Proterozoic Continents

- Wyoming Province
  - Archean terrane exposed in Wyoming and Black Hills

- Laurentia was probably attached to Australia, Antarctica and Siberia
Grenville Orogeny
(The building of Rodinia)
Figure 3. Precambrian provinces. Modified and compiled from Lisenbee and DeWitt (1993), Nelson (1993), Sears (2006), and Sims and others (2004).

Figure 12-1c
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Rodinia
“Motherland”
Forms
1.2-1.0 Grs
Belt Supergroup, Montana
West Coast of Laurasia
Formed Colonies called Stromatolites
Stromatolites
Mats of Cyanobacteria
Modern Stromatolites: Shark Bay, Australia
Proterozoic Events

- Widespread glaciation
  - Gowganda deposits
  - 2.3 Ga
- Stromatolites
  - Proliferate
  - Diverse shapes 1.2 Billion years ago
- Early Eukaryotes
Major endosymbiotic Events

- Union of 2 prokaryotic cells
  - Mitochondrion
    - Allow cells to derive energy from their food by respiration
    - Evolved from 1 prokaryotic cell
  - Chloroplast
    - Site of photosynthesis
    - Protozoan consumed, retained cyanobacterial cell
Algae

- Multicellular protists
- Algal ribbons wound into loose coils
  - 2.1 Billion years ago
Algae

• Prokaryotic forms
  – Gunflint flora 2 Billion years ago
  – Lake Superior

• Acritarchs
  – Multicellular forms abundant after 2 Billion years
  – Eukaryote?

A  Prokaryotes, Gunflint – 1.9 Ga
B  Acritarch – 750 Ma
C  Acritarch
Proterozoic Life

• Complex organisms can be identified from trace fossils
  – None present until about 570 Million years ago
    • Belt Supergroup, Montana
    • 1.3 Billion years ago

No bioturbation!
Worms haven't messed up the layers

Greyson Shale, Belt Supergroup, NW Montana
Proterozoic Life

- Trace fossils provide evidence for past life in Neoproterozoic
- Increasingly complex and varied
Simple horizontal worm trace fossils. No burrowing or branching.
Ediacaran Fauna

- Non-skeletal fossils
  - Similar to Cnidaria
  - Imprints of soft-bodied organisms
  - < 570 M years ago

- Ediacarian fauna
  - Lived before predators
  - Some similar to modern forms
Proterozoic Life

- Possible arthropod fossils - embryos
- Bilateral symmetry
Proterozoic Life

• Skeletal fossils
  – Vase-shaped and tubular
  – Small size
Oldest animal
Amoeba with a skeleton
750 Ma
Bilateral symmetry
580 Ma
First clear multicellular animals - Ediacaran Fauna
570 Ma
Ediacaran: 
*Charnia*

Suspension feeder

Bilateral symmetry
holdfasts
Ediacaran: *Dickinsonia*

Bottom feeder?

Up to 6 feet across!

Bilateral symmetry
Ediacaran: 
*Tribachidium* 
Radial symmetry 
3-fold 

Ancestor to echinoderm?
Echinoderms

• Spiny-skinned form
• Five-fold symmetry
  – Starfishes
    • Predators
    • Lower Paleozoic
  – Sea urchins
    • Regular sea urchins
      – Radially symmetrical bodies
    • Irregular sea urchins
      – Bilaterally symmetric
      – Burrowers
Ediacaran: Mawsonites

Sea anemone

Ancestor to cnidarians?
Cnidarians

- Jellyfish and corals
- Radial symmetry
- Inner and outer body layer
  - Jelly-like layer in between
- Use tentacles to catch prey
  - Stinging cells
- Sexual and asexual reproduction
Ediacaran: 
*Sprigina*

*Bilateral symmetry*

*Ancestor to arthropods?*
Arthropods

• Insects, crabs, spiders, lobsters, trilobites

• Trilobite
  – Three-lobed body
    • Central, left- and right- lobed
  – External skeleton
  – Gill-like structure for respiration
  – Legs
  – Primitive eyes

• Common in Cambrian
Ediacaran: Kimberella

Mollusk?
Mollusks

- Clams, snails, octopuses
  - Shell of aragonite, calcite, or both
- Mantle
  - Fleshy, sheetlike organ
  - Secretes shell
- Radula
  - File-like structure for food
- Base of Cambrian

- Monoplacophorans
  - Primitive mollusks
Cloudina

One of the many

“Small shellies”
Figure 12-14
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The three major animal groups may have formed by the end of the Proterozoic
Figure 3-23
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Visual Overview
Major Events of the Proterozoic Eon

EARLY ORDOVICIAN
Near the end of the Proterozoic, shifting events formed the major continents of the Paleozoic Era.

ANOTHER SUPERCONTINENT? (550 million years ago)
A second supercontinent may have formed after the breakup of Rodinia.

RODINIA (1 billion years ago)
The supercontinent contained nearly all of Earth's landmasses.

When atmospheric oxygen reached a moderate level about 2 billion years ago, banded iron formations, which contained weekly oxidized iron, disappeared.

Time (billion years ago)
- 2.5: Multicellular algae
- 2.0: Stromatolites more abundant
- 1.6: Maximum development of stromatolites
- 1.0: More complex archeans
- 0.55: More complex animal fossils
- 0.5: Glacial deposits
- 0.4: Carbon dioxide
- 0.3: Decrease in carbon dioxide

Continents grow larger

Explosive radiation of animals
Major ideas

Belt Supergroup sediments deposited in a failed rift in western Montana about 1.4 billion years ago. Muds, silstones and limestones with no bioturbation and only stromatolites as fossils.

True multicellular life (differentiated cells) possibly by 705 Ma, but definitely by 600 Ma.

Relatively little grazing during the Precambrian. Consequently, stromatolites flourish. Stomatolites dominates for much of the Proterozoic.

Very little predation during the end of the Precambrian. Consequently, soft-bodied organisms can be preserved as fossils.

All three major animal groups by the end of the Precambrian.

Many phyla may developed before the end of the Precambrian, e.g., the Ediacaran Fauna.