A few of this week’s topics

- What does it mean to be alive?
- Living things – life’s diversity
- The scientific method
Biology - study of life

- All living things:
  - 1. sense and respond to environment
  - 2. capture and use energy
    - Metabolism = all the chemical reactions in a cell
    - Homeostasis = maintain internal operating conditions within a range
  - 3. reproduce, develop, grow
    - New cells only arise from previous cells
4. are composed of at least one cell
   - Some are unicellular
   - Some are multicellular

5. contain DNA
   - Genes provide the instructions for the cell
Genus and species

Binomial nomenclature

Every living organism has two names which represent the genus and species:

- *Felis domesticus*  
- *Canus familiaris*
- *Mus musculus*
- *R. rattus*
Life’s diversity

• 2 million species have been described
  • could be over 15 million species

• Living things are classified = Taxonomy
No nucleus in cell  Presence of nucleus in cell
Eukarya

- **Kingdom Animalia**
- 3 characteristics?
- motile, multicellular, consumers

What IS this??
Example of an animal useful to humans

- Diabetes drug from venom/saliva

Gila monster (lizard)
Kingdom **Plantae** (400 million years)

370 feet
Plants – characteristics?

- Multicellular
- Photosynthesis

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{O}_2 + \text{starch} \]

Sunlight is ultimate energy source for life – why?

- Plants are producers
Example of a plant useful to humans: Aloe

(b) Aloe (Aloe barbadensis)

Source of aloe vera, used to treat burns and dry skin.

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Kingdom **Fungi** = molds, fungus, yeast

- Secrete chemicals to break down and absorb food from dead or living matter
2 important fungal medicines:

- **Cyclosporin** (1971) *Tolypocladium inflatum*
  - Suppresses immune system… so…..
  - Used in organ transplants, psoriasis, rheumatoid arthritis
Penicillin antibiotic
- From bread mold
- Revolutionized medicine
Kingdom **Protista** also called **protozoa**

- **Unicellular**
  - Have a nucleus (Domain *Eukarya*)
Fig. 1.7  Euglena
Domain **Bacteria**

3.5 billion years old

- Prokaryotic cells
  - No nucleus
  - Single-celled

On octopus mouth

intestine

plant roots
Domain Archaea

Methanosarcina mazei makes methane from acetate

Fig. 1.5
- Extremophiles
  - Have been found in thermal vents, salt crystals, ice, acid environments
- Extraterrestrial life?

Geyser (hot!)  
MARS
“Chance favors the prepared mind” Louis Pasteur

**SCIENCE**

- Science - a *process* of discovery

  - objective
  - explain world using *natural* processes

Why is the fish dead?

- fish dead because there was a curse on it
- fish dead because there’s no food in its tank
Scientific method

1. OBSERVATION

2. HYPOTHESIS

- educated guess
- comes before the experiment
- must be testable and falsifiable
Hypothesis = “educated” guess

(a) All of us generate hypotheses

Intuition, Luck, Logic, Experience, Imagination

HYPOTHESIS

Observation

QUESTION

(b) Scientific hypotheses are testable and falsifiable

Capable of being evaluated through observations of the measurable universe

Able to be proved false
Hypothesis must be **Testable**

- Zinc lozenges ward off the common cold
- Colds are disturbances in psychic energy
- Meditation improves the immune system
- Hypothesis must be falsifiable

- Eggs lead to heart disease
- Hormone treatment is good for menopausal women
- The earth is round
- **Hypothesis** – educated guess
- **Theory** – supported by all data, a unifying concept
  - Theory of gravity
  - Round earth
Mars year = 687 earth days
Mercury = 87.8 earth days
The Experimental Method

1. **Control group** = often a “no treatment” group
2. Experimental groups

EXPERIMENTAL VARIABLE (compare control and experimental groups, what is different)?
3. **controlled variables**
keep constant to insure only one experimental variable per experiment
4. Measurement

- Length, weight, count, etc...
- Results = data obtained and analyzed
Never ignore data and stay away from preconceived ideas

“Ignore it, Jeffries. It’s unscientific.”
minimize bias

- Placebo
- Double blind studies
Placebo effect

- The placebo effect is the observable, or felt improvement in health not attributable to treatment.

