# Listening and Note-taking

## Part 1: Introduction

### *A. Abbreviations and symbols*

Using symbols abbreviations and symbols will help you to take notes faster when you are reading or listening.

**Test yourself**: What words or ideas to these common abbreviations and symbols mean or present?

1. ∵
2. ∴
2. <
3. >
4. /
5. Δ
6. ↑
7. →
8. ↓
9. ↔
10. ~
11. ∝
12. et. al.
13. *
14. w/ or c
15. w/o
16. cf.
17.viz
18. asap

Use this link to check your answers and find other common symbols and abbreviations:

Note-Taking Abbreviations (University of Adelaide)

What other abbreviations and/or symbols do you use when you take notes? Make a list.

### *B. Note-taking Systems*

1. Three effective systems for note-taking are the **Cornell Method**, **Outlines**, and **Mind Maps**. Use this link to see examples of each method:

   Camosun Lib Guides: Studying – Notes

*Different note-taking systems offer various advantages:*

The **Cornell** method of note-taking gives you a way to review and summarize your notes immediately after you have finished making them. They will provide you with a useful study and revision tool.

**Outlines** help you to show the difference between main ideas, supporting details and examples. The information which is most general begins at the left. More specific support is indented to the right. You can use numbers and letters, bullet points, or a combination in your outline:

**Example**:

A. Main point (general)
    1. Support for main point (specific)
        a) example or minor support
        b) example or minor support

**Mind maps** are an effective way to record main ideas and to show how main ideas relate to one another and to the supporting detail. They work well for students with a 'visual' learning style.

*The best note-taking method is the one that works best for you.*

2. Watch the video on "Evolution by Natural Selection" from Chapter 1 of *Concepts of Biology*, an online biology textbook. As you listen, note key words or ideas.

   Evolution by Natural Selection

3. Watch the video a second time. Compare your notes to the three model outlines: Cornell notes, an outline and a mind map.

   Which outline format do you like the best for reading? For listening?

## Cornell Method

Concepts of Biology: 1.1 Themes and Concepts "Evolution by Natural Selection" Charles Molnar

| **Cue: (This is the questions/key word column.)** | **Notes: (This is the note-taking column.)** |
|---|---|
| Charles Darwin | Evolution by natural selection = explains all of biology |
| Too many organisms born – environment limits survival | Organisms vary <u>because of</u> genetic variation<br>More born than environment can support, e.g. acorns on oak tree<br>• Environment limits survival, e.g. space, food, light |
| **Important!!**<br><br>Organisms with most suitable variations survive – pass variations on and form new species in time | **Who/what survives is not random!!**<br>Organisms that survive are best suited to the <u>current environment</u> – evolution does not look into the future!!<br>• Selects on variation present in the here and now. |
| Basis of evolution by natural selection | Variations passed on through genes to offspring > changes gene pool > over time that population can become its own species |

*Summary*: Natural selection is the foundation of biology. Suitability to current environment explains why some organisms don't survive – other do and go on to produce new species.

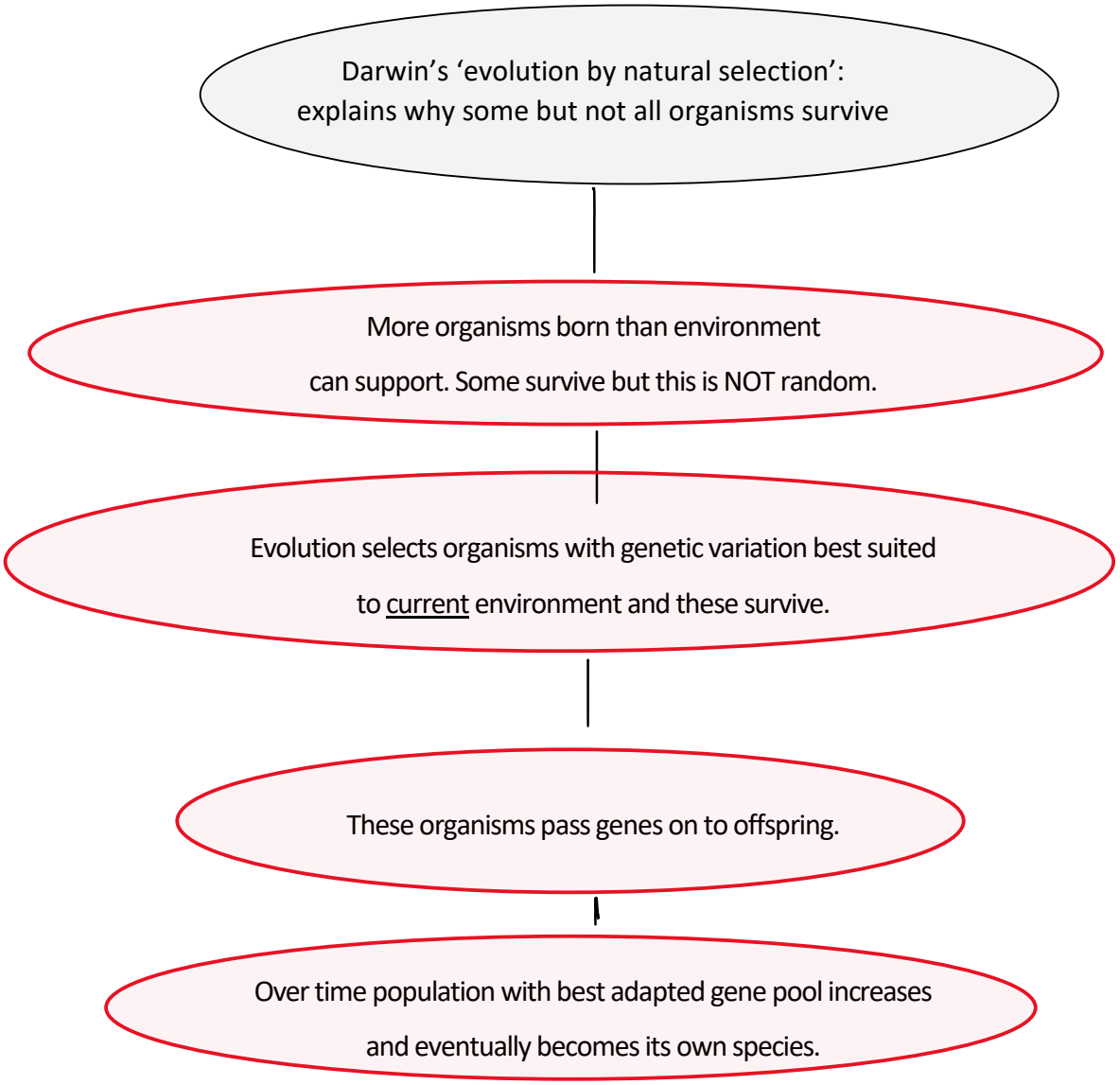
## Outline

A. Charles Darwin's theory of natural selection is foundation for all biology disciplines
    1. Explains why some organisms survive and others do not
B. How natural selection works
    1. Organisms are different <u>because of</u> genes
    2. Too many organisms born for environment to support, e.g. acorns or salmon

   a. Limits from environment may be light, food etc.

3. Survival is NOT random
   a. Only organisms with best variation for the **current** environment will survive
4. Natural selection can produce new species
   a. Variation passed on thru genes to offspring
   b. Through time gene pool changes and population can become a new species

## Mind Map


Darwin's 'evolution by natural selection':
explains why some but not all organisms survive
More organisms born than environment
can support. Some survive but this is NOT random.
Evolution selects organisms with genetic variation best suited
to current environment and these survive.
These organisms pass genes on to offspring.
Over time population with best adapted gene pool increases
and eventually becomes its own species.

**Transcripts**

"Evolution by Natural Selection"

From *Concepts of Biology* Ch. 1.1 "Themes and Concepts of Biology"

https://opentextbc.ca/biology/chapter/1-1-themes-and-concepts-of-biology/

"Nothing in biology makes sense, except in light of evolution." Evolution by natural selection is the bedrock of the understanding of life. Everything from biochemistry to ecosystems can only be understood in light of Darwin's great idea. Unlike other big ideas humans have come up with, like quantum mechanics or relativity, you can grasp the essence of evolution by natural selection with a few examples and a few statements of facts and inferences.

Organisms vary. If you're in a classroom, look around. What could be more obvious? You are all different from the neighbors sitting around you. And it's not just true for human. It's true for fruit flies, or corn kernels, any population. The origin of the variation you can see around you is genetic. It's determined by our genes. Each acorn, like each human, is different because of sexual reproduction that we'll cover later on in a video.

More organisms are born than the environment can support. It's pretty easy to understand with things like salmon. Each female salmon lays thousands of eggs that get fertilized. Or acorns from an oak tree. Not all those acorns can survive. Something in the environment is going to be limiting. It could be the amount of space, the amount of prey that's available, the amount of light, the amount of nutrients. Any one of those factors can limit this vast production of offspring. And the critical part to remember here is that who survives is non-random.

The organisms that survive are those with the variations that best suit them to the current environment. Evolution can't look ahead. Natural selection occurs right here, right now. It can't predict the future. It can only provide the selection on the variation that's present. So think about those acorns from an oak tree, each of them different, some of them better able to survive in the current environment. Maybe they germinate a day earlier. Maybe they grow their leaves and expose them to sunlight faster than their neighbors can. This bit, this change, this variation, let's them survive. And the critical part is they pass those variations on to their offspring so that over time the gene pool of that population changes. And that's it. With a changing gene pool, if you just expand the timescale, that population has the possibility to

become so different that it can become its own species. And there's the basis of evolution by natural selection.

