Chapter 1: Life on Earth

REVIEW QUESTIONS
Chapter 1: Review

- Name three characteristics that define something as “Alive”.

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• What is the difference between a hypothesis, a theory and a law?
Name three characteristics that define something as “Alive”.

Within the three DOMAINS, how are organisms categorized?

What is the difference between a hypothesis, a theory and a law?

What is an adaptation?
Chapter 1: Review

- Name three characteristics of organisms that are “alive”.
- Within the three DOMAINS, how are organisms categorized?
- What is the difference between a hypothesis, a theory and a law?
- What is an adaptation?
- What is the difference between Sexual Selection and Natural Selection?
Chapter 17: The History of Life

Lecture Road Map:

- The Beginning of Life
- Earliest Organisms
- Early Multicellular Organisms
- Life invading Land
- Extinction
- Human Evolution
Chapter 17: The History of Life

The Beginning of Life

- Central Dogma: beliefs held by the majority of the population
  - Spontaneous generation
Chapter 17: The History of Life

The Beginning of Life

- **Central Dogma**: beliefs held by the majority of the population
  - Spontaneous generation: Redi Experiment

![Image of jars with meat, flies, and other stages of the Redi Experiment]
Chapter 17: The History of Life

The Beginning of Life

- **Central Dogma**: beliefs held by the majority of the population
  - Spontaneous generation: Pasteur/Tyndall Experiment

The broth in a flask is boiled to kill preexisting microorganisms

The long, S-shaped neck allows air, but not microorganisms, to enter the flask

If the neck is later broken off, outside air can carry microorganisms into the broth
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The Beginning of Life

- Central Dogma: beliefs held by the majority of the population
- Slow shift in dogma refuting spontaneous generation
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The Beginning of Life

• Modern scientific theory on origins of life relatively recent (1900s)
  ○ Atmosphere less Oxygen-rich: primarily water vapor, methane, ammonia and hydrogen (Miller/Urey)
  ○ Pre-biotic evolution of organic molecules
An electric spark simulates a lightning storm

Energy from the spark powers reactions among molecules thought to be present in Earth’s early atmosphere

Boiling water adds water vapor to the artificial atmosphere

When the hot gases in the spark chamber are cooled, water vapor condenses and any soluble molecules present are dissolved

Organic molecules appear after a few days
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The Beginning of Life

- Modern scientific theory on origins of life relatively recent (1900s)
  - Actual composition might have been slightly different, but experiments still yield organic compounds
  - Addition of heat and UV light energy
  - Meteorites carry amino acids
Chapter 17: The History of Life

The Beginning of Life

- Organic molecules would have taken hundreds of millions ($\times 100,000,000$) of years to accumulate
  - UV radiation – no ozone layer, also destructive power
  - Today, relatively short shelf life (consumed or reactive with O$_2$)
Chapter 17: The History of Life

The Beginning of Life

- Organic molecules would have taken hundreds of millions (X100,000,000) of years to accumulate
  - UV radiation – no ozone layer
  - Today, relatively short shelf life (consumed or reactive with O2)
  - Role of clay: high affinity for particle adherence
Chapter 17: The History of Life

The Beginning of Life

- DNA requires complex proteins to reproduce; complex proteins are encoded in DNA
Chapter 17: The History of Life

The Beginning of Life

- DNA requires complex proteins to reproduce; complex proteins are encoded in DNA
- RNA likely the first self-replicating informational molecule: **ribozymes** catalyze cellular reactions sans protein
Chapter 17: The History of Life

The Beginning of Life

- DNA requires complex proteins to reproduce; complex proteins are encoded in DNA
- RNA likely the first self-replicating informational molecule: **not alive**
Chapter 17: The History of Life

The Beginning of Life

- Vesicle formation a physical/chemical process... forming first cells
  - Proteins
  - Lipids
  - Shake vigorously
Chapter 17: The History of Life

