Honors Biology – Unit 3 – Chapter 15b
"TRACING EVOLUTIONARY HISTORY – THE HISTORY OF LIFE"

1. spontaneous generation, Louis Pasteur, S-shaped flask experiment

2. Miller-Urey experiment, early gases in Earth's atmosphere

3. 3 requirements for life: protein, RNA, phospholipids

4. the road to modern organisms:

    - anaerobic cells → aerobic cells
    - unicellular organisms → multicellular organisms
    - prokaryotic cells → eukaryotic cells
    - chemosynthesis using H_2S → photosynthesis using H_2O
    - fermentation → cellular respiration
    - heterotrophs → autotrophs
    - asexual reproduction → sexual reproduction
    - Bacteria → Archaea → Eukarya → Protista → Fungi/Plantae/Animalia

5. structure of viruses

6. the lytic cell: infection, growth, replication, lysis

7. features of bacteria:

    - background information
    - respiration vs. fermentation
    - 3 ways of reproduction
    - uses of bacteria

Honors Biology – Chapter 15b Word Roots
"TRACING EVOLUTIONARY HISTORY – THE HISTORY OF LIFE"

chemo- = chemical; **auto-** = self; **-troph** = food (*chemoautotroph*: an organism that obtains both energy and carbon from inorganic chemicals, making its own organic compounds from CO_2 without using light energy); **hetero-** = different (*chemoheterotroph:* an organism that obtains both energy and carbon from organic molecules)

endo- = inner, within (*endospore:* a thick-coated protective cell produced within a bacterial cell that can become dormant to survive harsh environmental conditions; *endotoxin:* a poisonous component of the outer membrane of gram-negative bacteria, released only when the bacteria die)

exo- = outside (*exotoxin:* a poisonous protein secreted by certain bacteria)

-gen = produce (*methanogen:* Archaea that produce methane as a metabolic waste product)

halo- = salt; **-philos** = loving (*extreme halophile:* a microorganism that lives in a highly saline environment)

photo- = light; **auto-** = self; **-troph** = food, nourish (*photoautotroph:* an organism that obtains energy from sunlight and carbon from CO2)

-phyte = plant (*gametophyte:* the multicellular haploid form in the life cycle organisms undergoing alternation of generations)

proto- = first; **bio-** = life (*protobiont:* an aggregate of abiotically produced molecules surrounded by a membrane or membrane-like structure)

stromato- = something spread out; **-lite** = a stone (*stromatolite:* layered rocks that result from the activities of prokaryotes that bind thin films of sediment together)

PROPERTY OF:

HONORS BIOLOGY – UNIT 3 – CHAPTER 15b NOTES

TRACING EVOLUTIONARY HISTORY – THE HISTORY OF LIFE

Spontaneous Generation

- theory that life arises from non-life (early-mid 1700's)
  EX: rotting meat became covered with flies and maggots
- Francesco Redi: claimed maggots arose from eggs, not meat
  EX: experiment with covered and uncovered jars of meat
  all the meat spoiled, but maggots were only on the uncovered meat
- John Needham: claimed spontaneous generation can occur
  EX: boiled a sealed bottle of gravy, later saw micro-organisms
  he didn't kill all the micro-organisms
- Lazzaro Spallanzani: claimed Needham was wrong
  EX: prepared 2 flasks of gravy (open and sealed) and boiled
  the open flask contained micro-organisms, but the sealed flask didn't
  they entered the gravy through the air (no spontaneous generation)
- Louis Pasteur: scientist who disproved spontaneous generation (1864)
  EX: placed nutrient broth in flask with a long, curved neck
  after 1 year, no micro-organisms
  after the neck is broken off, micro-organisms grew within 1 day

The First Signs of Life

- Earth is 4.6 billion years old
- early atmosphere produced from volcanic activity and meteors
- early atmosphere contained water vapor (H_20), carbon monoxide (CO), hydrogen (H_2), nitrogen (N_2), carbon dioxide (CO_2), ammonia (NH_3), and methane (CH_4)
- no oxygen (O_2) in early atmosphere
  EX: rocks from this time period do not contain rust (iron oxide)

Early Molecules

- Stanley Miller and Harold Urey's experiment:
  They proved the organic molecules (such as proteins) could have been naturally made from the gases in the early atmosphere.
- EX: They recreated the early atmosphere in a flask, passed an electrical current through it (for activation energy), and showed that proteins spontaneously formed.
- RNA is thought to be the first genetic material – originally produced inside volcanoes by archaebacteria.
- RNA can self-replicate (make copies of itself during reproduction)
- EX: An experiment simulated volcanic conditions and showed that RNA could naturally and spontaneously form there.
- Phospholipids could also spontaneously form from atmospheric gases and automatically arrange themselves into a cell membrane (phospholipid bilayer).

