

"The universe is full of magical things patiently waiting for our wits to grow sharper."
- Eden Phillpotts

"All of science is nothing more than the refinement of everyday thinking."
- Einstein

Biology 1 with Tyler Flisik

Fall 2018

Biology is the study of life

Greek and Latin root for Biology

- ▶ Bi(ola) = life
- ▶ log(y) = discourse, the study of

What defines something as *alive*?

1. The ability to assimilate and use _____
2. The ability to respond to their environment
3. The ability to maintain a relatively constant _____ environment
4. Have _____ from other living things
5. The ability to _____
6. Composed of one or more _____ with information encoded by _____
7. Are highly organized when compared to inanimate objects
8. The ability to grow and develop

Non-living objects are not self-sustaining

- ▶ Inanimate

Characteristics of Living Things

- ▶ Living organisms use energy



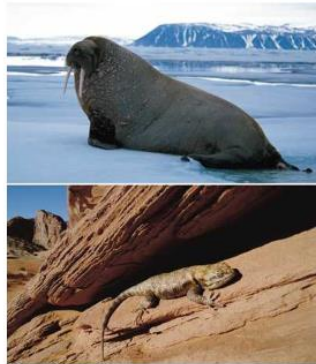
Characteristics of Living Things

- ▶ Living organisms respond to their environment



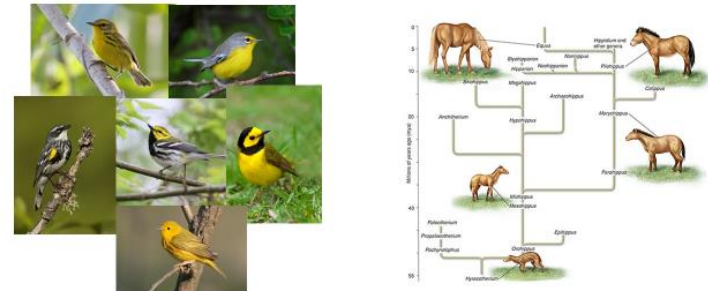
Characteristics of Living Things

- Living organisms maintain _____ or some relatively constant internal environment



Characteristics of Living Things

- Living things have evolved from other living things



Characteristics of Living Things

- Living organisms reproduce



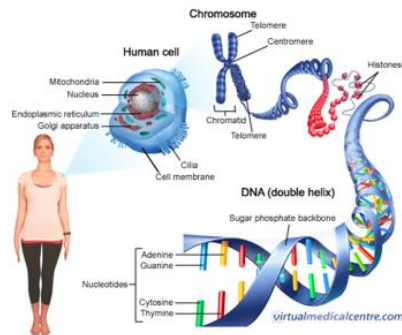
Characteristics of Living Things

- Living things are composed of one or more cells



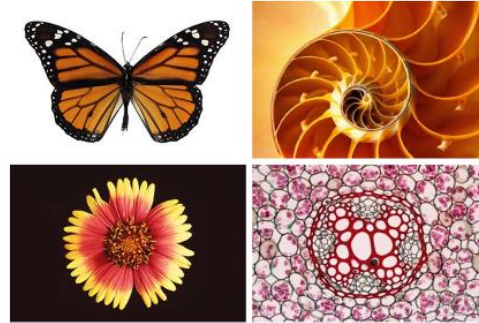
Characteristics of Living Things

- ▶ Living organisms contain DNA
 - ▶ Inherited information base that codes for *everything*!



Characteristics of Living Things

- ▶ Living organisms are highly organized compared to inanimate objects



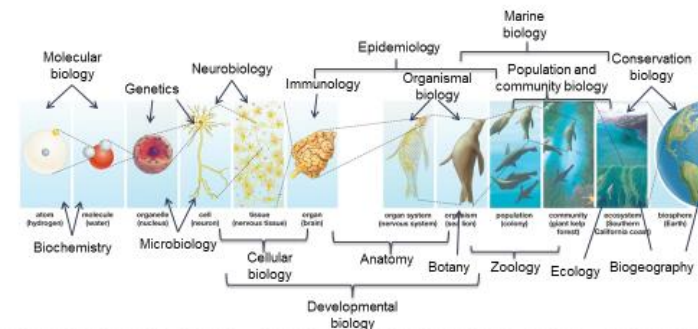
Characteristics of Living Things

- ▶ Living organisms grow and develop



Hierarchy of life

Life is organized and studied at many different levels



How does one do the *science*?