Lecture Road Map:
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Chapter 17: The History of Life

Earliest Organisms

- Early Earth environment:
  - constant volcanic explosions
  - Frequent meteor strikes
  - Radioactive decay
  - No ozone
Earliest Organisms

- Early Earth environment: multiple meteor strikes
- Hundreds of millions of years for Earth to cool and allow liquid water to condense
  - Very shortly after, LIFE
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Earliest Organisms

- Early Earth environment
- Hundreds of millions of years for Earth to cool and allow liquid water to condense
- **Precambrian Era:**
  - Fossils 3.5 BILLION years old
Chapter 17: The History of Life

Earliest Organisms

- Early Earth environment
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Precambrian Era:
- Fossils 3.5 BILLION years old
- Prokaryote: no true nucleus
Chapter 17: The History of Life

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Chapter 17: The History of Life

Earliest Organisms

• Early Earth environment

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• Precambrian Era:
  o Fossils 3.5 BILLION years old
  o Prokaryote: no true nucleus
  o Anaerobic: no atmospheric O2
  o Absorb nutrients from environment until exhausted
Chapter 17: The History of Life

Earliest Organisms

• Cellular Evolution
  ○ Able to use energy to synthesize more complex molecules: PHOTOSYNTHESIS
Chapter 17: The History of Life

Earliest Organisms

- Cellular Evolution
  - Able to use energy to synthesize more complex molecules: PHOTOSYNTHESIS

Recall: what is the word for an organism that “self-feeds”? 
Earliest Organisms

• Cellular Evolution
  ○ Able to use energy to synthesize more complex molecules: **PHOTOSYNTHESIS**
  ○ By-product of photosynthesis is oxygen, which had accumulated in significant amounts 2.3 BYA
Chapter 17: The History of Life

Earliest Organisms

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Chapter 17: The History of Life

Earliest Organisms

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  - By-product of photosynthesis is oxygen, which had accumulated in significant amounts 2.3 BYA
  - Organisms had not evolved to use oxygen; with disappearing anaerobic resources, prokaryotes became predatory
  - Not efficient; utilizing O2 would vastly increase efficiency, lending significant evolutionary advantages
Earliest Organisms

- Cellular Evolution
- Phagocytosis → Internal membranes
  - Near the cell’s DNA could have given rise to a true nucleus (Eukaryotes)
  - 2 BYA
Capturing Energy:

• Precursors to mitochondria and chloroplasts may have been *symbiotic* bacteria
Chapter 17: The History of Life

Lecture Road Map:

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Earliest Multicellular Organisms

- With predation, it becomes advantageous to be larger: 2 possible solutions
  - Decrease metabolic activity (surface area to cytoplasmic volume issue)
  - Join with other cells to be a larger, unified body
Earliest Multicellular Organisms

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  - Decrease metabolic activity (surface area to cytoplasmic volume issue)
  - Join with other cells to be a larger, unified body
    - ALGAE (1.2 BYA)
Chapter 17: The History of Life

Earliest Multicellular Organisms

- Join with other cells to be a larger, unified body
  - Harder for single-celled predators to engulf
  - Allows for the rise of structural specialization
Earliest Multicellular Organisms

- Early Animals: appear in the fossil record between 610-544 MYA (Precambrian)
Earliest Multicellular Organisms

- Early Animals: appear in the fossil record between 610-544 MYA (Precambrian)
- Cambrian Period (Paleozoic Era): radiation of full spectrum of modern invertebrates
### Table 17-1 The History of Life on Earth

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<td>251–202</td>
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### Silurian

- **444–416**
- Many fishes, trilobites, and mollusks
- First vascular plants

### Ordovician

- **488–444**
- Dominance of arthropods and mollusks in the ocean
- Invasion of land by plants and arthropods
- First fungi

### Cambrian

- **542–488**
- Marine algae flourish
- Origin of most marine invertebrate phyla
- First fishes