"Science and Medicine"
From *Concepts of Biology* Ch. 1.1 "Themes and Concepts of Biology"
https://opentextbc.ca/biology/chapter/1-1-themes-and-concepts-of-biology/

It's interesting to contemplate ideas of science and medicine that have been disproven over time. And it's hard sometimes to imagine that the ideas that were once held as universally true could be so absolutely wrong. I like to think of the model of health that Western societies had before the germ idea, and that was that health and well-being, disease and healthiness, was based on balance of the four humors. That you had blood and black bile and yellow bile and phlegm, and the idea of the physician was to keep these in balance by purgatives, emetics and most obviously by bleeding. And that by manipulating these liquids, these humors, health could by restored. Now that's just not the way we understand medicine now. And what I like to think of is how will humans appraise us in the future? And I think we're going to come off about the same as the four humors, at least in some domains.
When we think of how cancer treatment has evolved in the, mainly in the 20$^{th}$ century, the idea was to create compounds that would kill actively growing cells, interfere with DNA copying, or the movement of chromosomes, and thus render cells that are actively growing, and the fastest growing ones would be cancer cells, to knock those out. But since this medicine, this chemotherapy, was given systemically, it would also make other cells in the body die, like your hair follicles and the gut lining, so people would be massively unwell, unhappy, and losing their hair. It was really a fight to kill the tumour cells before you did irreparable damage to the human undergoing this treatment.
And as we can see now, the advances in molecular biology, immunology and nanotechnology are precision targeting of cancer cells, leaving the rest of the body undamaged by these treatments. So we're moving into a domain that's going to seem precise, and accurate and effective, and leave behind this 'well-meaning, the best we could do', but what I think the future will look back on is this almost barbaric treatment to eliminate cancer.

If we lose the world's largest organism, we'll lose a scientific treasure trove. Because Pando's trunks are genetically identical, they can serve as a controlled setting for studies on everything from the tree microbiome to the influence of climate on tree growth rates.

05:39

The good news is, we have a chance to save Pando, by reducing livestock grazing in the area and further protecting the vulnerable young saplings. And the time to act is today. Because as with so many other marvels of our natural world, once they're gone it will be a very, very long time before they return.

## Reading & Notetaking: Column Notes

**Column notes** are useful if you are doing research for an essay or report. You can easily see the main and supporting ideas, and there is a far right column for you to make a note of information about the text you may need later.

Study the Column notes for the next extract from Chapter 1 of *Concepts of Biology*: "Levels of Organization of Living Things".

Then read the extract and compare with the notes.

| **Main ideas** | **Supporting material** | **Names, citations, questions & clarification** |
|---|---|---|
| Living things are organized/structured<br><br>Hierarchical:<br>**small to large** | ***Atom:*** nucleus + electrons ><br><br>***Molecule:*** 2+ atoms ><br><br>***macromolecules***: biologically important (e.g. DNA) ><br><br>***organelles***: macromolecules surrounded by membranes / exist within cells + have specialized function ><br><br>***cell***: smallest unit of structure + function in living organisms;<br>classified as:<br>• prokaryotic, or<br>• eukaryotic ><br><br>***tissue***: cells combined; carry out some function ><br><br>***organs***: groups of tissue w/ similar function; in plants and animals > | https://opentextbc.ca/biology/<br><br>Prokaryote: single cell organism/ no organelle + membrane or nucleus + membrane<br><br>Eukaryotes: have organelle & nuclei with membrane<br><br>APA citation: Molnar, C., & Gair, J. (2015). *Concepts of Biology – 1st* |

| | | |
|---|---|---|
| | ***organ system***, e.g. circulatory system w/ heart and blood vessels ><br><br>***organism/ microorganism***: individual living entity, e.g. tree, prokaryote, eukaryote ><br>***population***: individuals of a species in an area, e.g. white pine trees in forest ><br><br>***community***: set of populations in an area, e.g. trees, flowers, insects, etc. in a forest ><br><br>***ecosystem***, e.g. a forest + non-living parts (like nitrogen in water) ><br><br>***biosphere***: all ecosystems + land,water, parts of atmosphere | *Canadian Edition*. BCcampus. Retrieved from https://opentextbc.ca/biology/ |

## Reading & Notetaking: Cornell Method

### Part 1: Introduction

C. Abbreviations and symbols

Using symbols abbreviations and symbols will help you to take notes faster when you are reading or listening.

**Test yourself**: What words or ideas to these common abbreviations and symbols mean or present?

10. ∵
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12. >
13. /
14. Δ
15. ↑
16. →
17. ↓
18. ↔

10. ~
11. ∝
12. et. al.
13. *
14. w/ or c
15. w/o
16. cf.
17. viz
18. asap

Use this link to check your answers and find other common symbols and abbreviations:

https://www.adelaide.edu.au/writingcentre/sites/default/files/docs/learningguide-notetakingabbreviations.pdf

*What other abbreviations and/or symbols do you use when you take notes? Make a list.*

### D. Active Reading: Annotating a Text

**Annotating** a text while you read can make note-taking more efficient.

When you annotate a text, you add information to it as you read. A text annotation can be adding a note or question in the margin, or simply underlining or highlighting a key work or main point.

For more information, watch "Active Reading // 3 Easy Methods". The video describes three active reading strategies:

https://pressbooks.pub/roughwritersguide/chapter/writing-notes-and-annotating/

### E. Note-taking Systems

Four common systems for note-taking are the **Cornell Method**, **Column Notes, Outlines**, and **Mind Maps**.

Use this link to see examples of each method:

https://camosun.libguides.com/Studying/notes

## Part 2: Cornell Method of Note-taking

A. Watch the short video on the **Cornell Method** of notetaking. Answer the questions as you listen.

1. How can the Cornell Method help you to learn?
2. What information goes at the top of the page?
3. What information goes in the larger box on the right?
4. When do you add this information?
5. What information goes in the column on the left?
6. When do you add this information?
7. What do you write at the bottom of the page?
8. Which part of the notes should you focus on when studying? Why?

D. Read the extract on “Properties of Life” from Chapter 1 of *Concepts of Biology*, an online biology textbook: https://opentextbc.ca/biology/

As you read, **annotate the text**: add notes in the margin, underline or highlight key words and main ideas.

Then study the Cornell notes and compare with your annotations on the text.

# 1.1 Themes and Concepts of Biology

## Properties of Life

All groups of living organisms share multiple key characteristics or functions: order, sensitivity or response to stimuli, reproduction, adaptation, growth and development, regulation, homeostasis, and energy processing. When viewed together, these eight characteristics serve to define life.

### Order

Organisms are highly organized structures that consist of one or more cells. Even very simple, single-celled organisms are remarkably complex. Inside each cell, atoms make up molecules. These in turn make up cell components or organelles. Multicellular organisms, which may consist of millions of individual cells, have an advantage over single-celled organisms in that their cells can be specialized to perform specific functions, and even sacrificed in certain situations for the good of the organism as a whole. How these specialized cells come together to form organs such as the heart, lung, or skin in organisms like the toad shown in Figure 1. 2 will be discussed later.

Figure 1.2 A toad represents a highly organized structure consisting of cells, tissues, organs, and organ systems.

## Sensitivity or Response to Stimuli

Organisms respond to diverse stimuli. For example, plants can bend toward a source of light or respond to touch. Even tiny bacteria can move toward or away from chemicals (a process called chemotaxis) or light (phototaxis). Movement toward a stimulus is considered a positive response, while movement away from a stimulus is considered a negative response.


Figure 1.3 The leaves of this sensitive plant (Mimosa pudica) will instantly droop and fold when touched. After a few minutes, the plant returns to its normal state.

## Reproduction

Single-celled organisms reproduce by first duplicating their DNA, which is the genetic material, and then dividing it equally as the cell prepares to divide to form two new cells. Many multicellular organisms (those made up of more than one cell) produce specialized reproductive cells that will form new individuals. When reproduction occurs, DNA containing genes is passed along to an organism's offspring. These genes are the reason that the offspring will belong to the same species and will have characteristics similar to the parent, such as fur color and blood type.

## Adaptation

All living organisms exhibit a "fit" to their environment. Biologists refer to this fit as adaptation and it is a consequence of evolution by natural selection, which operates in every lineage of reproducing organisms. Examples of adaptations are diverse and unique, from heat-resistant Archaea that live in boiling hot springs to the tongue length of a nectar-feeding moth that matches the size of the flower from which it feeds. All adaptations enhance the reproductive potential of the individual exhibiting them, including their ability to survive to reproduce. Adaptations are not constant. As an environment changes, natural selection causes the characteristics of the individuals in a population to track those changes.

## Growth and Development

Organisms grow and develop according to specific instructions coded for by their genes. These genes provide instructions that will direct cellular growth and development, ensuring that a species' young will grow up to exhibit many of the same characteristics as its parents.


Figure 1.4 Although no two look alike, these kittens have inherited genes from both parents and share many of the same characteristics.

## Regulation

Even the smallest organisms are complex and require multiple regulatory mechanisms to coordinate internal functions, such as the transport of nutrients, response to stimuli, and coping with environmental stresses. For example, organ systems such as the digestive or circulatory systems perform specific functions like carrying oxygen throughout the body, removing wastes, delivering nutrients to every cell, and cooling the body.

## Homeostasis

To function properly, cells require appropriate conditions such as proper temperature, pH, and concentrations of diverse chemicals. These conditions may, however, change from one moment to the next. Organisms are able to maintain internal conditions within a narrow range almost constantly, despite environmental changes, through a process called homeostasis or "steady state"—the ability of an organism to maintain constant internal conditions. For example, many organisms regulate their body temperature in a process known as thermoregulation. Organisms that live in cold climates, such as the polar bear, have body structures that help them withstand low temperatures and conserve body heat. In hot climates, organisms have methods (such as perspiration in humans or panting in dogs) that help them to shed excess body heat.


Figure 1.5 Polar bears and other mammals living in ice-covered regions maintain their body temperature by generating heat and reducing heat loss through thick fur and a dense layer of fat under their skin.

## Energy Processing

All organisms (such as the California condor shown in Figure 1.6) use a source of energy for their metabolic activities. Some organisms capture energy from the sun and convert it into chemical energy in food; others use chemical energy from molecules they take in.


Figure 1.6 A lot of energy is required for a California condor to fly. Chemical energy derived from food is used to power flight. California condors are an endangered species; scientists have strived to place a wing tag on each bird to help them identify and locate each individual bird.

## Cornell Notes

Concepts of Biology: 1.1 Themes and Concepts

| **Cue: (This is the questions/key word column.)** | **Notes: (This is the note-taking column.)** |
|---|---|
| Life? Answer 4 questions –<br>Q. <u>1</u> Shared properties of life? | Biology = study of life - answers 4 questions:<br><br>Everything "alive" has 8 properties |
| 1) Order =<br>Organisation single & multicellular organisms | 1) Order: organisms highly organized<br>Organisms = 1 or more cells<br>• Atoms > molecules > organelles > cells: single or multicellular organisms<br>• multicellular organisms can be specialised/ sacrificed/ form organs, e.g. heart, lung |
| 2) <u>Sensitivity/ response to Stimuli</u><br>Orgs move > (+) and < (-) stimulus | 2) Sensitivity/ response to stimuli: organisms respond to stimuli<br>• Movement towards = + response/ Movement away = neg. response |
| 3) <u>Reproduction</u><br>Pass DNA to offspring – single & multicell orgs. different | 3) Reproduction: DNA w/ genes passed to offspring<br>• Single cell organisms: duplicate DNA then divide it equally<br>• Multicellular organisms: many produce specialized repro. cells |
| 4) <u>Adaptations:</u><br>Org's change w/ the environment | 4) Adaptation(s) = "evolution by natural selection"<br>• Improve ability to reproduce<br>• Change w/ the environment |
| 5) <u>Growth and development</u> | 5) Growth and development: happens according to instructions coded by genes |
| 6) <u>Regulation:</u><br>Mechanisms that co-ordinate internal function, e.g. digestion | 6) Regulation<br>• all organisms need "mechanisms to coordinate internal functions", e.g. like transport of nutrients; response to stimuli<br>• organ systems have specific functions, e.g. digestive system |

| | |
|---|---|
| 7) <u>Homeostasis</u><br><br><br><br><br><br>8) <u>Energy processing</u> | 7) Homeostasis = "steady state" or "ability to…maintain constant internal conditions", e.g. *thermoregulation* regulates body temperature:<br>• e.g. polar bears can conserve heat in the cold/ humans perspire to reduce body heat<br><br>• Energy processing: all organisms use an energy source to metabolize, e.g. solar energy converted to chemical energy in food<br><br>**Notes take from online text version in March 2023* |

<u>Summary</u>:

Biology studies life and answers 4 questions. Q. 1 = What are the shared properties of living things?

8 properties: order; sensitivity/response to stimuli; reproduction; adaptation; growth & development; regulation; homeostasis; energy processing

## Reading & Notetaking: Mind Maps

**Mind maps** are an effective way to record the main ideas and to show how they are related.

Read the final extract from Chapter 1 of *Concepts of Biology*: "Branches of Biological Study".

Use the information in the extract to complete the mind map. Then read the extract and compare with the notes.

Molecular biology - study of biological process at molecular level

1) _____ - study of microorganisms

neurobiology - studies biology of nervous system

paleontology - 2) _____ used to study life's history

zoology & botany - animals and plants

biotechnology - use biology to create products

3) _____ - cells, tissues, organs

4) _____ – interactions of organisms in their environment

many branches and sub-disciplines

BRANCHES OF BIOLOGICAL STUDY

Biology in 20 C -

description and manipulation of DNA has changed biology – better understanding of history of life, body, origins, our survival

Forensic science
- gives evidence for court
- examine material from crimes

## Branches of Biological Study

The scope of biology is broad and therefore contains many branches and sub disciplines. Biologists may pursue one of those sub disciplines and work in a more focused field. For instance, molecular biology studies biological processes at the molecular level, including interactions among molecules such as DNA, RNA, and proteins, as well as the way they are regulated. Microbiology is the study of the structure and function of microorganisms. It is quite a broad branch itself, and depending on the subject of study, there are also microbial physiologists, ecologists, and geneticists, among others.

Another field of biological study, neurobiology, studies the biology of the nervous system, and although it is considered a branch of biology, it is also recognized as an interdisciplinary field of study known as neuroscience. Because of its interdisciplinary nature, this sub discipline studies different functions of the nervous system using molecular, cellular, developmental, medical, and computational approaches.

Figure 1.12 Researchers work on excavating dinosaur fossils at a site in Castellón, Spain.

Paleontology, another branch of biology, uses fossils to study life's history. Zoology and botany are the study of animals and plants, respectively. Biologists can also specialize as biotechnologists, ecologists, or physiologists, to name just a few areas. Biotechnologists apply the knowledge of biology to create useful products. Ecologists study the interactions of organisms in their environments. Physiologists study the workings of cells, tissues and organs. This is just a small sample of the many fields that biologists can pursue. From our own bodies to the world we live in, discoveries in biology can affect us in very direct and important ways. We depend on these discoveries for our health, our food sources, and the benefits provided by our ecosystem. Because of this, knowledge of biology can benefit us in making decisions in our day-to-day lives.

The development of technology in the twentieth century that continues today, particularly the technology to describe and manipulate the genetic material, DNA, has transformed biology. This transformation will allow biologists to continue to understand the history of life in greater detail, how the human body works, our human origins, and how humans can survive as a species on this planet despite the stresses caused by our increasing numbers. Biologists continue to decipher huge mysteries about life suggesting that we have only begun to understand life on the planet, its history, and our relationship to it. For this and other reasons, the knowledge of biology gained

through this textbook and other printed and electronic media should be a benefit in whichever field you enter.

### Forensic Scientist

Forensic science is the application of science to answer questions related to the law. Biologists as well as chemists and biochemists can be forensic scientists. Forensic scientists provide scientific evidence for use in courts, and their job involves examining trace material associated with crimes. Interest in forensic science has increased in the last few years, possibly because of popular television shows that feature forensic scientists on the job. Also, the development of molecular techniques and the establishment of DNA databases have updated the types of work that forensic scientists can do. Their job activities are primarily related to crimes against people such as murder, rape, and assault. Their work involves analyzing samples such as hair, blood, and other body fluids and also processing DNA found in many different environments and materials. Forensic scientists also analyze other biological evidence left at crime scenes, such as insect parts or pollen grains. Students who want to pursue careers in forensic science will most likely be required to take chemistry and biology courses as well as some intensive math courses.

## Section Summary

Biology is the science of life. All living organisms share several key properties such as order, sensitivity or response to stimuli, reproduction, adaptation, growth and development, regulation, homeostasis, and energy processing. Living things are highly organized following a hierarchy that includes atoms, molecules, organelles, cells, tissues, organs, and organ systems. Organisms, in turn, are grouped as populations, communities, ecosystems, and the biosphere. Evolution is the source of the tremendous biological diversity on Earth today. A diagram called a phylogenetic tree can be used to show evolutionary relationships among organisms. Biology is very broad and includes many branches and sub disciplines. Examples include molecular biology, microbiology, neurobiology, zoology, and botany, among others.

*Exercises*

*Glossary*

**atom:** a basic unit of matter that cannot be broken down by normal chemical reactions

**biology:** the study of living organisms and their interactions with one another and their environments

**biosphere:** a collection of all ecosystems on Earth

**cell:** the smallest fundamental unit of structure and function in living things

**community:** a set of populations inhabiting a particular area

**ecosystem:** all living things in a particular area together with the abiotic, nonliving parts of that environment

**eukaryote:** an organism with cells that have nuclei and membrane-bound organelles

**evolution:** the process of gradual change in a population that can also lead to new species arising from older species

**homeostasis:** the ability of an organism to maintain constant internal conditions

**macromolecule:** a large molecule typically formed by the joining of smaller molecules

**molecule:** a chemical structure consisting of at least two atoms held together by a chemical bond

**organ:** a structure formed of tissues operating together to perform a common function

**organ system:** the higher level of organization that consists of functionally related organs

**organelle:** a membrane-bound compartment or sac within a cell

**organism:** an individual living entity

**phylogenetic tree:** a diagram showing the evolutionary relationships among biological species based on similarities and differences in genetic or physical traits or both

**population:** all individuals within a species living within a specific area

**prokaryote:** a unicellular organism that lacks a nucleus or any other membrane-bound organelle

**tissue:** a group of similar cells carrying out the same function

**Reading and Notetaking: Outline Notes**

**Outlines** help you to show the difference between main ideas, supporting details and examples.

The information which is most general begins at the left. More specific support is indented to the right. You can use numbers and letters, bullet points, or a combination in your outline.

**Example**:

A. Main point (general)
    1. Support for main point (specific)
        a) example or minor support
        b) example or minor support

Study the outline for the next extract from Chapter 1 of *Concepts of Biology*: "The Diversity of Life".

As you read, **annotate the text**: add notes in the margin, underline or highlight key words and main ideas.

Then read the outline and compare with your annotations of the text.

## The Diversity of Life

The science of biology is very broad in scope because there is a tremendous diversity of life on Earth. The source of this diversity is evolution, the process of gradual change during which new species arise from older species. Evolutionary biologists study the evolution of living things in everything from the microscopic world to ecosystems.

In the 18th century, a scientist named Carl Linnaeus first proposed organizing the known species of organisms into a hierarchical taxonomy. In this system, species that are most similar to each other are put together within a grouping known as a genus. Furthermore, similar genera (the plural of genus) are put together within a family. This grouping continues until all organisms are collected together into groups at the highest level. The current taxonomic system now has eight levels in its hierarchy, from lowest to highest, they are: species, genus, family, order, class, phylum, kingdom, and domain. Thus species are grouped within genera, genera are grouped within families, families are grouped within orders, and so on.

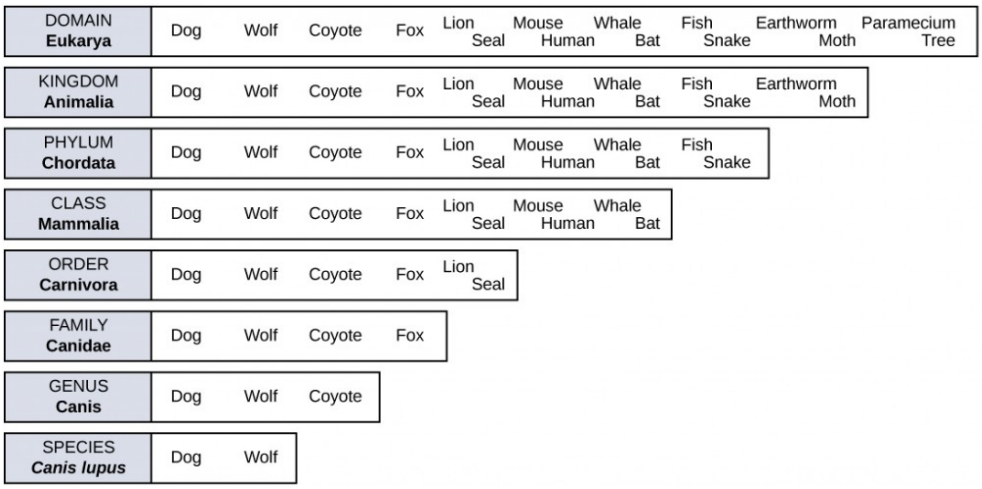


Figure 1.9 This diagram shows the levels of taxonomic hierarchy for a dog, from the broadest category—domain—to the most specific—species.

The highest level, domain, is a relatively new addition to the system since the 1990s. Scientists now recognize three domains of life, the Eukarya, the Archaea, and the Bacteria. The domain Eukarya contains organisms that have cells with nuclei. It includes the kingdoms of fungi, plants, animals, and several kingdoms of protists. The Archaea, are single-celled organisms without nuclei and include many extremophiles that live in harsh environments like hot springs. The Bacteria are another quite different group of single-celled organisms without nuclei. Both the Archaea and the Bacteria are prokaryotes, an informal name for cells without nuclei. The recognition in the 1990s that certain "bacteria," now known as the Archaea, were as different genetically and biochemically from other bacterial cells as they were from eukaryotes, motivated the recommendation to divide life into three domains. This dramatic change in our knowledge of the tree of life demonstrates that classifications are not permanent and will change when new information becomes available.

In addition to the hierarchical taxonomic system, Linnaeus was the first to name organisms using two unique names, now called the binomial naming system. Before Linnaeus, the use of common names to refer to organisms caused confusion because there were regional differences in these common names. Binomial names consist of the genus name (which is capitalized) and the species name (all lower-case). Both names are set in italics when they are printed. Every species is given a unique binomial which is recognized the world over, so that a scientist in any location can know which organism is being referred to. For example, the North American blue jay is known uniquely as *Cyanocitta cristata*. Our own species is *Homo sapiens*.


Figure 1.10 These images represent different domains. The scanning electron micrograph shows (a) bacterial cells belong to the domain Bacteria, while the (b) extremophiles, seen all together as colored mats in

this hot spring, belong to domain Archaea. Both the (c) sunflower and (d) lion are part of domain Eukarya.

## Evolution in Action

### Carl Woese and the Phylogenetic Tree

The evolutionary relationships of various life forms on Earth can be summarized in a phylogenetic tree. A phylogenetic tree is a diagram showing the evolutionary relationships among biological species based on similarities and differences in genetic or physical traits or both. A phylogenetic tree is composed of branch points, or nodes, and branches. The internal nodes represent ancestors and are points in evolution when, based on scientific evidence, an ancestor is thought to have diverged to form two new species. The length of each branch can be considered as estimates of relative time.

In the past, biologists grouped living organisms into five kingdoms: animals, plants, fungi, protists, and bacteria. The pioneering work of American microbiologist Carl Woese in the early 1970s has shown, however, that life on Earth has evolved along three lineages, now called domains—Bacteria, Archaea, and Eukarya. Woese proposed the domain as a new taxonomic level and Archaea as a new domain, to reflect the new phylogenetic tree. Many organisms belonging to the Archaea domain live under extreme conditions and are called extremophiles. To construct his tree, Woese used genetic relationships rather than similarities based on morphology (shape). Various genes were used in phylogenetic studies. Woese's tree was constructed from comparative sequencing of the genes that are universally distributed, found in some slightly altered form in every organism, conserved (meaning that these genes have remained only slightly changed throughout evolution), and of an appropriate length.

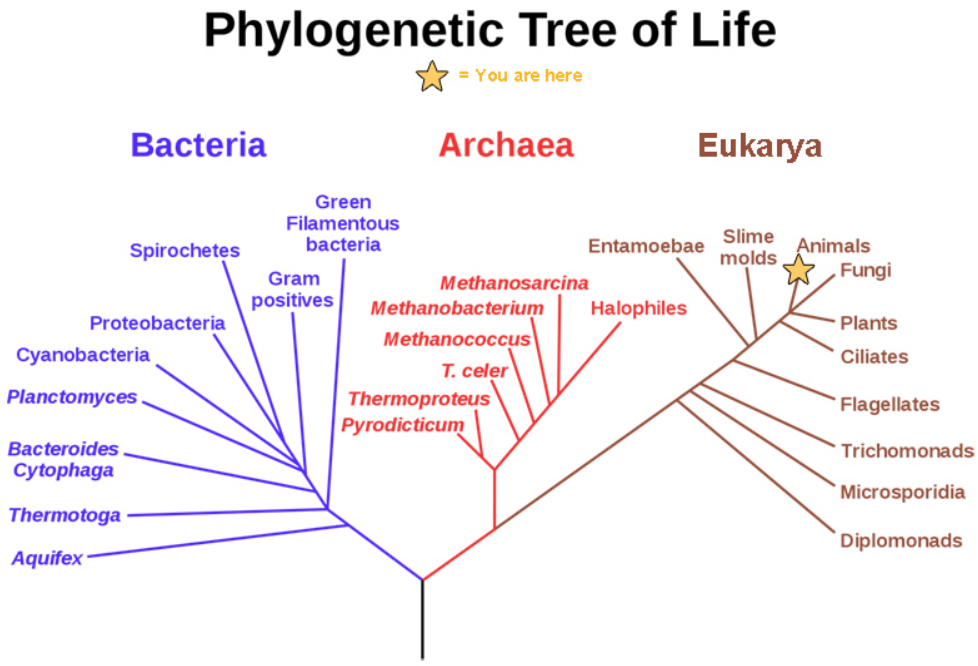


Figure 1.11 This phylogenetic tree was constructed by microbiologist Carl Woese using genetic relationships. The

tree shows the separation of living organisms into three domains: Bacteria, Archaea, and Eukarya. Bacteria and Archaea are organisms without a nucleus or other organelles surrounded by a membrane and, therefore, are prokaryotes.

## Outline

**Diversity of life: because of evolution**

A. Carl Linnaeus in C18
   1. proposed **hierarchical taxonomy** based on **form**

      a) Taxonomy has 8 levels – low to high = species > genus > family > order > class > phylum > kingdom > domain (see p. 2)
      b) 3 domains (highest level)
         i) Eukarya – cells with nuclei; Includes fungi, plants, animals, protists (?)
         ii) Archaea –or single-celled org. w/o nuclei, e.g. *extremophiles* living in difficult environment (*prokaryotes)*
         iii) Bacteria –**also** single-celled org. w/o nuclei (*prokaryote)*, **but** genetically & biochemically different
   2. Responsible for **binomial naming system**: Genus + species, e.g. Homo sapien

B. Carl Woese
   1. Phylogenetic Tree – diagram showing **evolutionary relationships** (see p. 4)

      a) Form – consists of branch points/nodes
         i) Internal nodes represent ancestors/ times when evidence suggests ancestor changed and formed new species
         ii) Length of branch = estimate of relative time
      b) Proposed main as 8$^{th}$ level and Archaea as new domain
      c) Used **genetic relationships** NOT similarities in form