Scientific method

- ▶ _____ = Carefully observe the some phenomena and consider what we already know and what we don't know about the unknown phenomena.
- ▶ **Question** = Narrow focus to a specific question. What do we want to know?
- ▶ **Formulate** _____ = Our proposed explanation for the unknown phenomena. What we think is happening. Must be testable!
- ▶ **Experimentation** = Design an experiment to test your hypothesis and collect data.
 - ▶ Quantitative data: Deals with numbers. Things that can be measured.
 - ▶ Ex: Height, weight, length, time
 - ▶ Qualitative data: Deals with descriptions. Things that cannot be measured.
 - ▶ Ex: Color, texture
- ▶ **Results** = Analyze data and display results in figures or tables.
- ▶ **Conclusion** = Do our results support or refute our hypothesis? How do our findings relate to the big picture?

How does one do the *science*?

- ▶ The scientific method is a stepwise procedure but does not require the investigator to continue linearly through the steps. Revisions are constantly made as new information is uncovered.



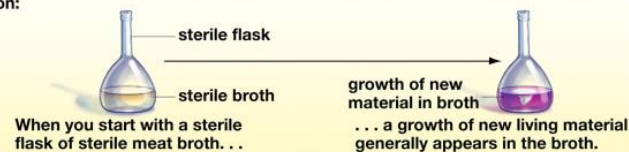
Famous example of Scientific Method

Louis Pasteur 1860's

- ▶ Can life be created spontaneously?

Scientific method at work: Pasteur tests "spontaneous generation"

Observation:



Question: What is the source of the living material?

Make a Prediction

- ▶ Formulate a testable hypothesis

Hypothesis:

Hypothesis 1

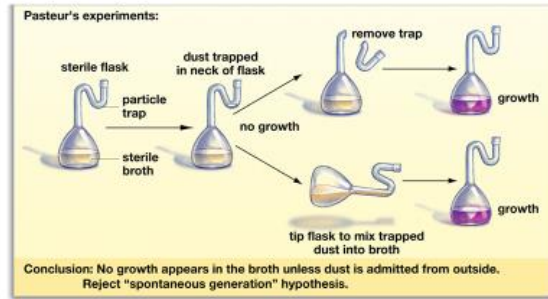
The living material is derived from nonliving material (spontaneous generation).

Hypothesis 2

The living material is derived from living material outside the flask.

Experimentation

- Design an experiment that tests your hypothesis while minimizing other variables.



"Without speculation, there is no good and original observation"
– Charles Darwin

Observation

- Carefully review the unknown
- Understand the variables influencing the unknown
 - _____: an adjustable condition in an experiment
 - Variables can be biotic or abiotic
 - **Abiotic variables:** temperature, lighting, precipitation, timing
 - **Biotic variables:** interaction with other organisms, chemical processes
- Example experiment: Observation
 - Indoor plants = florescent lighting
 - Outdoor plants = sunlight
 - Spectrum of light



Scientific Method

Questions

- What do you want to understand about the unknown?
- Can you test for the unknown?
- What are the variables?
- What do we already know about the unknown?
 - Literature search

Example experiment: Question

- Do plants grow better under florescent lighting or natural lighting (sunlight)?

"No great discovery was made without a bold guess"
-Marie Curie

Formulate a hypothesis

- Be specific. Fully address the question.
- Is the hypothesis testable?
- Is the hypothesis falsifiable?
 - _____: the potential to be proven false.
 - Good example: All animals have teeth
 - Bad example: There are sasquatch in Canada

Example experiment: Hypothesis

- Hypo 1: The plant will grow better under sunlight.
- Hypo 2: On average, the lemon button fern (*Nephrolepis cordifolia*) will grow more new leaves under natural light, than under florescent light, when all other variables are held constant.