### Precambrian

- **About 1,000**
- First animals (soft-bodied marine invertebrates)
- 1,200
- First multicellular organisms
- 2,000
- First eukaryotes
- 2,200
- Accumulation of free oxygen in the atmosphere
- 3,500
- Origin of photosynthesis (in cyanobacteria)
- 3,900–3,500
- First living cells (prokaryotes)
- 4,000–3,900
- Appearance of the first rocks on Earth
- 4,600
- Origin of the solar system and Earth

- **4,600**
- Origin of the solar system and Earth
Earliest Multicellular Organisms

- Early Animals: appear in the fossil record between 610-544 MYA (Precambrian)
- Cambrian Period: almost all major groups of animals on earth today were present at this time
Invertebrates are 97% of animal diversity!
Earliest Multicellular Organisms

- Early Animals: appear in the fossil record between 610-544 MYA (Precambrian)
- Cambrian Period: almost all major groups of animals on earth today were present at this time
- Predation pressure favored improved mobility and sensory system
Earliest Multicellular Organisms

- Silurian Period (Paleozoic Era): anatomically complex organisms
Earliest Multicellular Organisms

- Silurian Period (Paleozoic Era): Chambered Nautilus survives today, completely unchanged
Chapter 17: The History of Life

Earliest Multicellular Organisms

- Silurian Period (Paleozoic Era)
  - Exoskeletons enhanced durability and mobility
Earliest Multicellular Organisms

- **Silurian Period (Paleozoic Era)**
  - Exoskeletons enhanced durability and mobility
  - Internal skeletons didn’t evolve until fish appeared, approximately 530 MYA
Earliest Multicellular Organisms

- **Silurian Period (Paleozoic Era)**
  - Exoskeletons enhanced durability and mobility
  - Internal skeletons didn’t evolve until fish appeared, approximately 530 MYA
  - By 400 MYA, fish were diverse and the dominant predator of the prehistoric seas
Chapter 17: The History of Life

Lecture Road Map:
- The Beginning of Life
- Earliest Organisms
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- Life invading Land
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Life Invading Land: Plants

- 475 MYA: began to move out of the water and into shallow banks
  - Competition for resources
  - Unfiltered sunlight (for harnessing food energy)
Chapter 17: The History of Life

Life Invading Land: Plants

- 475 MYA: began to move out of the water and into shallow banks
  - **Overcome**: gravity, wind

Simple solution: vacuoles and turgor pressure
Chapter 17: The History of Life

Life Invading Land: Plants

- 475 MYA: began to move out of the water and into shallow banks
  - Overcome: gravity, wind
  - Still require moisture for reproductive units
Chapter 17: The History of Life

Life Invading Land: Plants

- 475 MYA: began to move out of the water and into shallow banks

- Seed plants (375 MYA): Late Devonian Period
# The History of Life on Earth

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## Paleozoic

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<td>359–299</td>
<td>Forests of tree ferns and club mosses</td>
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## Precambrian

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Chapter 17: The History of Life

Life Invading Land: Plants

• 475 MYA: began to move out of the water and into shallow banks

• Seed plants (375 MYA): reproductive units encased in drought-resistant grains
  o Wind-pollinated
Chapter 17: The History of Life

Life Invading Land: Plants

- 475 MYA: began to move out of the water and into shallow banks
- Seed plants (375 MYA): reproductive units encased in drought-resistant grains
  - Wind-pollinated
  - Conifers: flourished during Permian
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<td>Massive marine extinctions, including trilobites</td>
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<td>Flourishing of reptiles and the decline of amphibians</td>
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#### Carboniferous

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Chapter 17: The History of Life

Life Invading Land: Plants

- 475 MYA: began to move out of the water and into shallow banks
- Seed plants (375 MYA): reproductive units encased in drought-resistant grains
- Flowering plants (140 MYA): evolved from conifer-like plants, enticed animals to carry pollen
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Chapter 17: The History of Life

