

Biology and the Process of Science

Ch. 1

I. The fundamental tenets of biology

- A. Cell Theory
- B. Evolutionary Theory
Pattern, mechanism, phylogenies

II. The process of science

- A. Intro to the scientific method
- B. Experimental design
- C. Where does science not apply?

I.A. Cell theory

which proposes

1. that all organisms are made of cells, and
2. that all cells come from preexisting cells.

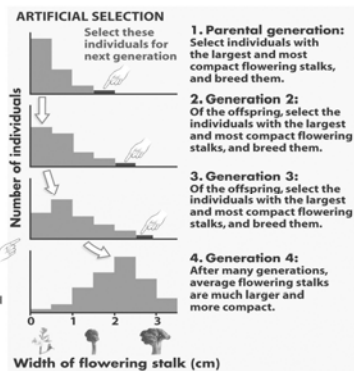
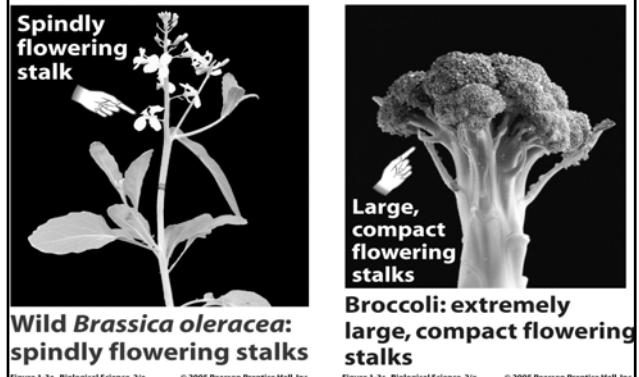
B. Theory of evolution

Darwin & Wallace (1858)

Pattern:

- species change through time
- species related by common ancestry

Species change through time



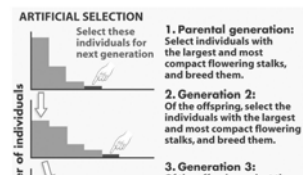
These charts, called histograms, are charts that illustrate how the width of the flowering stalk changed through time in response to selection

Theory of evolution: mechanism (how does it happen?)

Natural selection

Necessary conditions:

- Heritable variation within populations.
- Environmental conditions lead to greater reproductive success of individuals with certain versions of traits.



Evolution ties together the field of biology

Ecological interactions determine the fitness of organisms in an evolutionary context.

Evolution of organisms influence the ecological interactions in which they partake.

Typical feeding posture in giraffes



Why do giraffes have long necks?

Biodiversity

The different forms of life on Earth, in terms of genetic diversity within species, species diversity in communities (and globally), and diversity of ecosystems across landscapes.

Phylogenies: the Tree of Life

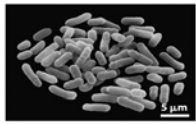
How are organisms related to each other?

Linnaean Taxonomy



Figure 1-4 Biological Science, 2/e © 2005 Pearson Prentice Hall, Inc.

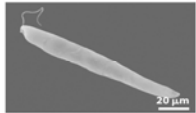
5 Kingdom scheme



KINGDOM MONERA
(includes all prokaryotes)



KINGDOM FUNGI



KINGDOM PROTISTA
(includes several groups of unicellular eukaryotes)