Scientific Method

Experimental design

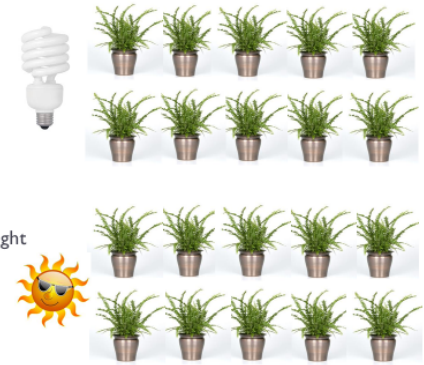
- ▶ Experiments should be designed to test ____ question at a time.
 - ▶ Design experiments to reduce the number of variables
 - ▶ Excess variables compound the results
- ▶ Experimental _____
 - ▶ Used for comparison
- ▶ _____!!
 - ▶ Take an average of multiple trials ("on average")
- ▶ Repeatability!
 - ▶ Experiments should be able to be replicated by other scientists

▶

Scientific Method

Example experiment: Experimental Design

- ▶ How are we going to test for growth?
 - ▶ Plant height, number of new leaves or flowers
- ▶ What are our variables?
 - ▶ Abiotic: _____
 - ▶ Biotic: _____
- ▶ Sample size?
- ▶ Final design:
 - ▶ 10 lemon button fern plants under each type of light
 - ▶ Same amount water
 - ▶ Same temperature
 - ▶ Light 12 hrs, Dark 12 hrs
 - ▶ # of leaves counted once a week for six months



▶

Scientific Method

Results

Data is represented in tables or graphs

- ▶ Bar graphs or Histograms: used to compare groups
- ▶ Line graphs or Scatter Plots: used to show trends, typically across time or temperature, or the relationship between two variables

Independent variable: the variable that is changed or manipulated

- ▶ Typically on the x-axis

Dependent variable: the variable that is being measured

- ▶ Typically on the y-axis

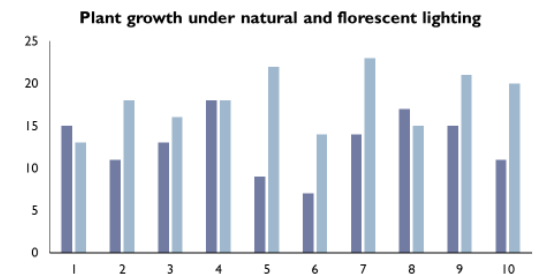
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Scientific Method

Conclusion and Discussion

Graph results

Plant #	# of new leaves	
	Florescent	Sunlight
1	15	13
2	11	18
3	13	16
4	18	18
5	9	22
6	7	14
7	14	23
8	17	15
9	15	21
10	11	20



- ▶ Do the findings support or refute hypothesis?
 - ▶ Reconsider and refine hypothesis and experiment
 - ▶ Nothing is proven!!

▶

Scientific Method

Conclusion and Discussion

Graph results

Plant #	# of new leaves	
	Florescent	Sunlight
1	15	13
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3	13	16
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5	9	22
6	7	14
7	14	23
8	17	15
9	15	21
10	11	20
Avg.	13	18

Case Study

- At the Cedar Creek Long Term Ecological Research (LTER) site in Minnesota, researchers from the University of Minnesota can use experimental plots to determine the effects of varying levels of soil nitrogen on the effects of grassland productivity.

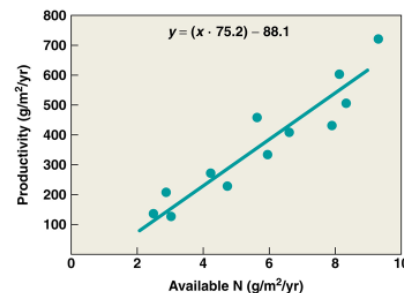


- What do we notice about the experimental plots at the Cedar Creek site?
- What would be the independent variable and dependent variable in a study on soil nitrogen?

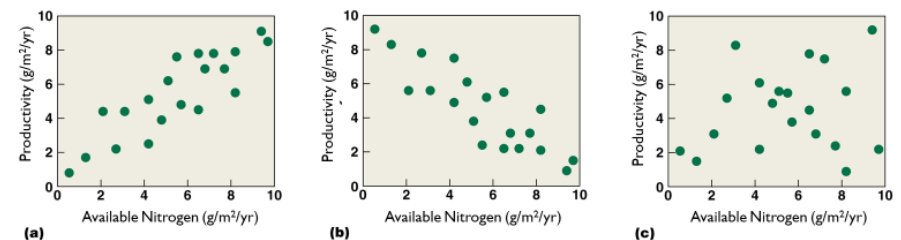
Scientific Method

Results

- The graph to the right shows the changes in grassland productivity as it relates to the amount of nitrogen (N) available in the soil.
- Linear regressions models can be used to make predictions about unknown circumstances
 - How much grassland productivity would you expect in an area with 6 grams per meter of available nitrogen
 - Productivity (y) = $(6 \times 75.2) - 88.1 = 363.1$