Life Invading Land: Plants

- **475 MYA**: began to move out of the water and into shallow banks
- **Seed plants (375 MYA)**: reproductive units encased in drought-resistant grains
- **Flowering plants (140 MYA)**: evolved from conifer-like plants, enticed animals to carry pollen
  - *First pollinators thought to be beetles*
Chapter 17: The History of Life

Life Invading Land: **Animals**

- Arthropod ancestors (400 MYA): group that today includes spiders, crabs, scorpions and centipedes
# The History of Life on Earth

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## Paleozoic Period

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### Carboniferous
- **Time Range**: 359–299
- **Major Events**: Forests of tree ferns and club mosses | Dominance of amphibians and insects | First reptiles and conifers

### Devonian
- **Time Range**: 416–359
- **Major Events**: Fishes and trilobites flourish | First amphibians, insects, seeds, and pollen

### Silurian
- **Time Range**: 444–416
- **Major Events**: Many fishes, trilobites, and mollusks | First vascular plants

### Ordovician
- **Time Range**: 488–444
- **Major Events**: Dominance of arthropods and mollusks in the ocean | Invasion of land by plants and arthropods | First fungi

### Cambrian
- **Time Range**: 542–488
- **Major Events**: Marine algae flourish | Origin of most marine invertebrate phyla | First fishes

### Precambrian
- **Time Range**: About 1,000
- **Major Events**: First animals (soft-bodied marine invertebrates) | First multicellular organisms | First eukaryotes | Accumulation of free oxygen in the atmosphere | Origin of photosynthesis (in cyanobacteria) | First living cells (prokaryotes) | Appearance of the first rocks on Earth | Origin of the solar system and Earth

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Chapter 17: The History of Life

Life Invading Land: *Animals*

- Arthropod ancestors (400 MYA): group that today includes spiders, crabs, scorpions and centipedes
  - *Already had exoskeleton*
Life Invading Land: **Animals**

- Arthropod ancestors (400 MYA): group that today includes spiders, crabs, scorpions and centipedes
  - Flight perfected very quickly: mayflies, stoneflies, dragonflies
Chapter 17: The History of Life

Life Invading Land: Animals

- Arthropod ancestors (400 MYA)
- First Amphibians (350 MYA): evolved from lobe-finned fishes
  - More oxygen
  - Less competition for resources
Life Invading Land: **Animals**

- Arthropod ancestors (400 MYA)
- First Amphibians (350 MYA): evolved from lobfins
  - Still reliant on moist habitat (dessication)
  - Simple lung structure
### TABLE 17-1 The History of Life on Earth

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  - 4,000–3,900 Appearance of the first rocks on Earth
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Chapter 17: The History of Life

Life Invading Land: **Animals**

- Arthropod ancestors (400 MYA)
- First Amphibians (350 MYA)
- **First Reptiles (310 MYA)**
  - skin preventing desiccation
  - Waterproof eggs
  - Sophisticated lung structure
Chapter 17: The History of Life

Life Invading Land: Animals

- Arthropod ancestors (400 MYA)
- First Amphibians (350 MYA)
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| Mesozoic  | Cretaceous | 146–65     | Flowering plants appear and become dominant |
|           |            |            | Mass extinction of marine and terrestrial life, including dinosaurs |

| Jurassic   | 202–146    | Dominance of dinosaurs and conifers |
|           |            | First birds |

| Triassic   | 251–202    | First mammals and dinosaurs |
|           |            | Forests of gymnosperms and tree ferns |

| Paleozoic  | Permian    | 299–251    | Massive marine extinctions, including trilobites |
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  - Most reptiles still remain quite small – temperature regulation
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  - **Archaeopteryx**: evolutionary modification of scales
Chapter 17: The History of Life

