

# 1

## *Studying Life* *Life: The Science of Biology*



# 1 Studying Life

## Discussion:

1. Why is learning Biology important to everyone?
2. How can a knowledge of Biology help me in my daily life?
3. What careers require some knowledge of Biology?

## 1.1 What is Biology?

Biology: the scientific study of living things

Living things: all the organisms descended from a single-celled ancestor.

Question: How do you know something is alive?

## 1.1 What is Biology?

Characteristics of living organisms  
(Let's simplify these in one word):

- Consist of one or more cells
- Contain genetic information
- Use genetic information to reproduce themselves
- Are genetically related and have evolved

## 1.1 What is Biology?

### Characteristics of living organisms:

- Can convert molecules from their environment into new biological molecules
- Can extract energy from the environment and use it to do biological work
- Can regulate their internal environment

## 1.1 The Cell Theory

The Cell theory states that:

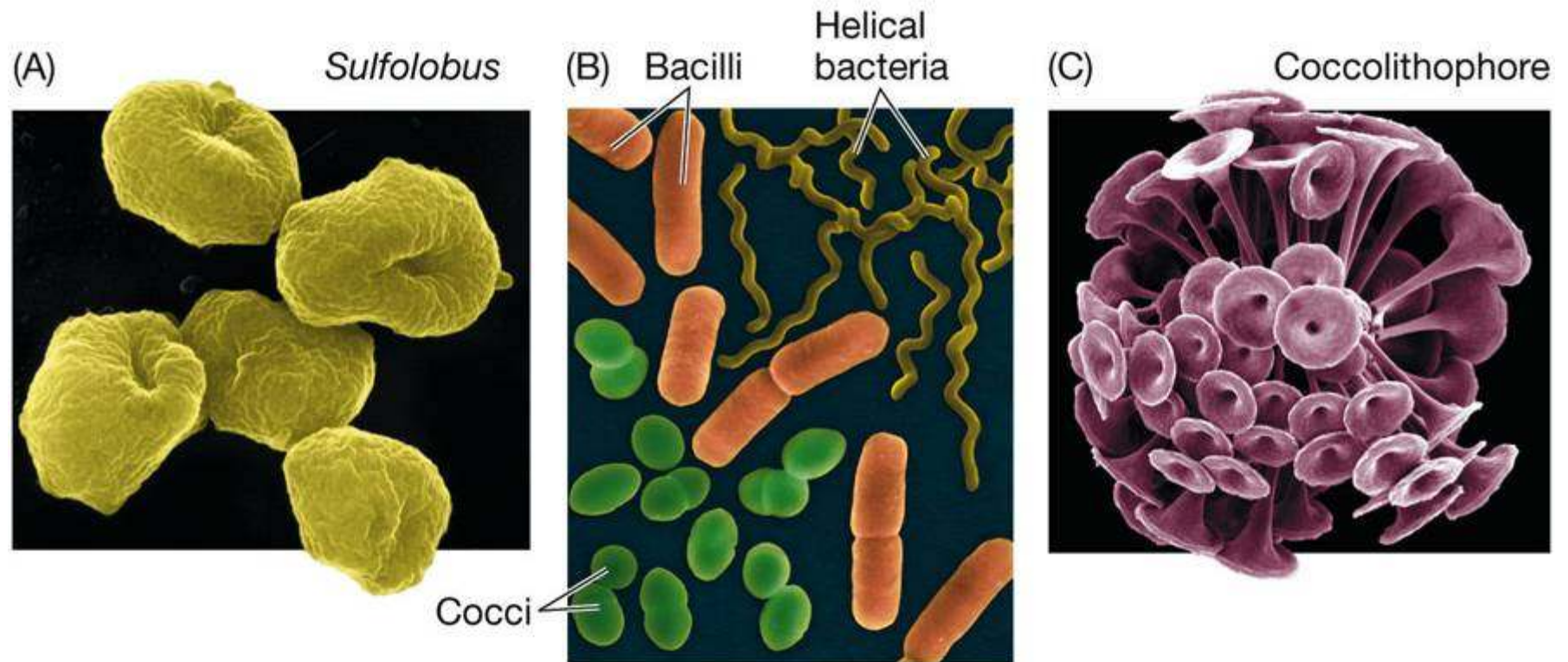
- 1.Cells are the more basic unit of life (the smallest thing that we can say is alive).
- 2.All living things are made of one or more cells.
- 3.Cells come from pre-existing cells.

## 1.1 What is Biology?

Evolution: a central theme

Living systems evolve through differential survival and reproduction.

## Figure 1.1 The Many Faces of Life (Part 1)





## Figure 1.1 The Many Faces of Life (Part 2)

(D) Scarlet banksia



(E) Stinkhorn mushrooms



(F) Balloon-winged katydid



(G) Giant tortoise

Galápagos hawk



**LIFE 8e, Figure 1.1 (Part 2)**

## 1.1 What is Biology?

*Unicellular* organisms: a single cell carries out all the functions of life

*Multicellular* organisms: made of many cells that are specialized for different functions

## Figure 1.2 All Life Consists of Cells

(A)



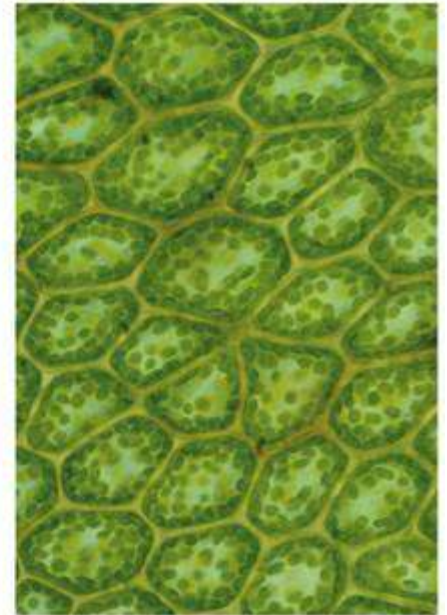
(B)



(C)



(D)



## 1.1 What is Biology?

### **Cell Theory:**

- Cells are the basic structural and physiological units of all living organisms.
- Cells are both distinct entities and building blocks of more complex organisms.

(Schleiden and Schwann 1838)

## 1.1 What is Biology?

### **Cell Theory:**

- All cells come from preexisting cells.
- All cells are similar in chemical composition.
- Most of the chemical reactions of life occur within cells.
- Complete sets of genetic information are replicated and passed on during cell division.

