

Maymester
BISC 445L

Maymester, Spring Semester



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La Brea Tar Pits



Whale watching



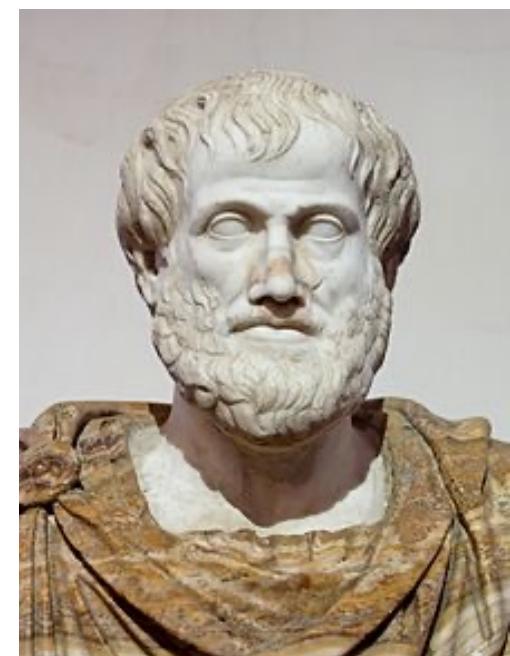
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SCIENTIFIC METHOD: hypothesis testing

At the core (from Aristotle): based on BOTH **inductive** and **deductive** reasoning

- Ask a question (based on previous info and observations)
- Propose an explanation (**hypothesis**) based on observations and current knowledge
- Design a procedure (observations/experiment); predicting results
- Collect data in nature or perform experiment
- Analyze data and interpret results

Strongly supported hypotheses are included in the general **theory** on the subject , which is used in general applications and further scientific studies

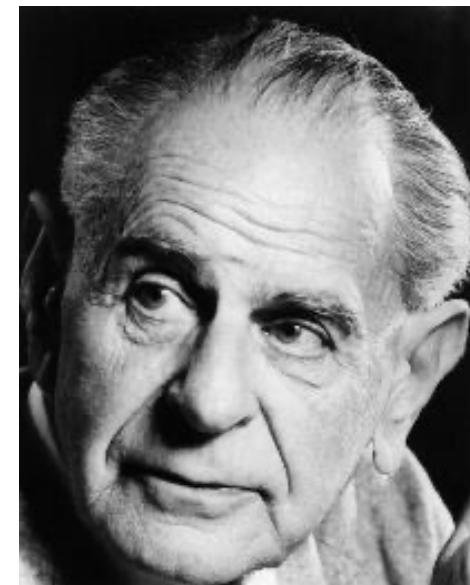


Aristotle

Modern Scientific Method: What is a proper SCIENTIFIC HYPOTHESIS?

- proposed explanation for a scientific question
- must be testable; more specifically it should be falsifiable
- Other scientists should be able to reproduce the results by following the same procedure
- testing a hypothesis means that results can:
 1. support the explanation (evidence supports the hypothesis)
 2. falsify the explanation (evidence rejects the hypothesis)

NOTE: we do not “prove” our hypothesis, we support it or falsify it



Karl Popper emphasized that it should be possible to falsify a scientific hypothesis

Scientific Method: What is a scientific HYPOTHESIS?

- “Chimpanzees are more closely related to humans than to gorillas”
 - Scientific hypothesis?

Scientific Method: What is a scientific HYPOTHESIS?