Life Invading Land: **Animals**
- Arthropod ancestors (400 MYA)
- First Amphibians (350 MYA)
- First Reptiles (310 MYA)
- Age of the Dinosaurs: Mesozoic
- **Mammals and Birds (200-150 MYA):** earliest fossils co-existed with dinosaurs (rat-like)
Chapter 17: The History of Life

Lecture Road Map:

- The Beginning of Life
- Earliest Organisms
- Early Multicellular Organisms
- Life invading Land
- Extinction
- Human Evolution
Extinction: the role of mass extinction

- Worst in the fossil record occurred at the end of the Permian, killing 90% of the world’s species (245 MYA)
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Chapter 17: The History of Life

Extinction: the role of mass extinction

- Worst in the fossil record occurred at the end of the Permian, killing 90% of the world’s species
- Changes in climate most frequently associated with past mass extinctions
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Extinction: the role of mass extinction

- Worst in the fossil record occurred at the end of the Permian, killing 90% of the world’s species
- Changes in climate most frequently associated with past mass extinctions
  - Difficulty adapting to new conditions
Extinction: the role of mass extinction

- Worst in the fossil record occurred at the end of the Permian, killing 90% of the world’s species
- Changes in climate most frequently associated with past mass extinctions
- Catastrophic events: volcanic eruptions
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Extinction: the role of mass extinction

- Worst in the fossil record occurred at the end of the Permian, killing 90% of the world’s species
- Changes in climate most frequently associated with past mass extinctions
- Catastrophic events: meteorite impact
  - Chicxulub Crater
Chapter 17: The History of Life

Extinction: the role of mass extinction

- Worst in the fossil record occurred at the end of the Permian, killing 90% of the world’s species
- Changes in climate most frequently associated with past mass extinctions
- Catastrophic events: meteorite impact
  - Chicxulub Crater: impact same time dinosaurs disappeared
NEVER FORGET
12/21/65000000 b.c.

SAVE YOURSELF MAMMAL! WE WILL FEND OFF THE ASTEROIDS!
Chapter 17: The History of Life

Lecture Road Map:

- The Beginning of Life
- Earliest Organisms
- Early Multicellular Organisms
- Life invading Land
- Extinction
- Human Evolution
Human Evolution

- Primate Group
  55 MYA
Human Evolution

- Primate Group
- **Complex binocular vision** with increased depth perception
Chapter 17: The History of Life

Human Evolution

- Primate Group
- Complex binocular vision
- Grasping hands
Human Evolution

- Primate Group
- Complex binocular vision
- Grasping hands
- Larger Brain
  - Coordination
  - Social Interaction
Chapter 17: The History of Life

Human Evolution
- Primate Group
- Complex binocular vision
- Grasping hands
- Larger Brain
- Oldest Hominids found in Africa
  6 MYA
Chapter 17: The History of Life

Human Evolution

- Primate Group
- Complex binocular vision
- Grasping hands
- Larger Brain
- Oldest Hominids found in Africa
  - Could walk upright: Bipedal
Chapter 17: The History of Life

Human Evolution

- Primate Group
- Complex binocular vision
- Grasping hands
- Larger Brain
- Oldest Hominids found in Africa
- Genus *Homo* (2.5 MYA): tools
(a) *Homo habilis*

(b) *Homo ergaster*

(c) *Homo neanderthalensis*
Chapter 17: The History of Life

Human Evolution

- Primate Group
- Complex binocular vision
- Grasping hands
- Larger Brain
- Oldest Hominids found in Africa
- Genus *Homo* (2.5 MYA)
  - Neanderthals (*H. sapiens?*) – 150,000 years ago
  - Cro-Magnons – 100,000 years ago
  - *H. sapiens* – multiple lineages simultaneously
Modern *H. sapiens*:

- Energy capture/storage efficiency: able to survive up to 3 weeks without food
- Desiccation prevention: able to survive up to 3 days without water
- Able to survive only about 3 hours without wi-fi