KINGDOM ANIMALIA

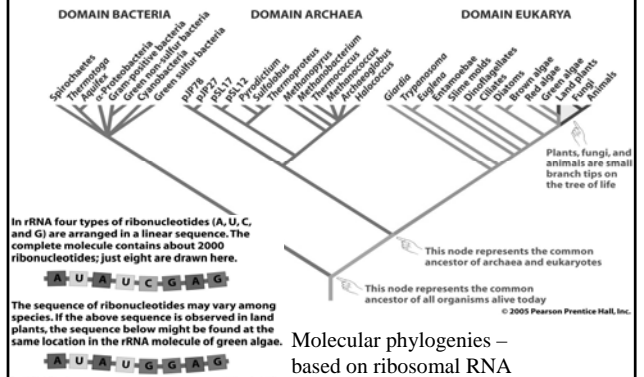


KINGDOM PLANTAE

Figure 1-6 Biological Science, 2/e

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3 Domain Scheme

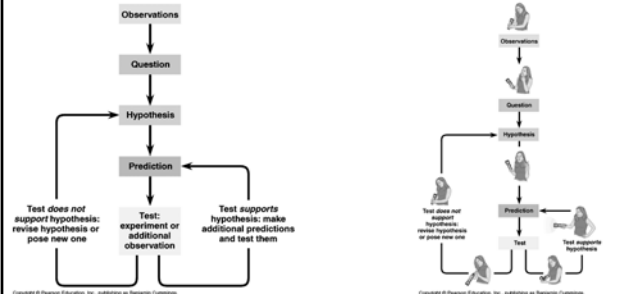


II. The Process of Science

What are the steps of the scientific method?

A. Intro to the scientific method

Science is a process of inquiry that includes repeatable observations and testable hypotheses.



Terminology:

hypothesis – “a proposed explanation for a phenomenon or set of phenomena” (Freeman)

theory - a proposed explanation for a very general class of phenomena that bind a wide variety of independent observations and experiments into a logically consistent whole.

- theories based on a wealth of accumulated evidence.

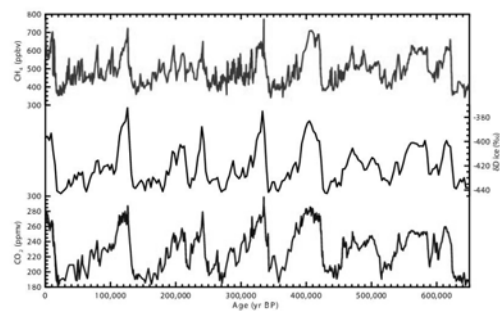
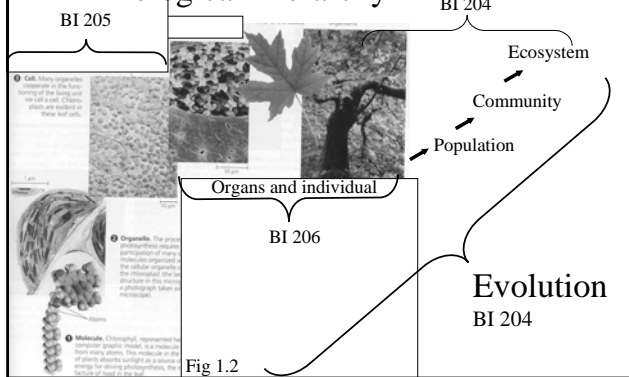
(e.g., evolution)

What do you need for scientific approach?

- 1) Ideas that are testable by repeatable experiments;
- 2) Verifiable/falsifiable by observations and measurements.

Pattern and mechanism
Correlation vs. causation

Biological Hierarchy



<http://www.realclimate.org/index.php/archives/2005/11/650000-years-of-greenhouse-gas-concentrations/>

Here's the more recent 650,000 year record from the EPICA ice core in Antarctica. The black line is the temperature proxy.

II. Experimental design

Stuff to pay attention to in experimental design

Alternative hypotheses

Controls

Controlling for confounding variables

Distinguishing between correlation and causation

Things to think about:

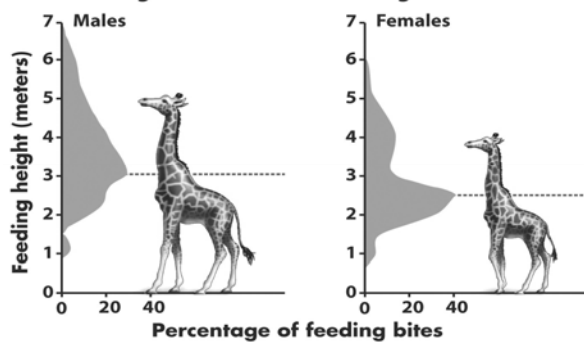
1. Key to hypotheses/theories is that they are testable, falsifiable. How do the researchers in the examples structure their questions and hypotheses to allow them to be tested?
2. What are alternative hypotheses and null hypotheses? How are they used to structure the experiments and observations?
3. What role do experimental controls play in experimental design? How are they related to alternative hypotheses?
4. How do you distinguish between correlation and

Why Do Giraffes Have Long Necks? An Introduction to Hypothesis Testing

The Food Competition Hypothesis: Prediction and Tests

- One of the three predictions of the food competition hypothesis, that giraffes feed high in trees, does not hold true (**Figure 1.9**); thus, there may be better alternative hypotheses to explain neck length in giraffes.

