

Chapter 1: The Study of Life

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1 The Science of Biology

Section goals: - Id similarities btw natural sciences - summarize scientific method
- compare inductive and deductive reasoning - Desc the goals of basic sciec and
applied science.

Definition 1. *Biology* is simply the study of life.

1.1 The process of Science

Definition 2. *science* knowledge that covers general truths or the operation of
general laws, especially when acquired and tested by the scientific method.

Definition 3. *scientific method* a method of research with defined steps that
include experiments and careful observation.

Definition 4. *hypothesis* is a suggested explanation for an event which one can
test.

Note: some sciences do not test by experiment, but instead look for evidence
for or against a hypothesis (E.g. archeology).

Definition 5. *theory* a tested and confirmed explanation for observations or
phenomena.

1.2 Natural sciences

Definition 6. *natural sciences* Scientific fields that relate to the physical world
and its phenomena and processes. E.g. astronomy, biology, chemistry, earth
science, and physics.

Other divisions:

Definition 7. *life sciences* the study of living things (includes biology)

Definition 8. *physical sciences* the study of nonliving matter (E.g. astronomy,
physics, chemistry)

Some disciplines fit both categories and are called *interdisciplinary*. E.g.
biochemistry, biophysics.

There are hard and soft(er) sciences: hard referring to sciences that use quantitative data, and soft(er) referring to sciences that use more qualitative data.

1.3 Scientific Reasoning

Here we focus on what it means *to know*. To gain knowledge, scientists rely on two modes of thinking: inductive reasoning and deductive reasoning.

Definition 9. *Inductive reasoning* a form of logical thinking that uses related observations to arrive at a general conclusion. In this realm, observations increase or decrease the likelihood of a conclusion.

Definition 10. *Deductive reasoning* a form of logical thinking that uses a general principle or law to forecast a specific result.

Deductive reasoning is concerned with binary states (the truth or falsity of claims), while inductive reasoning is more concerned with the *likelihood* of something being true or false.

Two modes of discovery:

Definition 11. *Descriptive (or discovery) science* aims to observe, explore and discover (usually using inductive reasoning).

Definition 12. *hypothesis based science* begins with a specific question or problem and a potential answer that can be tested (rely mostly on deductive reasoning).

1.4 The Scientific Method

First documented by Sir Francis Bacon (1561-1626). The following are the loose steps which most sciences follow (sometimes in a "looping" manner, going back to previous steps) which we call the *scientific method*: a useful process for making discoveries about the natural world.

The pet example provided in the text is that of a warm room and a student asks "Why is the classroom warm".

1.4.1 Proposing a Hypothesis

- We can propose several hypotheses. E.g.
 - "The classroom is warm because no one turned on the AC."
 - "The classroom is warm because there is a power failure, and so the AC doesn't work."
 - After a hypothesis is selected, a prediction can be made in the form "if ... then ..." E.g. - "If the student turns on the AC, then the classroom will no longer be too warm"

1.4.2 Testing a Hypothesis

Hypotheses must be *testable*. Hence they must be

Definition 13. *Falsifiable* a claim that can be shown to be false (or disproven) by experiment is said to be *falsifiable*.

Note: science doesn't *prove* things, but instead disproves or increases our confidence in a claim.

E.g. supernatural claims are *not* falsifiable, usually.

Experiments that test a hypothesis have variables and controls, are split into multiple *experimental groups* (separate groups to be tested within an experiment).

Definition 14. *variable* any part of the experiment that can vary or change during the experiment.

Definition 15. *control group* an experimental group where manipulations from the hypothesis are not carried out.

the scientific method is then given by the following steps:

1. Make an observation
2. Ask a question
3. Form a hypothesis that answers that question
4. Make a prediction based on that hypothesis
5. Do an experiment to test the prediction
6. Analyze results
 - If hypothesis is supported, go to 7.
 - If hypothesis is not supported, go back to 3. and try again.
7. Report the results

1.5 Two types of science: Basic Science and Applied Science

Definition 16. *Basic science* or "pure" science seeks to expand knowledge regardless of the short-term application of that knowledge. It is not focused on providing immediate value. "Knowledge for knowledge sake".

Definition 17. *Applied science* or "technology" aims to use science to solve real-world problems.

Definition 18. *serendipity* knowledge that is acquired by a "happy accident".

1.6 Reporting Scientific Work

Research needs to be reported so peers can be aware of new knowledge. This is done in

Definition 19. *Peer-reviewed manuscripts* scientific papers that a scientist's colleagues or peers review.

1.6.1 Parts of a scientific paper

1. *Abstract* - a concise summary at the beginning of the paper. Could include an outline

2. *Introduction* - starts with a brief, but broad, background on what is known in the field that the paper is within. Usually contains reasoning for the work being done. Refers to published work of other scientists.

3. *Materials and methods* - includes a complete and accurate description of the methods, techniques and substances used to gather data. The intent of this section is to allow other researchers to reproduce the results.

4. *Results* - a narration of findings without interpretation, usually including data

5. *Discussion* - interpretation of results, description of the relationships between variables, and explanations of observations. Usually, other researchers' work is cited here.

6. *Conclusion* - summarizes important experimental findings. May (usually) contain future directions for the work.

An acronym for this is **IMRAD**. Note, these sections usually won't be found in *review articles*, which are secondary papers that comment on the state of a field.

2 Themes and Concepts of Biology

Goals of the section:

- ID and describe properties of life
- Desc the level of organization among living things
- Recognize and interpret a phylogenetic tree
- list examples of different subdisciplines in biology

- 2.1 Properties of life**
 - 2.1.1 Sensitivity of Response to Stimuli**
 - 2.1.2 Reproduction**
 - 2.1.3 Adaptation**
 - 2.1.4 Growth and Development**
 - 2.1.5 Regulation/Homeostasis**
 - 2.1.6 Energy Processing**
 - 2.1.7 Evolution**
- 2.2 Levels of Organization of Living Things**
- 2.3 The Diversity of Life**
- 2.4 Branches of Biological Study**