## 1.1 What is Biology?

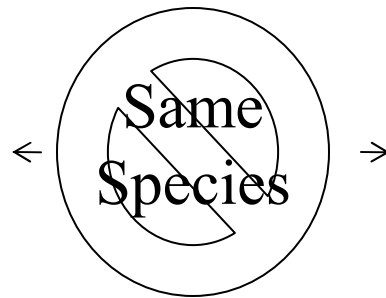
Charles Darwin proposed that all living organisms are descended from common ancestors.

**Evolution by natural selection**



## 1.1 What is Biology?

**Species:** a group of organisms that look alike and can breed successfully with one another to produce \_\_\_\_\_.



## 1.1 What is Biology?

Humans *select* for desired traits when breeding animals.

Darwin postulated that *natural selection* could occur through differential survival and reproductive success.



## 1.1 What is Biology?

Traits that increase the probability that the organism will survive and reproduce will become more common in the population.

Natural selection leads to **adaptation**.

## Figure 1.3 Adaptations to the Environment



**LIFE 8e, Figure 1.3**

## 1.1 What is Biology?

**DNA:** the information that is passed from parent to daughter cells

**Genome:** sum total of all the DNA in the cell

All cells in a multicellular organism have the same genome.

What cells are most commonly used in a criminal investigation?

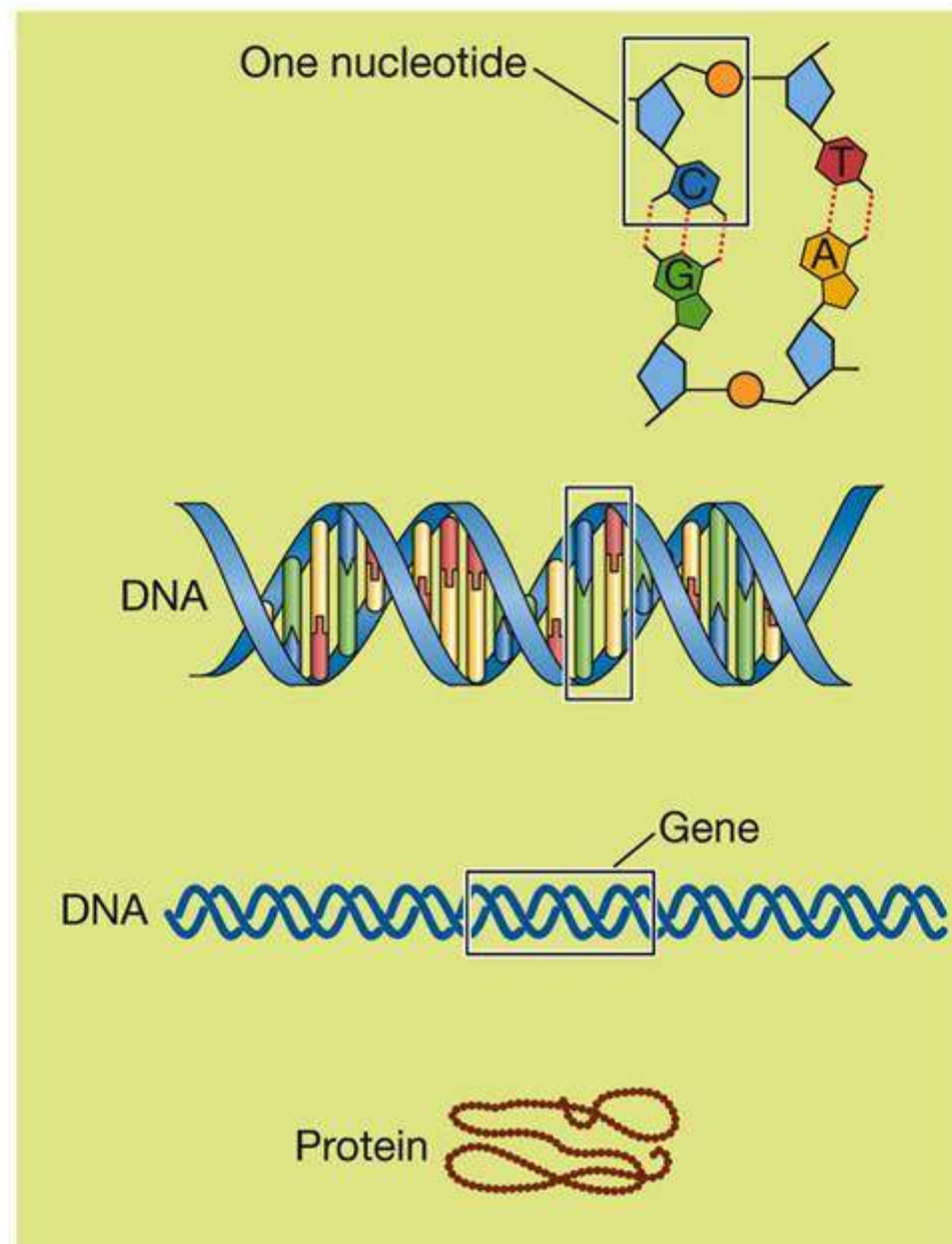
## 1.1 What is Biology?

**DNA:** repeating subunits—**nucleotides**

**Gene:** a specific segment of DNA molecule—contains information for making **proteins**

*Mutations* are alterations in the nucleotide sequence.