Most feeding is done below neck height.



Typical feeding posture in giraffes



The Sexual Competition: Hypothesis: Predictions and Tests

- An alternative hypothesis is that giraffes evolved long necks because males with longer necks win more fights than shorter-necked giraffes and can then father more offspring. Data support this hypothesis.

Observations

Insert movie
List from text

Why Are Chili Peppers Hot? An Introduction to Experimental Design

- The directed dispersal hypothesis states that capsaicin in chili peppers is an adaptation that discourages seed predation while not preventing seed dispersal.

- A **null hypothesis** expresses the alternative possibility that the explanation offered by the hypothesis does not apply.

(a) Chilies produce fruits that contain seeds.



Figure 1-10 Biological Science, 2/e

(b) Cactus mice are seed eaters.



(c) Curve-billed thrashers eat chili fruits.



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Chilies produce fruits that contain seeds.



Figure 1-10a Biological Science, 2/e © 2005 Pearson Prentice Hall, Inc.

Cactus mice are seed eaters.



Figure 1-10b Biological Science, 2/e © 2005 Pearson Prentice Hall, Inc.

Curve-billed thrashers eat chili fruits.

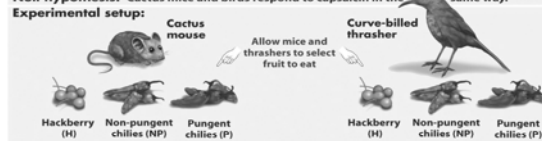


Figure 1-10c Biological Science, 2/e © 2005 Pearson Prentice Hall, Inc.

- Several cactus mice (seed predators) and curve-billed thrashers (seed dispersers) were offered fruits from (1) a variety of chili that does not make capsaicin, (2) a hot chili, and (3) hackberries (no capsaicin and do not look like chilies) (Figure 1.11).

Question: Does the presence of capsaicin in chilies deter some predators but not others?

Dispersal hypothesis: Capsaicin deters cactus mice (seed predators) but not birds (seed dispersers).
Null hypothesis: Cactus mice and birds respond to capsaicin in the same way.



Prediction: Both will eat hackberry, but only thrashers will eat pungent chilies.

Prediction of null hypothesis: No difference between thrashers and mice in fruit consumed.



Conclusion: The presence of capsaicin deters cactus mice but not thrashers.

- Thrashers and mice ate similar amounts of hackberries, but birds ate more chili peppers than hackberries (similar amounts of both kinds) and mice ate only a few mild chili peppers and no hot chilies.

- Researchers concluded that capsaicin prevents cactus mice, but not thrashers, from eating chili fruit; the dispersal hypothesis is supported.

- The experiment just described is well-designed: (1) it included a control group (the hackberries) to check for other factors that might influence the results; (2) experimental conditions were controlled to eliminate extraneous variables; and (3) the test was repeated to reduce the effects of random variation (sample size).

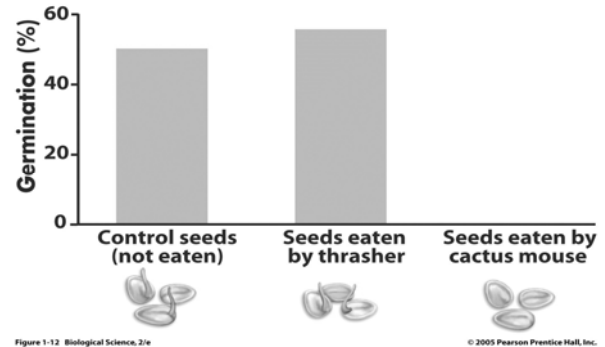
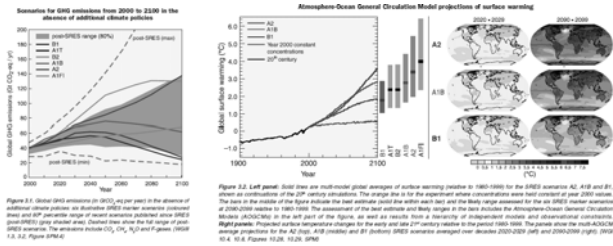