“Patients suffering pain after wisdom-tooth extraction got just as much relief from a fake application of ultrasound as from a real one, so long as both patient and therapist thought the machine was on”

- The Placebo Prescription" by Margaret Talbot, New York Times Magazine, January 9, 2000) *
Evolution

- Change through time
Change over time

“all organisms present of Earth today are descendents of a single common ancestor and all organisms represent the product of millions of years of evolution”

Also known as common descent
- **Species**
  - Group that can interbreed

- **Microevolution**
  - Change within a species or population over time

- **Speciation**
  - New species arise from ancestral species
What is a Species?

- One species is reproductively isolated from other species.
- Shares gene pool

Hobbs

Male lion  female tiger male ligers are sterile, female ligers are fertile
Female horse X male donkey  horse X zebra  False killer whale X bottle nose dolphin

Mandarin orange X pummelo
Fig. 16.3. All humans share a common ancestor
- Horses have undergone much speciation
Sharks have changed very little in 40 million years
Natural Selection

- How do we know what happened a long time ago (geological time)?
250 mya Pangaea – continents came together

dramatic environmental change
mass extinction

Fig 16.13
Geological Time Scale

- Age of Earth:
- When living organisms first appeared:

Humans have been on Earth for 0.04% of the history of life
- She: wore thick glasses and had brown hair in grade school, she had laser eye surgery and dyed her hair blond

- He: was a “98 pound weakling” before body building

- They have a boy, what will he inherit?

No inheritance of acquired characteristics, use and disuse of a structure does not lead to inherited change
Fig 14.8

Natural selection versus acquired characteristics

- **Lamarck’s proposal**
  - Originally, giraffes had short necks.
  - Giraffes stretched their necks in order to reach food.
  - With continual stretching, most giraffes now have long necks.

- **Darwin’s proposal**
  - Originally, giraffe neck length varied.
  - Struggle to exist causes long-necked giraffes to have the most offspring.
  - Due to natural selection, most giraffes now have long necks.
Natural Selection and common descent (1859) ~ evolution

Charles Darwin  
T.H. Huxley
HMS Beagle
Galapagos Islands

1836

Galapagos finches

Tortoise

marine iguana

Volcanic islands off the coast of Ecuador that contain unique species of plants and animals
FINCHES HAVE ADAPTED TO ENVIRONMENTS

Adaptive radiation Fig. 16.9
Fig. 14.6

Diet of seeds

a. Ground-dwelling finch

Beak to catch insects

b. Warbler finch

c. Cactus finch

Probes cacti for nectar

All descended from a single ancestral species
Natural Selection – how does it work?

1. **Random variation**
   
   A. All populations of organisms vary **randomly**

   - Variations are NOT imperfections but a normal aspect of species

(a) Variation in coat color

![Image of wolves in the snow]
B. Variation occurs due to **mutation** and sexual reproduction

- **mutation** = heritable change in DNA

- DNA also rearranges during formation of sperm and egg

C. Variation inherited from parent to offspring
What is a mutation?

- Most are **neutral mutations**: no effect on fitness

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“Mutant” melanin gene
Blond phenotype

normal melanin gene
brown phenotype
A few are **harmful mutations**:
- hemophilia

A few are **positive mutations**:
- beneficial (longer neck in giraffe)
2. Not all offspring survive

- Examples:
  - 1 sea star has 4 million offspring – which survive?
4 million in 11 generations (800 years) ! Which survive??
3. “Survival of the fittest”=

- The most “fit”, or adapted organisms survive and pass their genes on

- **Fitness** is determined by the environment

**Fitness** = reproductive success

**THIS IS NATURAL SELECTION**
Another adaptation to avoid predation

Fig 14.9

Brazilian alligator bug
Examples of adaptations (increase fitness)

a. Ground-dwelling finch

b. Western Diamondback Rattlesnake

c. Peacocks

d. Arctic Fox

e. Grasshopper

f. Eye of a tortoise
4. Descent with modification

Offspring inherit traits of parents =

Descent with modification =

Evolution
Natural selection results in adaptive traits increasingly represented in each succeeding generation.

May take a lot of time for change to be obvious and lead to a new species.

pg. 223
speciation

Ancestral species give rise to new species
The most well adapted (most fit) organisms survive to reproduce.

Traits that increase fitness are adaptations.
Artificial Selection – breeding of domesticated animals and plants by humans, this is NOT natural selection

- Cows, corn, dogs

Bulldog
Evolution

change through time
Earth *does* change
It’s not all due to catastrophe
Shaped by gradual, natural, slow processes
like erosion, wind, rain

How old is the earth?
The Grand Canyon was not produced by a catastrophe.
2. Fossils, pg. 224

- History of life recorded by remains of past
- Living matter buried in volcanic ash or sediments for >10,000 years
  - mineralized + pressure = hard

- Types
  - Impression
  - Bones, teeth
  - Amber
  - Petrified wood (organic materials replaced with minerals)
Incomplete record
- no preservation of soft organisms or parts
  - Jellyfish, hearts, brains
Why is the fossil record incomplete?