## Figure 1.4 The Genetic Code Is Life's Blueprint



**LIFE 8e, Figure 1.4**

## 1.1 What is Biology?

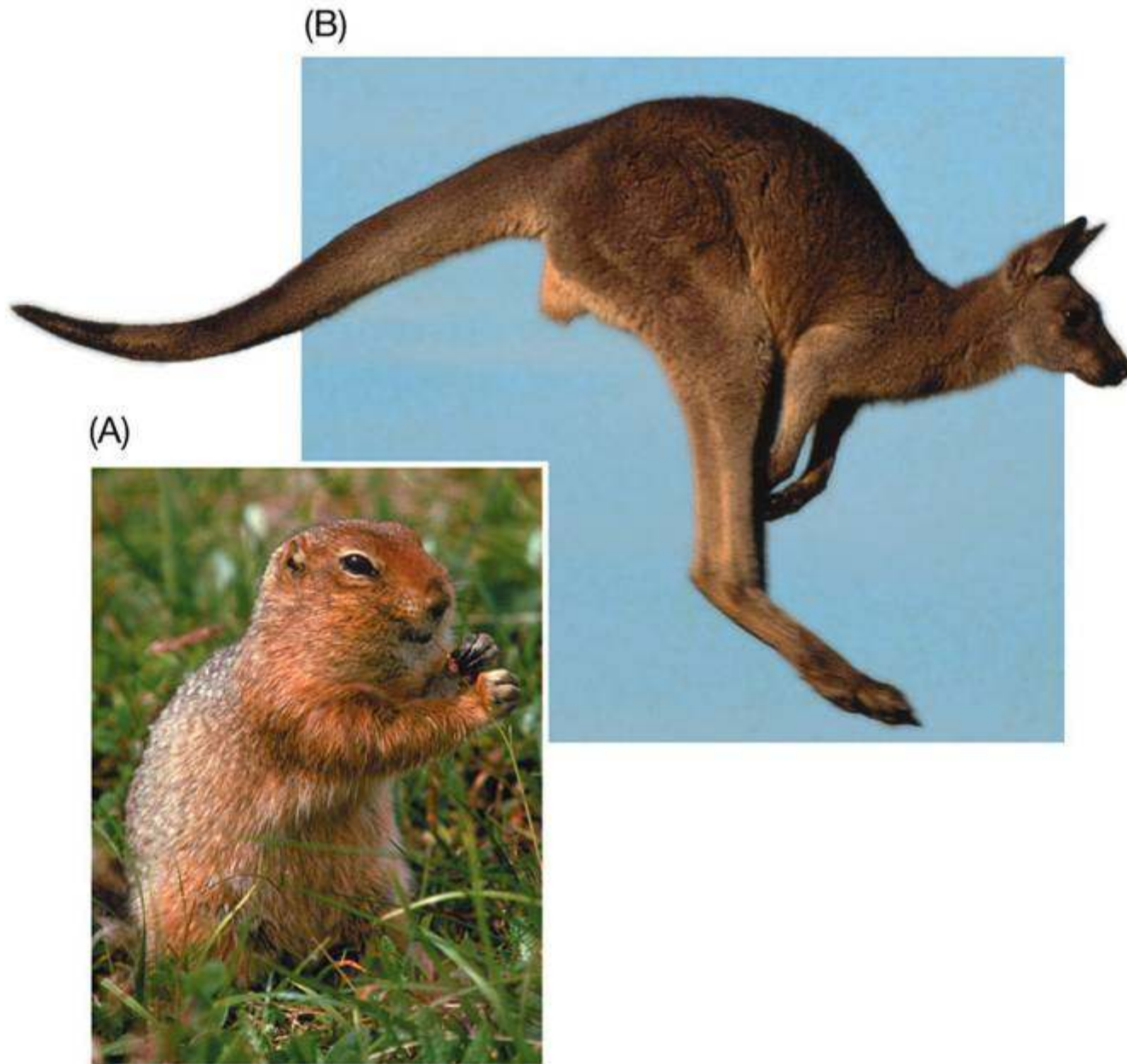
Cells acquire *nutrients* from their environment.

Nutrients supply energy and materials for building biological structures (*synthesis*).

Nutrient molecules contain energy in the chemical bonds.



## Figure 1.5 Energy from Nutrients Can Be Stored or Used Immediately



**LIFE 8e, Figure 1.5**

## 1.1 What is Biology?

Living organisms control their internal environment.

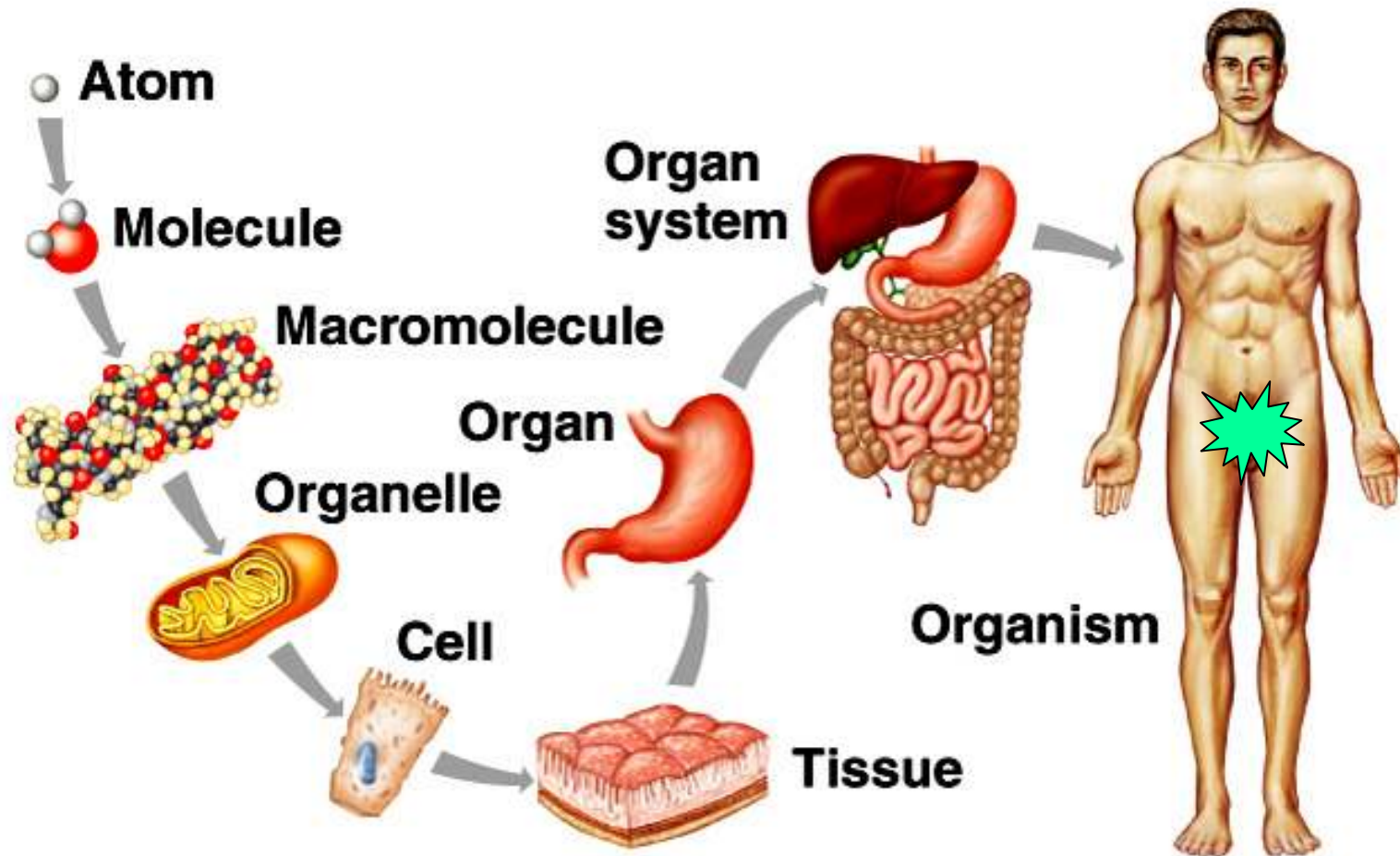
Multicellular organisms have an internal environment that is not cellular.

Cells are specialized, and organized into *tissues*, tissues are organized into *organs*.

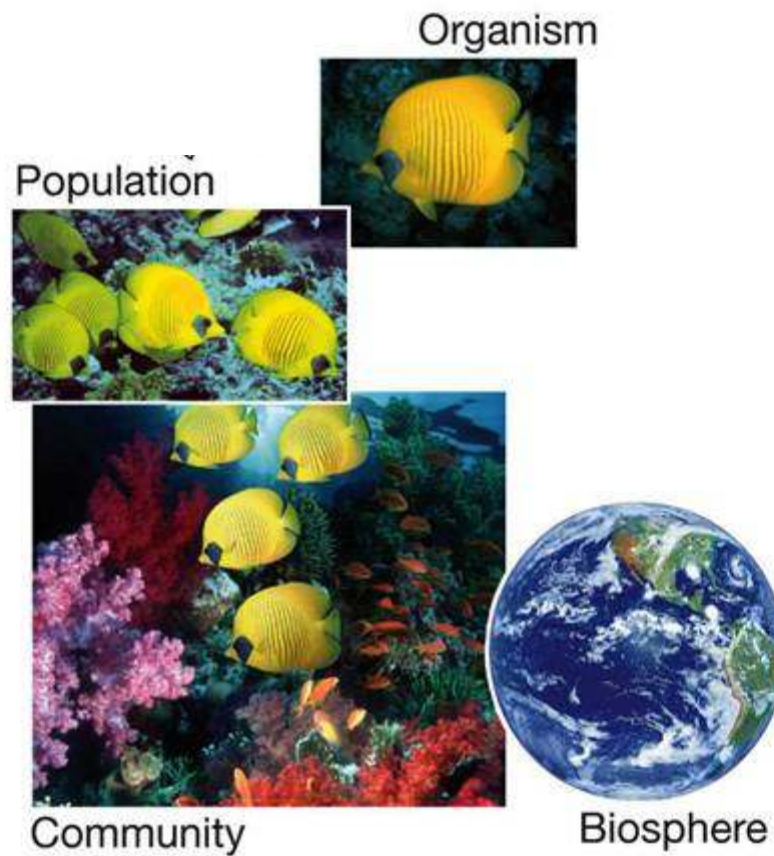
Can you name the organization of life from simple to advanced?



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## Figure 1.6 Biology Is Studied at Many Levels of Organization



**LIFE 8e, Figure 1.6**

Figure 1.7 Conflict and Cooperation

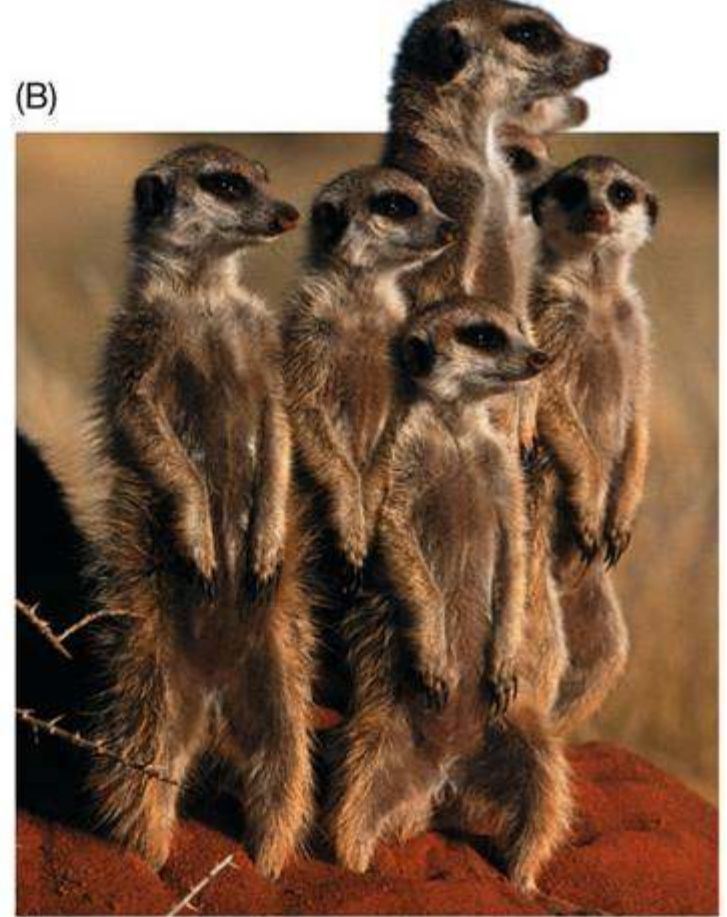
**Living organisms interact:**

They may be *territorial* or they may *cooperate*.

(A)



(B)



## 1.2 How is All Life on Earth Related?

All species on Earth share a *common ancestor*. **How do we know this?**

The *fossil record* allows study of evolutionary relationships.



## Figure 1.8 Fossils Give Us a View of Past Life



**LIFE 8e, Figure 1.8**

## 1.2 How is All Life on Earth Related?

Modern molecular methods allow biologists to compare genomes.

The greater the distance between genomes, the more distant the common ancestor.

## 1.2 How is All Life on Earth Related?

Life arose by chemical evolution.

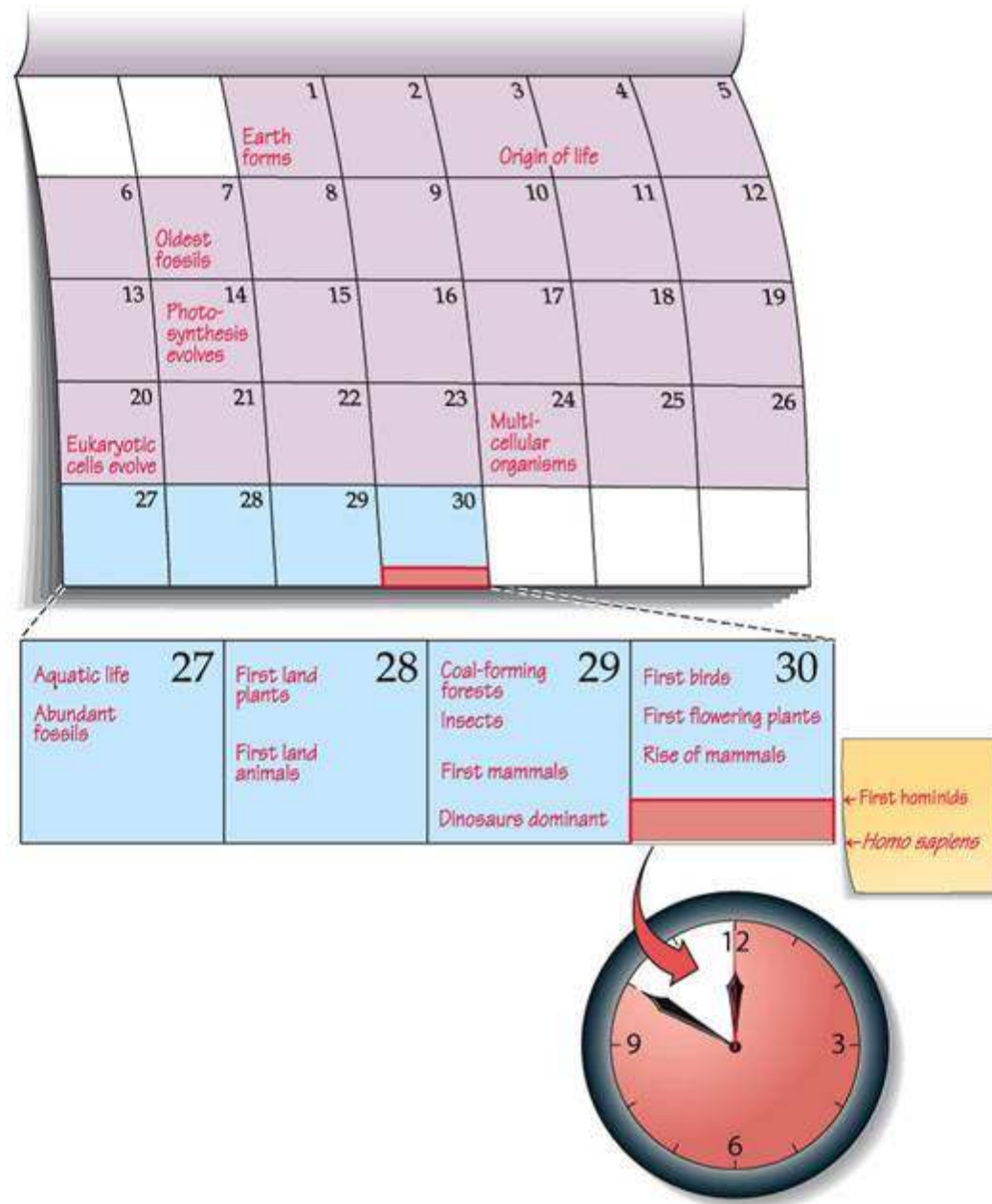
Molecules that could reproduce themselves were critical.

Biological molecules were then enclosed in *membranes*.

Evolution occurs! Any person having even a small amount of scientific background understands this.

There are two explanations that describe why evolution occurs. Can you think of them?

Figure 1.9 Life's Calendar



LIFE 8e, Figure 1.9



## 1.2 How is All Life on Earth Related?

For 2 billion years, life consisted of single cells—**prokaryotes**.

These cells were in the oceans, protected from UV radiation.

**Prokaryotes:**

1. **Lack a \_\_\_\_\_.**
2. **Are simple and \_\_\_\_\_.**
3. **Examples include all \_\_\_\_\_.**

## 1.2 How is All Life on Earth Related?

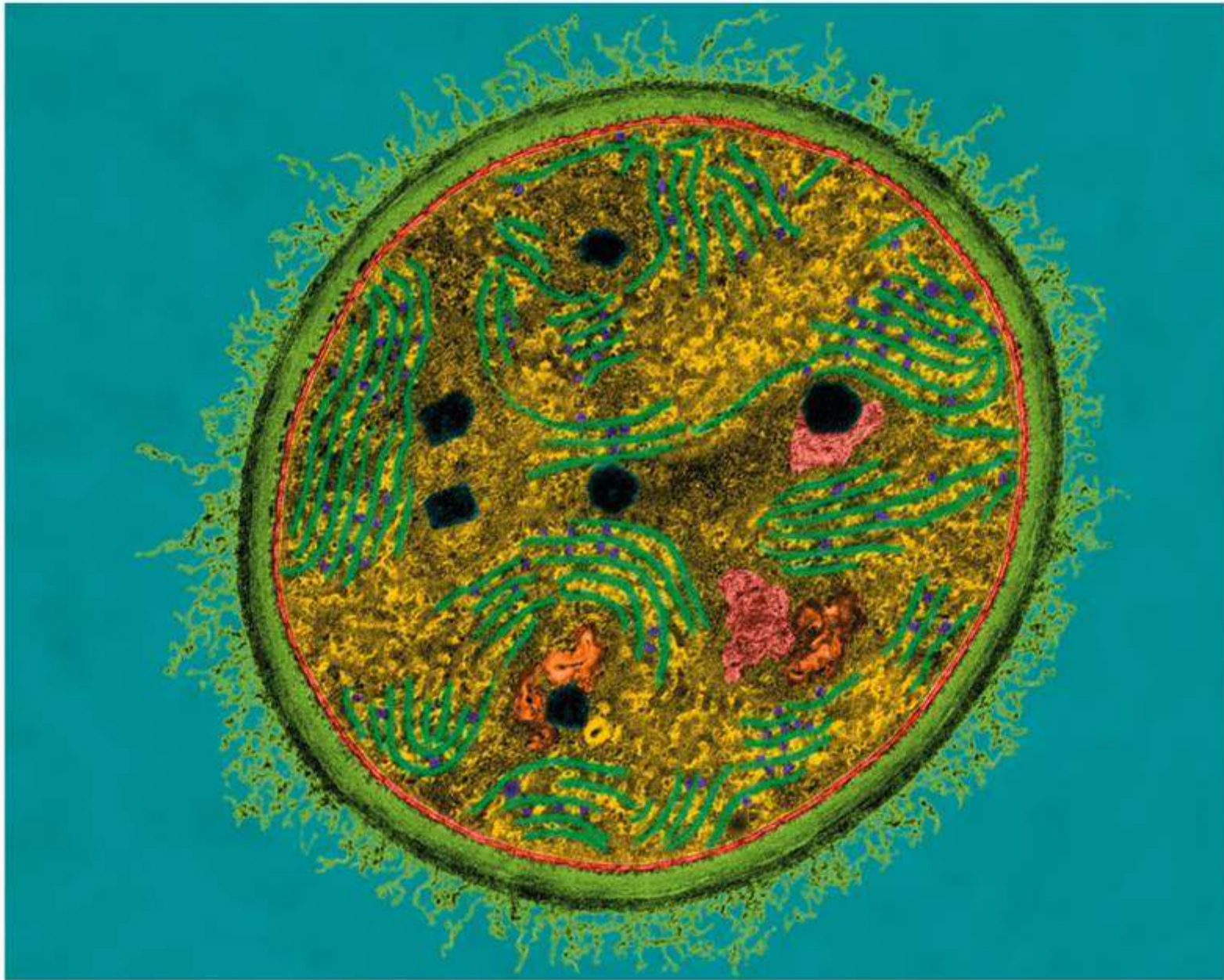
**Metabolism:** the sum of all chemical reactions that occur in cells.

Why is your body generally 98.6 degrees?

**Photosynthesis** evolved about 2.5 billion years ago.

What is the equation for photosynthesis?

## Figure 1.10 Photosynthetic Organisms Changed Earth's Atmosphere



**LIFE 8e, Figure 1.10**

## 1.2 How is All Life on Earth Related?

Consequences of photosynthesis:

- $O_2$  accumulated in the atmosphere
- Aerobic metabolism began
- Ozone layer formed—allowed organisms to live on land

## 1.2 How is All Life on Earth Related?

**Eukaryotic** cells evolved from prokaryotes.

**Organelles**—membrane bound compartments with specialized functions:

- *Nucleus*
- *Chloroplast*

## 1.2 How is All Life on Earth Related?

Multicellular organisms arose about 1 billion years ago.

**Cellular specialization:** Cells became specialized to perform certain functions.

## 1.2 How is All Life on Earth Related?

Evolution results in **speciation**.

Each species has a distinct scientific name, a *binomial*:

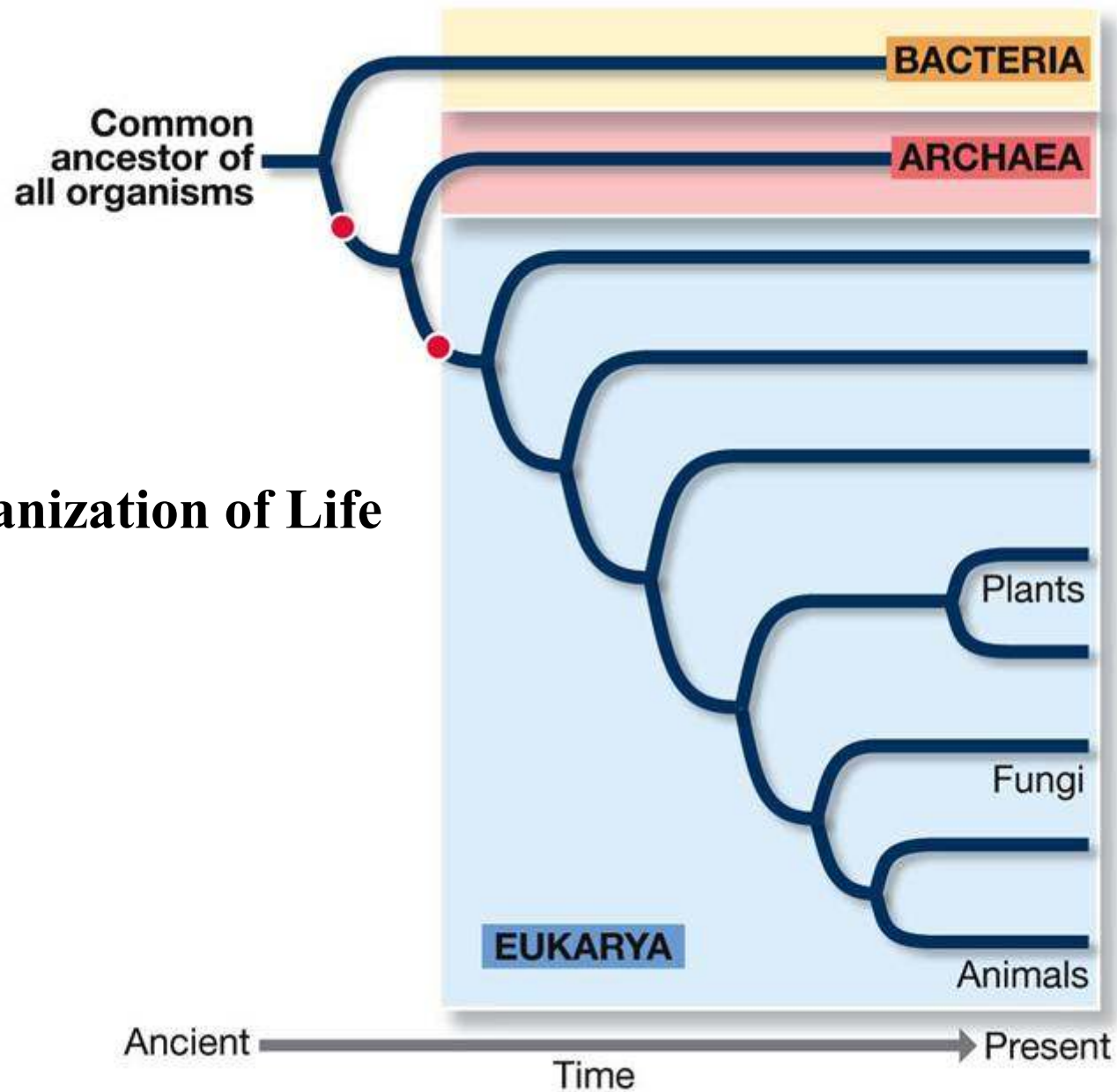
- Genus name
- Species name, for example,

*Homo sapiens*

Can you remember how to write scientific names?

Figure 1.11 The Tree of Life

## New Organization of Life





## 1.2 How is All Life on Earth Related?

The three **domains** of life are separated by molecular techniques:

- Bacteria
- Archaea
- Eukarya

Let's construct the Tree of Life using the six kingdoms.

## 1.2 How is All Life on Earth Related?

Multicellular Eukarya (plants, animals, and fungi) evolved from *protists*—unicellular microbial eukaryotes.

## 1.2 How is All Life on Earth Related?

*Autotrophs*: organisms capable of photosynthesis (light-lovers)

*Heterotrophs*: require a source of molecules synthesized by other organisms (got to munch and crunch)

## 1.3 How Do Biologists Investigate Life?

Biologists use many methods to expand our understanding of life.

Observation: improved by technological advances

Experimentation

Figure 1.12 Tuna Tracking



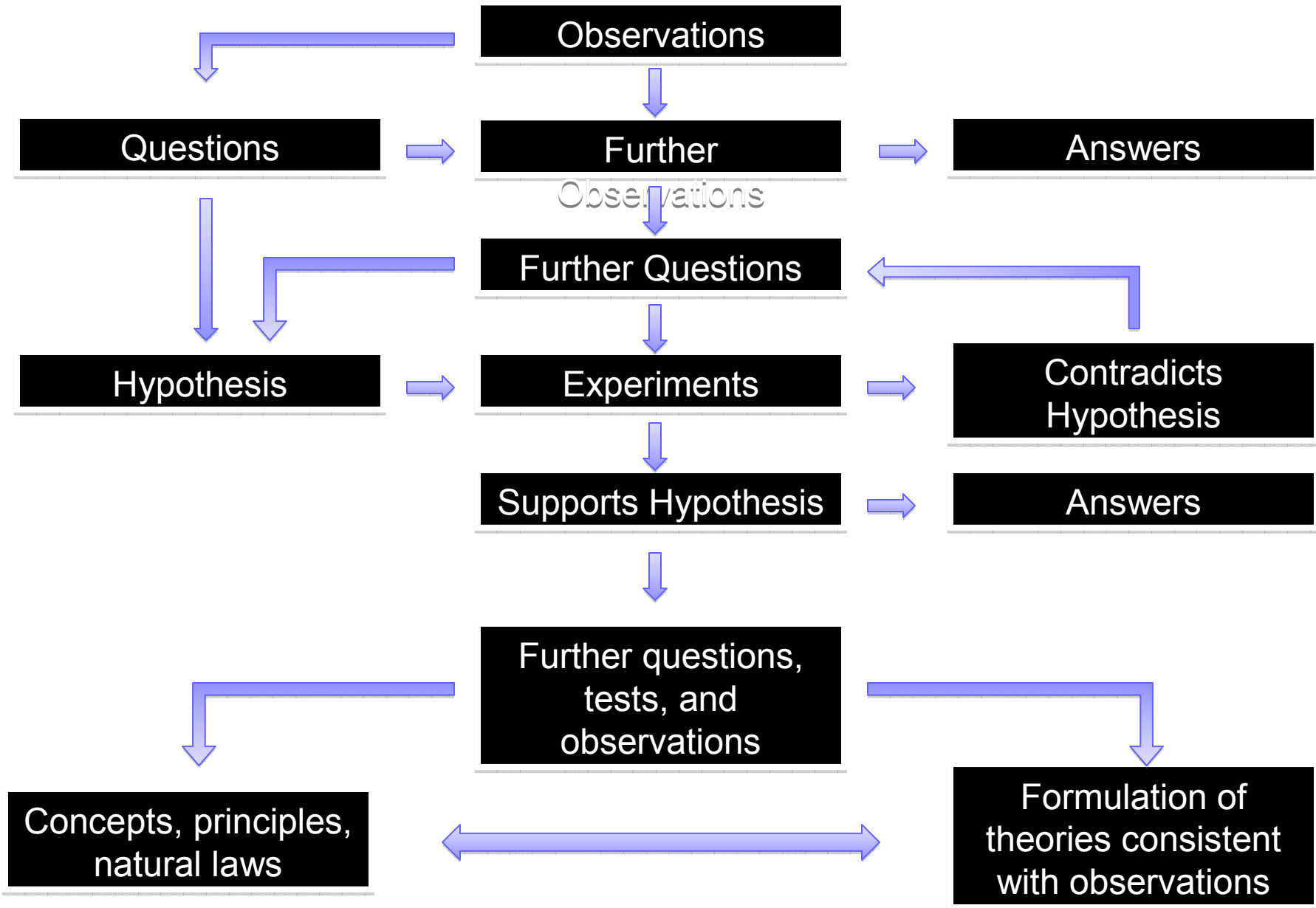
**LIFE 8e, Figure 1.12**

## 1.3 How Do Biologists Investigate Life?

### The **scientific method**:

- Observations
- Questions
- Hypotheses/Predictions
- Experimentation/Testing
- Conclusions
- Formulate concepts, theories, and/or laws

## 1.3 The Scientific Method



## 1.3 How Do Biologists Investigate Life?

*Inductive logic* leads to tentative answers or explanations called **hypotheses**.

*Deductive logic* is used to make predictions.

**Experiments** are designed to test the predictions.



## 1.3 How Do Biologists Investigate Life?

**Comparative experiments** look for differences between samples or groups.

**Controlled experiments** manipulate the *variable* that is predicted to cause differences between groups.

**Example:** Let's say that frogs located in a particular area of California are developing a genetic defect that makes them grow extra pairs of legs. Using the scientific method, how could we determine the reason for this?

Figure 1.13 Comparative Experiments Look for Differences between Groups (Part 1)

## EXPERIMENT

**HYPOTHESIS:** Something in the environment is causing developmental limb abnormalities in Pacific tree frogs.

### METHOD

1. Identify a test area of small ponds in an area where abnormal tree frogs have been found.
2. Collect and analyze water samples from the ponds.
3. Census the organisms in the ponds.
4. Look for correlations between the presence of frog abnormalities and the characteristics of the ponds.



Deformed  
hind leg



Figure 1.13 Comparative Experiments Look for Differences between Groups (Part 2)

## EXPERIMENT

### RESULTS

Pacific tree frogs were found in 13 of 35 ponds. Frogs with limb abnormalities were found in 4 of these 13 ponds. Water and census analyses of the 13 ponds containing frogs revealed no difference in water pollution, but did reveal the presence of snails infested with parasitic flatworms of the genus *Ribeiroia* in the 4 ponds with abnormal frogs.

	Pesticide residues in water?	Heavy metals in water?	Industrial chemicals in water?	Snails in water?	<i>Ribeiroia</i> in water?	<i>Ribeiroia</i> larvae in frogs?
Ponds with normal frogs	No	No	No	No	No	No
Ponds with abnormal frogs	No	No	No	Yes	Yes	Yes

**CONCLUSION:** Infection by parasitic *Ribeiroia* may cause abnormalities in the limb development of Pacific tree frogs.



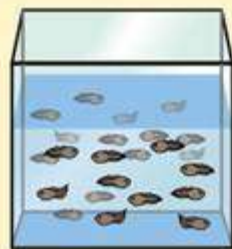
Figure 1.14 Controlled Experiments Manipulate a Variable (Part 1)

## EXPERIMENT

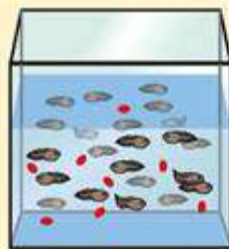
**HYPOTHESIS:** Infection of Pacific tree frog tadpoles by the parasite *Ribeiroia* causes developmental limb abnormalities.

