. Bilateral symmetry.

Arthropoda
segmented animals, including insects. Trilobites are the most important Paleozoic group. Bilateral symmetry.

Echinodermata
Sea urchins, star fish, brittle stars, and crinoids. Crinoids were common members of Paleozoic faunas. Most echinoderms have five-fold radial symmetry.
Mass extinctions