Three Requirements for Life on Earth

1. protein (used for the majority of cell's physical structure and chemical function)
2. RNA (genetic material that can self-replicate for the purpose of reproduction)
3. phospholipids (creates a cell membrane, separating the cell from its environment)

Early Cells

- All early cells were anaerobic (didn't use oxygen).
- All early cells were heterotrophs (they "ate" primitive molecules and broke them down using fermentation)
- Natural selection favored autotrophs – If you could make your own food, you were more likely to survive
- Early photosynthesis did not use H_2O. It was called "chemosynthesis" and used H_2S (hydrogen sulfide), which is found in volcanoes.
- Earliest heterotrophs = 3.5 billion years ago
- Earliest autotrophs = 3.4 billion years ago

The Road to Modern Organisms

- 2.2 billion years ago = autotrophs switched from using H_2S and started using H_2O
- Oxygen was the newest gas in the atmosphere – made as a "waste" product in photosynthesis.
- Ozone started to form in the atmosphere. Why? Ozone is made from oxygen.
- Organisms started to evolve the process of cellular respiration (now that oxygen was available).
- (oxygen → cellular respiration → 32 ATP)
- (no oxygen → fermentation → 2 ATP)
- 1.5 billion years ago = evolution of the first eukaryotic cells (Kingdom Protista)
- Eukaryotic cells have a nucleus and other membrane-bound organelles.
- Evolution favored sexual reproduction (reproduction with 2 parents instead of 1) instead of asexual reproduction.
- Sexual reproduction helps to increase genetic variation of a species.
- Evolution favored multicellular organisms instead instead of unicellular organisms.
- Having more than one cell helps in 2 ways:
    1. Cells can become specialized and have specific functions.
       EX: tissues, organs, organ systems
    2. This increases the surface area of the organism.

Review – 6 Major Steps in the Road to Modern Organisms

1. photosynthesis
2. oxygen in the atmosphere
3. cellular respiration / aerobic cells
4. eukaryotic cells
5. sexual reproduction
6. multicellular organisms

The Endo-Symbiotic Theory

- symbiosis = a close relationship between 2 organisms in which at least one benefits from the other
- The symbiotic theory explains how prokaryotic cells (bacteria) evolved into eukaryotic cells (Protista)
- First, the cell membrane of a large prokaryotic cell folded inward. This formed the nuclear envelope. Additional infoldings produced the rough ER, smooth ER, and Golgi apparatus.
- Second, the large prokaryotic cell "ate" a primitive mitochondrion.
- Third, the large prokaryotic cell "ate" a primitive chloroplast.
- How do scientists know that the mitochondrion was "eaten" before the chloroplast?
- Evidence for the theory:
    1. chloroplasts, mitochondria, and nuclei all have DNA
    2. chloroplasts, mitochondria, and nuclei all have their own membrane
    3. chloroplasts, mitochondria, and nuclei can all self-replicate
    4. chloroplasts and mitochondria both contain ribosomes;
       the nucleus produces ribosomes in the nucleolus
- How did they all benefit?
    1. The 3 organelles got protection from the big cell.
    2. The mitochondrion did cellular respiration and gave ATP to the big cell.
    3. The chloroplast did photosynthesis and gave glucose to the big cell.
    4. The nucleus gave protection to the DNA inside the big cell.

THE HISTORY OF LIFE

A. ***Anaerobic Cells*** (cells that do not use oxygen)
vs.
Aerobic Cells (cells that do use oxygen)

1st → anaerobic
2nd → aerobic

WHY? There was no oxygen in the early atmosphere.

B. ***Multicellular Organisms*** (organisms that have many cells)
vs.
Unicellular Organisms (organisms that only have one cell)

1st → unicellular
2nd → multicellular

WHY? Simple organisms evolved before more complex organisms.

C. ***Eukaryotic Cells*** (cells that have a nucleus and other membrane-bound organelles)
vs.
Prokaryotic Cells (cells that do not have a nucleus and membrane-bound organelles)

1st → prokaryotic
2nd → eukaryotic

WHY? Simple organisms evolved before more complex organisms.
The endo-symbiotic theory explains how eukaryotic cells (Protists) formed.

D. ***Photosynthesis Using H_2O*** (photosynthesis using water; creates oxygen gas)
vs.
Chemosynthesis Using H_2S (chemosynthesis using hydrogen sulfide)

1st → chemosynthesis using H_2S
2nd → photosynthesis using H_2O

WHY? Early organisms lived in volcanoes, where there is a lot of sulfur.

E. ***Fermentation*** (a way to make energy when O_2 isn't available – only makes 2 ATP)
vs.
Cellular Respiration (a way to make energy using O_2 – makes 32 ATP!)

1st → fermentation
2nd → cellular respiration

WHY? There was no oxygen in Earth's early atmosphere.
Oxygen was created when "photosynthesis using H_2O" evolved.

F. ***Autotrophs*** (organisms that do make their own food – photosynthesis)
vs.
Heterotrophs (organisms that do not make their own food)

1st → heterotrophs
2nd → autotrophs

WHY? Heterotrophs "ate" the primitive molecules inside the volcanoes.

G. ***Asexual Reproduction*** (reproducing by itself – only requires 1 parent)
vs.
Sexual Reproduction (reproducing with another organism – requires 2 parents)

1st → asexual reproduction
2nd → sexual reproduction

WHY? Simpler organisms evolved before more complex organisms.
Asexual reproduction only produces clones of the parent.
Sexual reproduction creates more genetic variation by combining traits of both parents.

H. ***Domain Archaea*** vs. ***Domain Eukarya*** vs. ***Domain Bacteria***

1st → Domain Bacteria
2nd → Domain Archaea
3rd → Domain Eukarya (Protists, Fungi, Plants, Animals)

WHY?

Bacteria, Archaea:	unicellular & prokaryotic
Early Eukarya (Protists):	unicellular & eukaryotic
Later Eukarya (Fungi, Plantae, Animalia):	multicellular & eukaryotic

PROPERTY OF:

HONORS BIOLOGY – UNIT 3 – CHAPTER 15b NOTES

TRACING EVOLUTIONARY HISTORY – BACTERIA & VIRUSES

Viruses

- non-cellular particle
- contains genetic material (DNA or RNA)
- also contains protein
- invade living cells
- come in a variety of shapes and sizes
- viral specificity = the virus can only invade certain types of cells or organisms (lock + key fit)
- must invade living host cells in order to replicate
- cannot replicate on it's own
- all viruses are parasites (depends on another organism and causes it harm)
- not considered a living thing ("non-living")
- there is no kingdom for viruses
- a lytic virus is a well-studied virus that infects bacterial cells

Infection by a Lytic Virus

- lytic viruses attack bacteria, causing them to burst open
- STEP 1: INFECTION = the virus attaches to the host bacterium using a lock and key fit and injects its DNA/RNA into the cell; the empty virus, without its DNA/RNA, "dies"
- STEP 2: GROWTH = the injected viral DNA uses enzymes from the bacterium to synthesize viral DNA and proteins; the host cell is not aware of this process
- STEP 3: REPLICATION = the viral DNA and proteins are assembled into hundreds of new viruses inside of the bacterium; the host cell is not aware of the process
- STEP 4: LYSIS = the bacterium bursts open, releasing all the viruses that were created; each new virus can now infect a new host cell using a lock and key fit

NOTE: There are many other categories of viruses besides lytic viruses. Their method of reproduction is similar to that of lytic viruses.

Bacteria

- prokaryotic (does not contain a nucleus or other organelles)
- unicellular (made of only one cell)
- could be autotrophic (can make its own food) or heterotrophic (can't make its own food)
- Archaebacteria (ancient bacteria) & Eubacteria (true bacteria)
- contain a cell membrane and a cell wall (but no cellulose, unlike plants)
- may contain 1 or more flagella (movement)
- basic shapes: bacillus (rod-shaped), coccus (spherical), spirillum (spiral)

Bacterial Respiration

- obligate aerobe = bacteria that requires oxygen to live
  (cellular respiration, 32 ATP per glucose)
- obligate anaerobe = bacteria that are poisoned by oxygen
  (fermentation, only 2 ATP per glucose)
- facultative anaerobe = can live with or without oxygen
  (cellular respiration or fermentation, 32 or 2 ATP per glucose)

Bacterial Reproduction

- BINARY FISSION = produces 2 identical daughter cells (asexual)
  (1) the cell doubles in size
  (2) the DNA is replicated
  (3) the cell divides in half, producing 2 identical cells
- CONJUGATION = produces different daughter cells (sexual)
  (1) a thin tube connects one bacterium to another
  (2) "donor" passes DNA to the "recipient" using a "pilus" (tube)
  (3) new combinations of genes are formed
- ENDOSPORES = a structure that allows bacteria to survive harsh conditions (asexual)
  The bacteria turns into a spore by shrinking and building a much thicker cell wall.

Importance of Bacteria

- used to make cheese, yogurt, sour cream, vinegar, and other foods
- used to "digest" oil spills (environmental cleanup)
- used to synthesize drugs (EX: human insulin)
- used to help produce vitamin K in human intestines (EX: *E. Coli*)
- used to help cows digest cellulose
- used to help decompose (break down) dead material in the environment
- used to help decompose material in water treatment plants
- used to convert nitrogen gas into usable forms in the soil