The Nature of Biology

The Nature of Science

- **Science** is an ongoing, human, cultural activity which involves the efforts of many people to describe the world in mutually acceptable terms.

- Scientific knowledge is the cumulative results of the best efforts of finite people.

- Science is never complete or perfect.
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The Scientist

• Fundamental Attitudes.
  
  – The events in the world are within the scope of human comprehension.
  
  – All experiences must eventually be explained with consistent terms.
  
  – Observations must be understandable and repeatable.
  
  – Generalizations must be testable.
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Common Methods

• Acquiring Knowledge.
  
  – Reproducible observations - foundation of scientific knowledge.
    • **Qualitative** - a simple description of an object of phenomenon.
    • **Quantitative** - careful measurements are made.
  
  – Generalizations - a summary explanation of the observation.
    
    • **Inductive reasoning** - formation of a general statement from specific observations (“persuasion”).
    • **Hypothesis** - initial, untested generalization (“educated guess”).
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Common Methods

• Acquiring Knowledge.
  – Experiment - practical test of the hypothesis.
    • Deductive reasoning - logical process of formulating predictions from hypothesis.
    • Controlled experiments - the control group and the experimental group differ in only one factor known as the controlled variable.
    • Fact - correct hypotheses that have been thoroughly tested
  – Theory (Laws and Principle)
    • Scientifically acceptable general principle offered to explain observed facts.
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The **Scientific Method**

- The set of procedures that form a rational approach to studying the natural world
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The **Scientific Method** includes:

- Observations
- Identification of a problem
- Observations (qualitative / quantitative)
- Hypothesis
- Observations/Experiments
- New data
- Conclusion

Conclusion --> **Theory** <-- Conclusion
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Why Study Biology?

• Biology is relevant
  – Great advances
  – Bioengineering
  – Population has grown
  – Emerging technologies
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Biology is Relevant

• Great Advances
  – 19th and 20th centuries
    • disease was caused by pathogens
  – Today
    • emphasis turning to physiological malfunctions
  – Past diseases fatal -- now treated

• News flash … Antibiotic resistance (‘superbugs’)

• Great Advances
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Biology is Relevant

• Bioengineering
  – New “Green” Revolution
    • development of new corn plant varieties
    • genetically enhanced
      – resist pests and draught
      – cold tolerant
  – Alleviate world hunger?
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Biology is Relevant

• Population growth
  – Tough decisions facing couples, nations, and beyond
  – Where to put new cities, farms, etc.?
  – How to monitor and manage exiting wildlife areas

• News flash … Scientist acknowledge role of humans in climate change. (‘Greenhouse gases’)
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Biology is Relevant

• Emerging Technologies (computers)
  – Bridging the gap between biology & technology
  – New career opportunities
    • biotechnology (labs)
    • applied technologies (fieldwork)
    • combination of both fields
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Biology can be Controversial

• Questions:
  – Family planning - birth control?
  – How much $$$ to spend - endangered species?
  – Biomedical research - human fetal tissue ethical?
  – Dangers in cloning animals? Humans?
  – Irradiated food safe to eat?

• News flash … Chefs join campaign against altered fish
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Biology can be Controversial

- Some controversies remain within biology
- Others involve economic, moral, ethical, & religious considerations
- Biology can help understanding
  - identify options
  - describe impacts
- News flash … Scientists seek approval to clone human embryos
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**Biology - the scientific investigation of life**

- Complementarity of structure and function.
  - Every structure had a function
  - Structure implies function / function emerges from structure.

- For Biologists, life is:
  - The set of characteristics that distinguish living systems (organisms) from nonliving systems (inanimate objects).
  - Properties of living systems.
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Properties of living systems

• Organization

  – The “Cell Theory”

  • The cell is the smallest unit capable of exhibiting all characteristics of life.
  
  • All living systems are composed of one or more cells.
  
  • All cells comes from pre-existing cells.
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Properties of living systems

- Levels of Organization

  - Each life form has levels of organization
    (atoms >> molecules >> cells >> tissues >> organs >> organ systems >> organism)

  - Molecules - cluster of atoms that are arranged in some order through molecular bonds

  - Polymers - large molecules joined together from monomers

  - Organelle - a structure with a specialized function within a cell
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Properties of living systems

• Levels of Organization

– Cell - a unit of living matter separated from its environment by a boundary (membrane)
– Tissues - groups a similar cells that have a common function
– Organs - a structure consisting of several tissues adapted as a group to perform a specific function
The Nature of Biology

Properties of living systems:

• Levels of Organization

  – Organ systems - group of organs that work together (performing specific functions)

  – Organism - an individual living thing
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Properties of living systems

• Metabolism
  
  – Chemical processes that occur in living cells.
  
  – Every living cell has the capacity to
    
    • Obtain and convert energy from its surroundings
    
    • Use energy to maintain itself, grow & make more cells
  
  – Metabolism is the foundation by which cells are able to maintain homeostasis.
- Metabolism is involved in all the of the following living processes:
  - Reproduction
  - Excretion
  - Nutrition
  - Respiration
  - Growth
  - Death
  - “Movement”

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Properties of living systems.
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Properties of living systems.

- Response to stimuli
  - Living organisms can respond to external stimuli.
  - Reaction of an organism to a stimulus is called behavior.
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Properties of living systems

• Homeostasis

  – Capacity to keep a physiological “steady-state” that supports life.

  – Examples:
    • the body’s ability to maintain a normal internal temperature.
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Properties of living systems:

- Growth & Development
  - Living systems grow & develop.
  - **Growth** - increase is size & number of cells.
  - **Development** - includes all the changes that take place between conception & death.
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Properties of living systems:

• Genetic material ("Genetic basis of life.")
  - **Genetic material** (*DNA, nucleic acids*) possesses a molecular code which regulates hereditary information of a living organism.
  - This genetic information is derived from previously living organisms.
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Properties of living systems

• Reproduction

  – Biogenesis - life comes from pre-existing life.

  – Living organisms produce offspring similar to themselves by transmitting at least some of their genetic material.
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Properties of living systems:

- Ecological relationships
  - In a given region, all living things are closely related with each other and the environment.
  - Ecological organization

(species >> population >> community >> ecosystem >> biome >> biosphere)