### METHOD

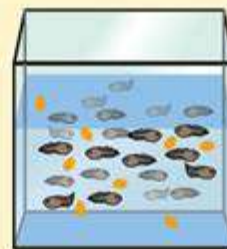
1. Collect *Hyla regilla* eggs from a site with no record of abnormal frogs.
2. Allow eggs to hatch in laboratory aquaria. Randomly divide equal numbers of the resulting tadpoles into control and experimental groups.
3. Allow the control group to develop normally. Subject the experimental groups to infection with *Ribeiroia*, a different parasite, and a combination of both parasites.
4. Follow tadpole development. Count and assess the resulting adult frogs.



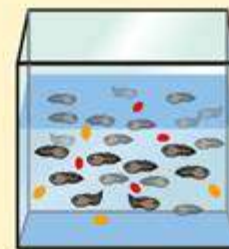
Control



Experiment 1

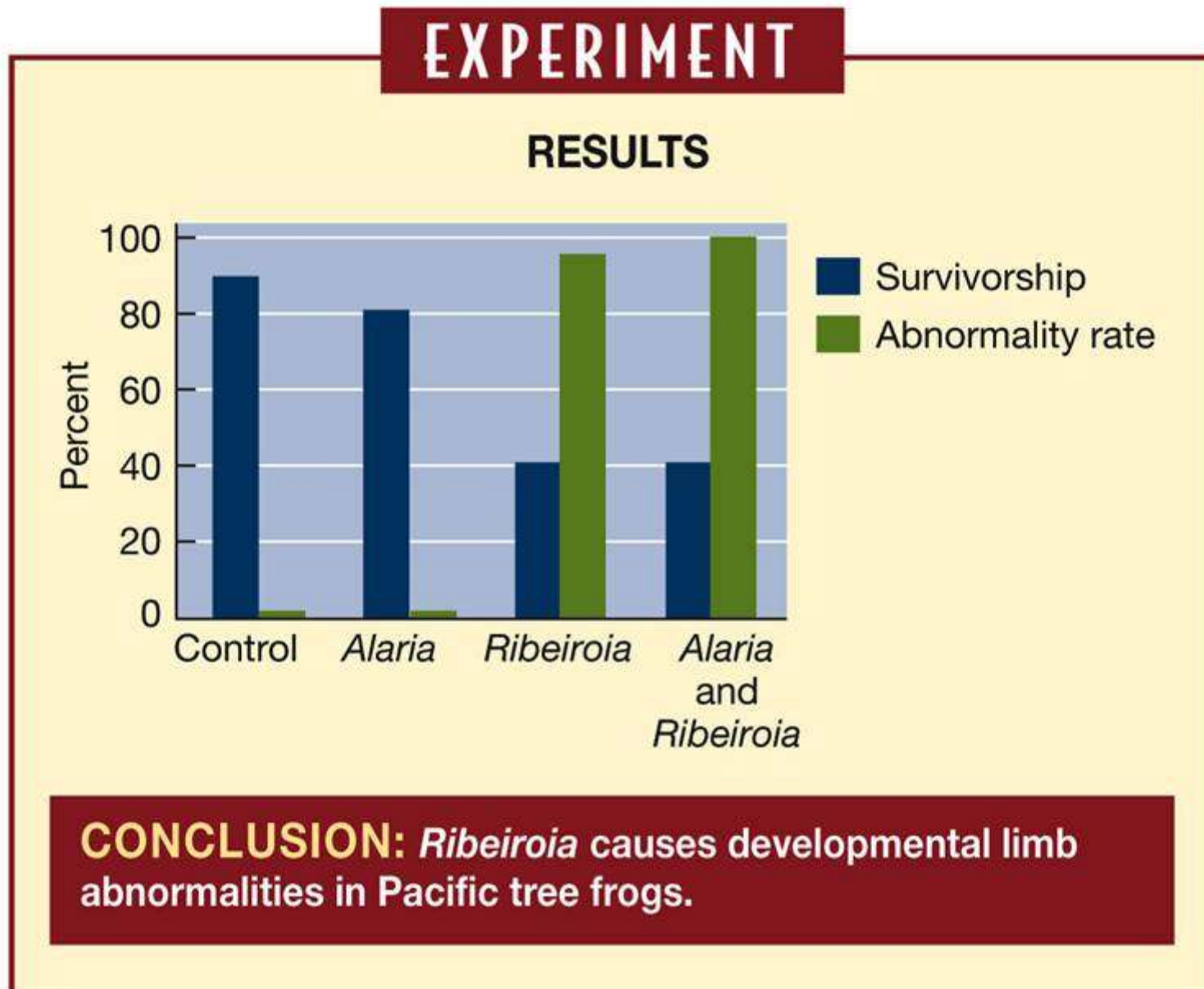


Experiment 2



Experiment 3

Figure 1.14 Controlled Experiments Manipulate a Variable (Part 2)



## 1.3 How Do Biologists Investigate Life?

*Independent variable*: the variable being manipulated

*Dependent variable*: the response that is measured

## 1.3 How Do Biologists Investigate Life?

Statistical methods help scientists determine if differences between groups are *significant*.

Statistical tests start with the **null hypothesis**—that there are no differences.



## 1.3 How Do Biologists Investigate Life?

Statistical methods are applied to **data** to determine the probability of getting a particular result even if the null hypothesis is true.

Statistical methods eliminate the possibility that results are due to random variation.

## 1.3 How Do Biologists Investigate Life?

Distinguishing science and non-science:

Scientific hypotheses must be testable,  
and have the potential of being rejected.

What is Pseudoscience, name some,  
then describe why we cannot accept  
them as science?

## 1.4 How Does Biology Influence Public Policy?

Biological knowledge allows advances in human pursuits such as medicine and agriculture.

These advancements raise ethical and policy questions.

What are some examples where advances in biological knowledge has created questions in ethics, politics, culture, religion, etc.?

## 1.4 How Does Biology Influence Public Policy?

Biological knowledge contributes to our understanding of human influences on our environment.

Biologists are called on to advise governments making policy decisions.

## 1.4 Conclusions

1. Biology is the study of life.
2. Cells are the most basic unit of life.
3. Evolution and natural selection is responsible for the diversity and adaptations of life on Earth.
4. All life on Earth past, present, and future is genetically related.
5. There are three domains of life: Bacteria, Archaea, and Eukarya. Domains are based on genomic research.
6. The Scientific Method is a process used in biological investigations to explain natural phenomena.
7. Science can tell us how the world works, but it cannot tell us what we should or should not do.
8. Science can be used to influence public perception and policy.
9. Remember: Knowledge is Power!