- 75% of the earth is ocean
- Many destroyed by weather
- Fossils don’t always form
  - A small number are buried in the right way (fast) to prevent decomposition
- Cant dig up entire earth, many still buried
- No soft parts
Impressions

Texas

New Jersey

http://digsfossils.com/fossils/footprints_main.html
1. An organism is rapidly buried in water, mud, sand, or volcanic ash. The tissues begin to decompose very slowly.

2. Water seeping through the sediment picks up minerals from the soil and deposits them in the spaces left by the decaying tissue.

3. After thousands of years, most or all of the original tissue is replaced by very hard minerals, resulting in a rock model of the original bone.

4. When erosion or human disturbance removes the overlying sediment, the fossil is exposed (as shown here looking from above).
Fig 16.10 Only the hard parts remain after fossilization process
99% of species once alive are extinct

~ 2 billion total

Stratification: simple = oldest = deepest

Succession of life forms
a. Visible strata.
Hadrosaurus, Haddonfield, NJ 1858
The NJ State Dinosaur
Coelacanths!

- 1938, a Coelacanth was caught at the mouth of the Chalumna River on the east coast of South Africa.

Coelacanth fossilized in rock dated 70 million years ago
Fossils found a few years ago

A bison-size rodent, *Phoberomys pattersoni*, grazed on aquatic grasses and roamed the riverbanks of ancient Venezuela about 8 million years ago.
Glyptodon and modern armadillo

Fig 14.4
Kutchicetus 40 mya
A famous hominid fossil

1974, Hadar, Ethiopia.

**Lucy** — *(Australopithecus afarensis)*

East Africa ... 3.2 million

Pelvis - walked upright on two legs. Arms – good climber
Lucy

300 individuals found
3 feet 8 inches tall
More ape-like than human
1. *Australopithecus afarensis*
2. *Australopithecus africanus*
3. *Homo habilis*
4. *Homo erectus*
5. Neandertal
archaeopteryx- a dinosaur/bird link

Late Jurassic period, and specimens have been found in limestone deposits in Bavaria, West Germany. The first specimen was discovered in 1861, and since then six skeletons have been found.
Red = reptile    Green = bird
5. Anatomy

Fig. 14.14

Homologous structures

Share a common evolutionary history but may be used for different functions
Analogous structures

- similar function but no shared evolutionary history.
Vestigial structures

- Function lost during evolution, no longer needed
- human appendix, whale leg bones, snake leg bones
This is your appendix........
6. Embryology pg. 226

- vertebrate body plan for development
  = shared descent
DNA evidence of relatedness of species

- Humans share 99.9% of DNA
- Human DNA is 99.01% similar to chimp
- 90% with mice
Pre- and post-evolutionary theory, page 218

<table>
<thead>
<tr>
<th>Pre-Darwinian View</th>
<th>Post-Darwinian View</th>
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<tbody>
<tr>
<td>1. The Earth is relatively young—age is measured in thousands of years.</td>
<td>1. The Earth is relatively old—age is measured in billions of years.</td>
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<td>2. Each species is specially created; species don’t change, and the number of</td>
<td>2. Species are related by descent—it is possible to piece together a history of</td>
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<td>species remains the same.</td>
<td>life on Earth, showing lines of descent.</td>
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<tr>
<td>3. Adaptation to the environment is the work of a creator who decided the</td>
<td>3. Adaptation to the environment is the interplay of random variations and</td>
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<td>structure and function of each type of organism. Any variations are</td>
<td>environmental conditions.</td>
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<td>imperfections.</td>
<td>4. Observation and experimentation are used to test hypotheses, including</td>
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<tr>
<td>4. Observations are supposed to substantiate the prevailing worldview.</td>
<td>hypotheses about evolution.</td>
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Table 14.1: Contrast of Worldviews
Mammals - what makes a mammal a mammal??
Duckbilled platypus - reptile, bird, or mammal?

Monotremes are the most primitive mammals

Ornithorhynchus anatinus
Marsupials – development in pouch
Placental mammals

- Born more fully developed
- Placenta in uterus
- Ex. Bat, polar bear, human, whale, cow, armadillo