Interpreting Different Results



- Which of the following scatter plots shows a negative relationship between available nitrogen and productivity?
- Which of the following scatter plots shows no relationship between available nitrogen and productivity?

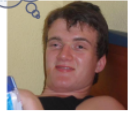
Scientific Method

Conclusions

- ▶ The conclusion or discussion section is where scientists interpret their results for a wider audience and relate their findings to a larger scale
 - ▶ Do the findings support or refute or hypothesis?
 - ▶ What research questions arose during the study?
 - ▶ What do the results mean for the health of the ecosystem?
 - ▶ How can the findings be used to aid in human or ecosystem health?
- ▶ Example statement: The findings from this experiment support the hypothesis that supplementing grassland soils with nitrogen-based fertilizer will increase grassland productivity. Greater grassland productivity will result in more available feed for livestock in Minnesota.



I have a theory!



Scientific theories vs. non-science theories

- ▶ Non-science “theories” are typically ideas or hypotheses
- ▶ **Scientific theory:** a general set of principles, supported by _____, that explains some aspect of nature
 - ▶ Scientific theories are supported or refuted, _____.
 - ▶ Ex. Theory of evolution by natural selection
- ▶ After many, many experiments in support a particular theory, the theory can be elevated to scientific law
 - ▶ Ex. Law of gravity



Intelligent Design and Creationism

Science _____ be falsifiable

- ▶ Can not test the existence of God
 - ▶ Probably shouldn't try it
- ▶ Science strives to explain the physical world
- ▶ Philosophy strives to explain the metaphysical



Evolution not Eviltion

“Seen in the light of evolution, biology is, perhaps, intellectually the most satisfying and inspiring science. Without that light it becomes a pile of sundry facts—some of them interesting or curious but making no meaningful picture as a whole”

—Theodosius Dobzhansky (1973)

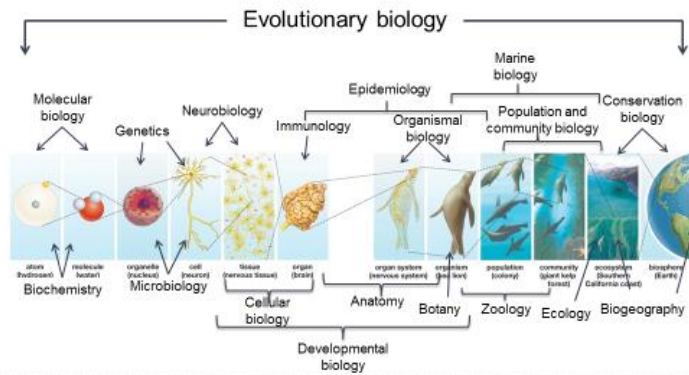
_____: the gradual modification of populations of living things over time

*Chief Unifying Principle in Biology

The appearance, behavior, and physiology of living things, have been and are being shaped by the influence of other living and non-living factors



The Study of Evolution



Evolution is Awesome!

Ask questions!

- ▶ Why do living things look the way that they do?
- ▶ How do living things acquire energy?
- ▶ How do females choose a mate?
- ▶ How do living things cope with the challenges of their habitat?
- ▶ How do we know how species are related?



Check Your Understanding

True or False: All living things can respond to their environment

True or False: A hypothesis must be provable in order to be deemed valid

True or False: Evolution is studied at all levels of biology

True or False: The independent variable is the variable that is typically being measured

Check Your Understanding

Which of the following lists the correct order for the scientific method?

- a. Question, Observe, Experiment, Hypothesis, Results, Discussion
- b. Observe, Hypothesis, Question, Experiment, Discussion, Results
- c. Observe, Question, Hypothesis, Experiment, Results, Discussion
- d. Question, Hypothesis, Observe, Experiment, Results, Discussion