Figure 1-12 Biological Science, 2/e © 2005 Pearson Prentice Hall, Inc.

III. Where does science not apply?

- A. Value judgments
- Policy recommendations
- Scenarios vs. predictions



IPCC 2007

III. Where does science not apply?

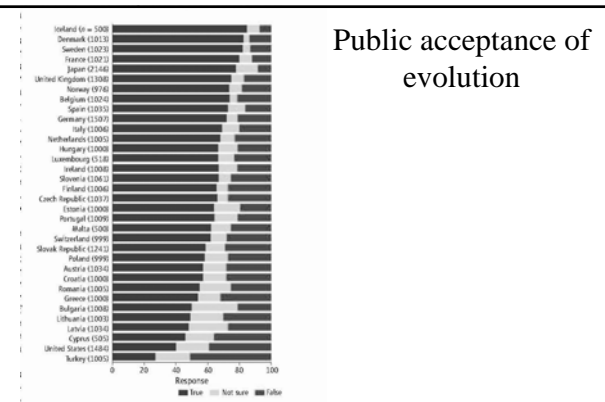
- B. Supernatural or spiritual phenomena

Does “intelligent design” disprove evolution or vice versa?

Does intelligent design fall within the realm of science?

“We are skeptical of claims for the ability of random mutation and natural selection to account for the complexity of life. Careful examination of the evidence for Darwinian theory should be encouraged.”

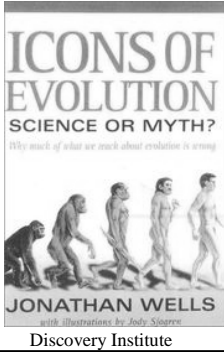
Discovery Institute



Public acceptance of evolution

Public acceptance of evolution in 34 countries, 2005. Miller et al. 2006 Science

ID skepticism about Darwinian evolution



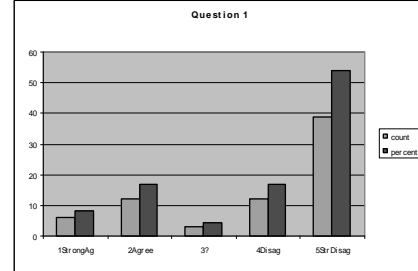
Vs.

Icons of Evolution:
Why much of what Jonathan
Wells writes about evolution
is wrong.

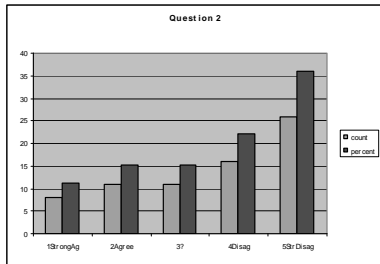
By Alan Gishlick
National Center for Science Education

<http://www.ncseweb.org/icons/pdfs.html>

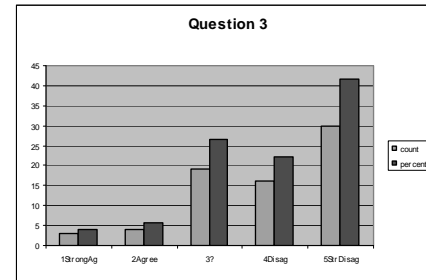
Q1. While there is some evidence for evolution, it is just a theory that has not been well proven.



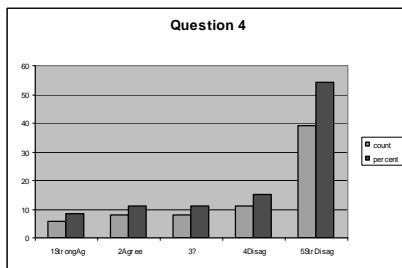
Q2. Intelligent design provides a scientifically credible alternative to evolution.