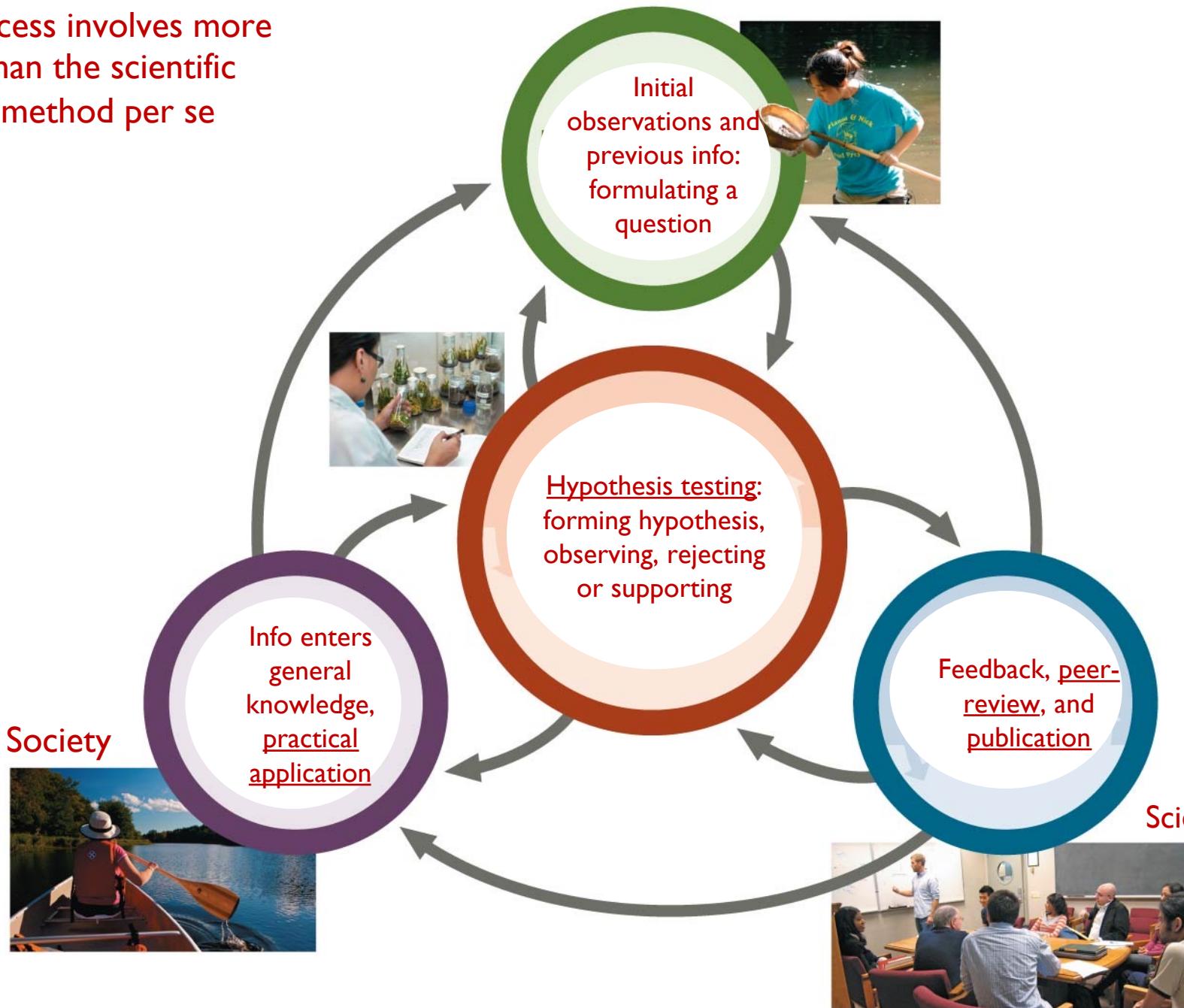
- “Vaccines cause autism”

- Scientific hypothesis?

Scientific Method: What is a scientific HYPOTHESIS?

- “Experiments on animals are unethical”
- Scientific hypothesis?

The modern scientific process involves more than the scientific method per se



Scientific Method: Variables

- Variables have to be **clearly defined, measurable and controllable**
- **Independent variable** – variable conditions whose effect is studied
- **Dependent variable** – what is being measured in the experiment in response to independent variable conditions
- **Controlled variables** – variables that are kept constant during the experiment



Null Hypothesis

Frequentist statistics, developed by biologists like Fisher, often recommend using H_0 and H_1

- H_0 : null hypothesis: a “conservative” hypothesis (e.g. “ H_0 :the new medicine is no better than the old medicine” or “ H_0 :the new pesticide does not improve crop yield”)
- H_1 the alternative hypothesis, is usually the new, alternative treatment or idea (e.g. “ H_1 :the new medicine is better than the old medicine”)
- The two should ideally be mutually exclusive
- Emphasis in most recommended statistical procedures is to **minimize the probability of rejecting the null, if the null is true**

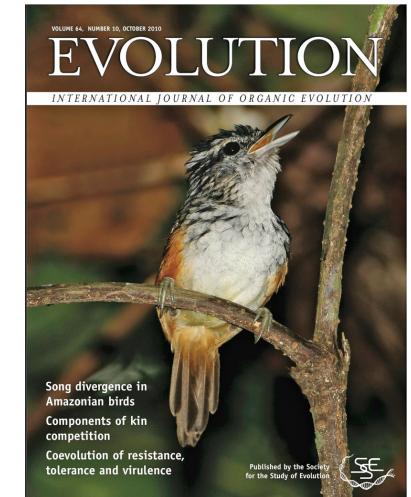
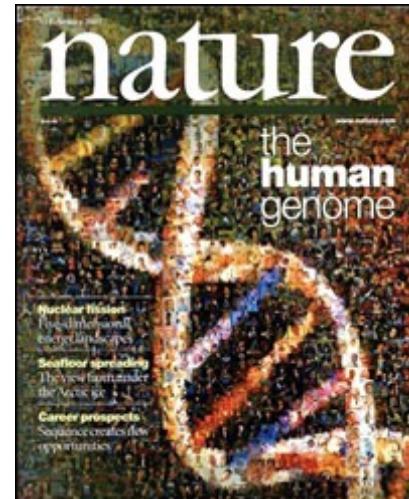


Ronald Fisher

The Scientific Method

- a **hypothesis** is a proposed answer to a scientific question (“educated guess”)
- many **facts** in science are hypotheses that have become strongly supported by evidence
- A scientific **theory** : is much broader in scope; encompassing many tested and interlinked hypotheses. E.g. theory of evolution, theory of quantum mechanics

Primary Sources of Scientific Literature



- Peer Reviewed Scientific Journals
- Anonymous review, by experts in the field



Evolution controversy

- Evolution: “Just a theory”?



Evolution controversy

- Do species evolve, change, and split into new species?
- The big one: evolution of humans and apes from a common ancestor?



Evolution controversy

- Do species evolve, change, and split into new species?
- The big one: evolution of humans and apes from a common ancestor?

YES

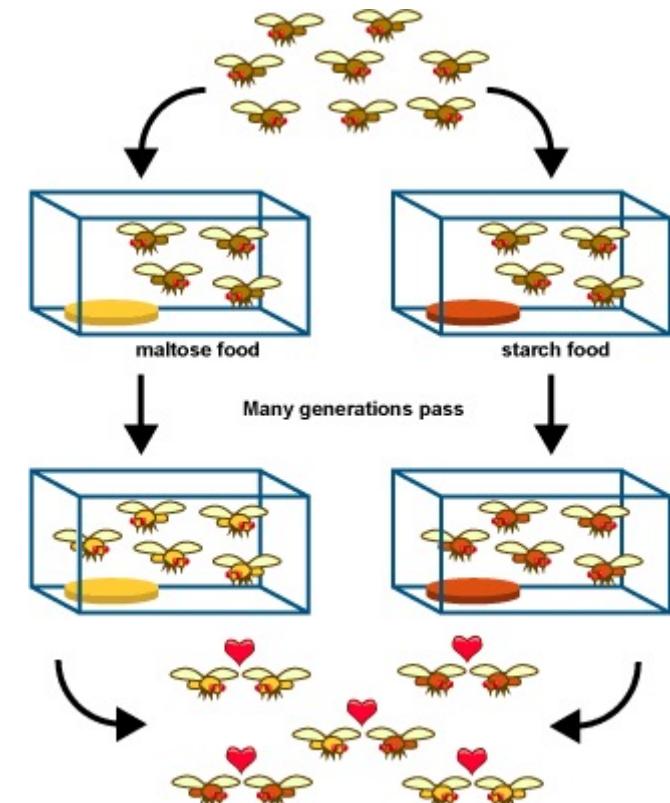
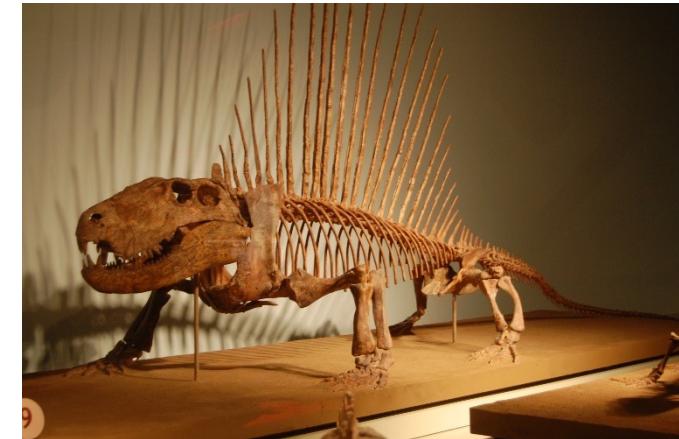
- No longer a **scientific** controversy

**“Theory” does not mean
“lacking in evidence”**



Testing Evolution

- Evolutionary theory: hypotheses have been tested numerous times the last 150 years
- Older species in the fossil record (going backwards) are less similar to modern ones; younger species more similar
- Experiments (e.g. artificial selection) have been conducted
- Gradual change approaching formation of new species has been observed



Theory of evolution by natural selection
= the central, unifying theory in biology

"Nothing in biology makes sense except in the light of evolution."

Theodosius Dobzhansky (1900-1975)



Scientific evolution controversy



Ship has sailed

Scientific evolution controversy

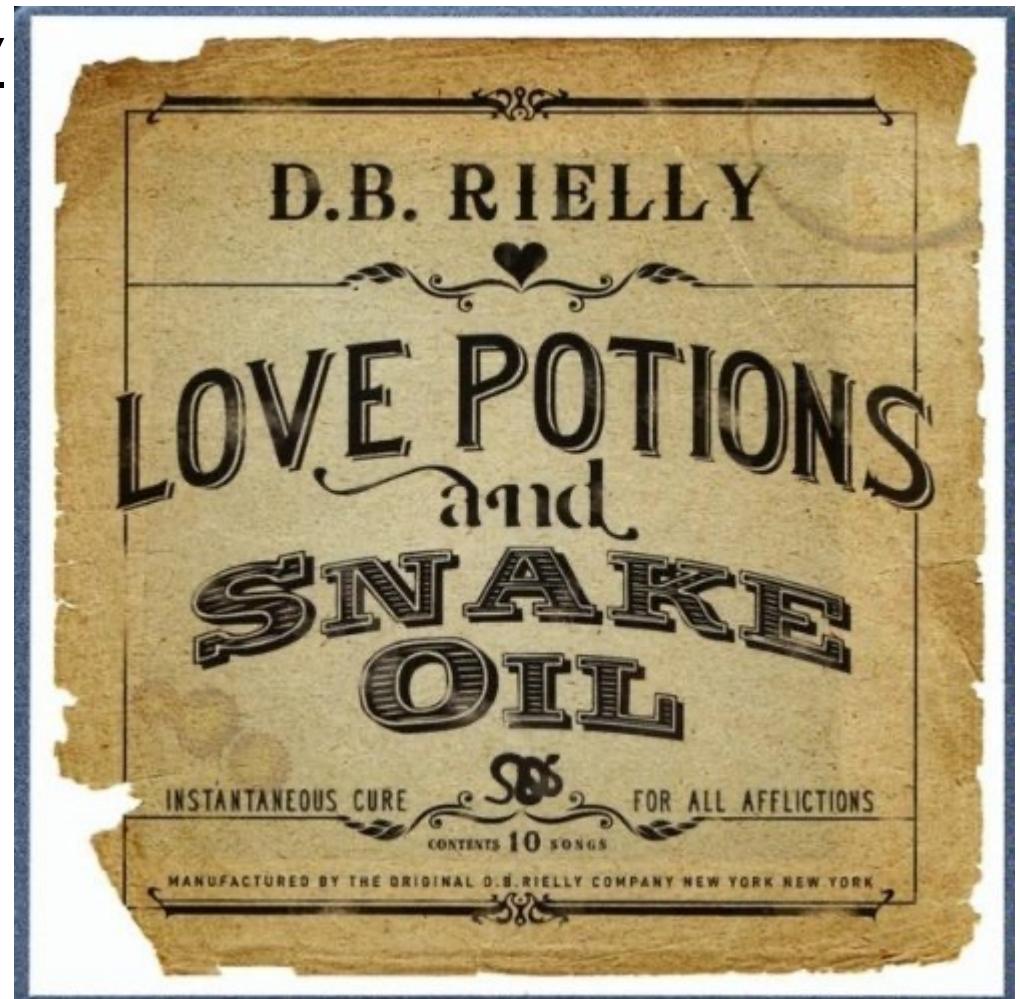
More on evolution later

Ship has sailed

Pseudoscience

Not testable or
reproducible OR already
falsified:

- Creationism
- “Intelligent design”
- Crystal healing
- Astrology
- Homeopathy
- And more...



Biology: what is life?



Reproduction

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Growth and development

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Order

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Response to the environment

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Regulation

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Evolutionary adaptation

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Energy processing

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- **Living organisms:** Reproduction, growth, adaptation, response to environment, order, regulation, energy processing (i.e. metabolism)

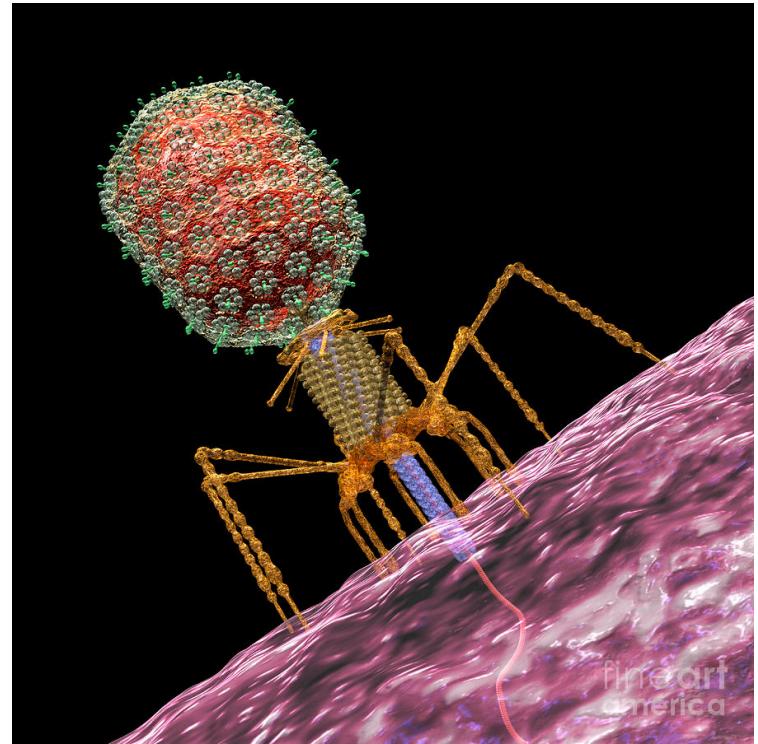
Bacteria? (sing. bacterium)

- Reproduction ✓
- Growth ✓
- Adaptation ✓
- Response to environment ✓
- Order ✓
- Regulation ✓
- Metabolism ✓



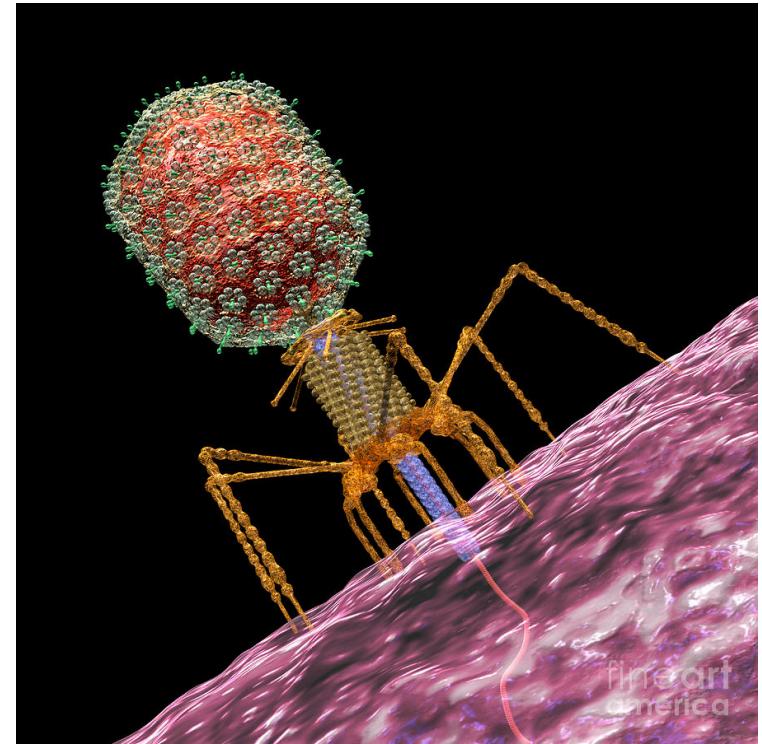
Virus?

- Reproduction ✓ (only parasitically)
- Growth -
- Adaptation ✓
- Response to environment -
- Order ✓
- Regulation -
- Metabolism - (makes use of host metabolism)



Virus?

- Reproduction ✓/- (**only parasitically**)
- Growth -
- Adaptation ✓
- Response to environment -
- Order ✓
- Regulation -
- Metabolism ✓ /- (only parasitically)



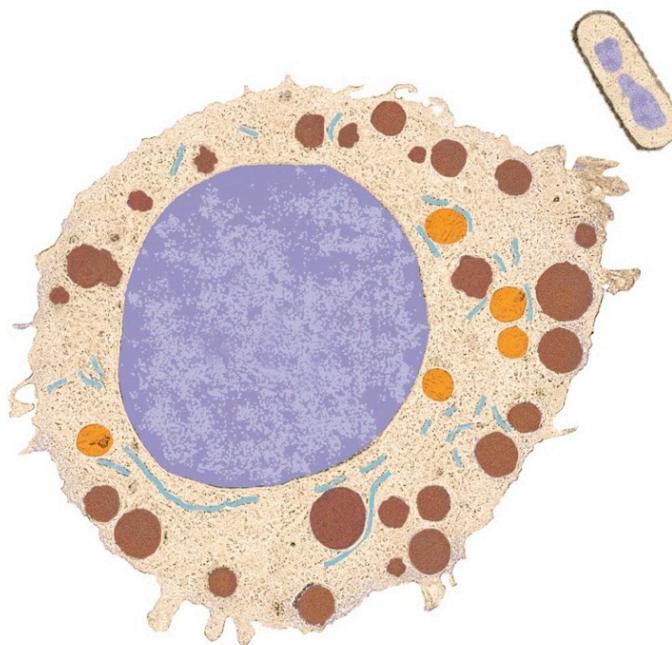
Viruses are not really living organisms, but still very important in biology

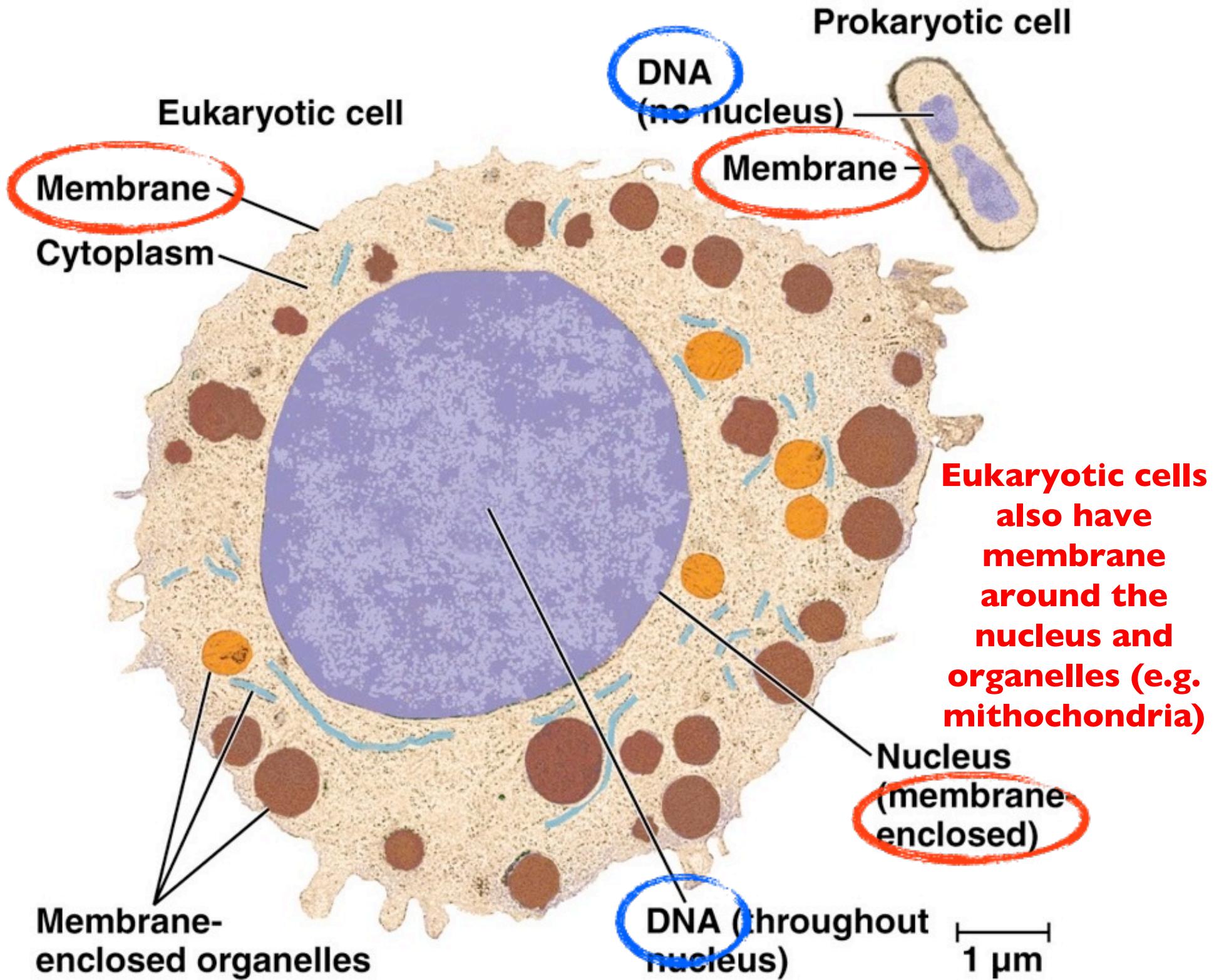
What makes up an individual living organism

The **cell** is the smallest unit of organization that can perform all activities required for life

All cells share certain characteristics, i.e., a cell membrane

Two main forms: **prokaryotic** and **eukaryotic**





Introduction to Genetics



- Living organisms usually show a great deal of variation
- Some (but not all) of the variation is heritable

19th century :

-Scientists know that much of the variation in nature is heritable

The big question at the time is:

*What principles account for the transmission
of traits from parent to offspring?*

Several hypotheses were proposed...

“Blending” vs. Particulate Inheritance

- **Blending:** the idea that genetic material contributed by the two parents mixes in a manner analogous to the way blue and yellow paints blend to make green
- **Particulate:** parents pass on discrete heritable units (genes) that retain their separate identities in offspring; i.e., more like a deck of cards than a pail of paint



Gregor Mendel tested these hypotheses



- Lived 1822-1884
- Discovered some of the fundamental laws of inheritance
- Work not fully appreciated until after his death

Gregor Mendel



- Austrian monk
- Conducted botanical experiments in the abbey gardens