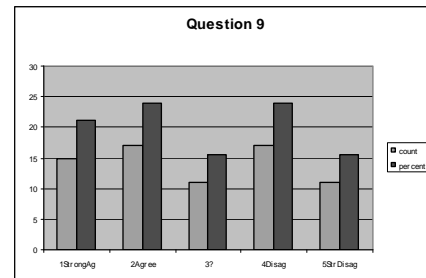
Q3. Evolution cannot explain the presence of complex structures in organisms, such as eyes or flagella, that must operate as a unit.



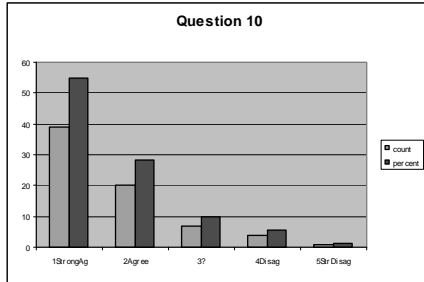
Q4. While it is clear that evolution can explain changes within species, it cannot explain how new species or groups of species may have arisen.



Q9. Scientists continue to debate details of evolution, but there's no **scientific** controversy about whether or not it occurs.



Q10. A scientific concept, such as evolution, does not become a “theory” until it is supported by an overwhelming body of evidence.



Does intelligent design fall within the realm of science?

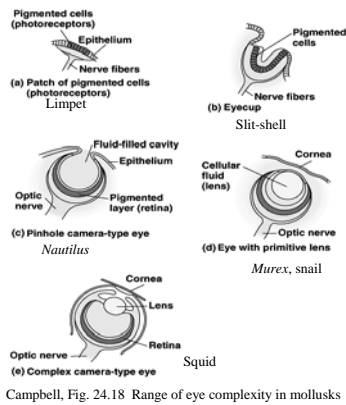
Some biological phenomena are so complex, they could not have arisen by the process of random mutations and natural selection.

Therefore, they must have been created by a higher power.

How do you test that?

Eyes:
Irreducible complexity?

A. Continued modification of older structures
Often fossil evidence of sequence not complete



What questions should scientists be asking?

- What are the alternative hypotheses?
- Are they testable/measurable?
- Do we stop scientific inquiry?

The Discovery Institute’s
“Wedge Strategy”

“...reverse the stifling dominance of the materialist worldview, and to replace it with a science consonant with Christian and theistic convictions.”

http://en.wikipedia.org/wiki/Discovery_Institute

Kitzmiller vs. Dover Area School District
Federal Court, Dec. 2005

Judge John E. Jones III “pointedly rejected intelligent design as a legitimate scientific theory. ‘To be sure, Darwin’s theory of evolution is imperfect,’ he wrote. ‘However, the fact that a scientific theory cannot yet render an explanation on every point should not be used as a pretext to thrust an untestable alternative hypothesis grounded in religion into the science classroom or to misrepresent well-established scientific propositions.’”

Time Dec. 20, 2005
<http://www.time.com/time/health/article/0,8599,1142625,00.html>

See Gordy Slack’s: “The Battle Over the Meaning of Everything” for more info.

What types of questions can science answer?

Measurable processes taking place within nature,
e.g., age of earth, mechanisms of genetic change

What types of questions can science not answer?

Is there God or other Higher Power?

Are what we call “the laws of nature” really the actions
of a Higher Power?

Did a Higher Power intend to create us using the process
of evolution?

The problems with ID are several-fold

- Confounds scientific process with faith-based spirituality.
- Attempts to re-define science EXCLUDING measurement based verification.
- Does not offer testable alternatives to current evolutionary theory.
- Etc...

Does evolution disprove religion or vice versa?

The bottom line:

Evolution does not “disprove” existence of a Higher
Power.

But neither can ID “disprove” evolution, because religion
is inherently faith-based.

End here

Induction - deriving a general principle
from a set of specific observations.

Example:

