BIO 101 COURSE GUIDE 1

INTRODUCTION TO BIOLOGY

Preamble:

Viewed from space, Earth offers no clues about the diversity of life forms that reside there. The first forms of life on Earth are thought to have been microorganisms such as Cyanobacteria that existed for billions of years in the ocean before plants and animals appeared. The mammals, birds, and flowers so familiar to us are all relatively recent, originating 130 to 200 million years ago. Humans have inhabited this planet for only the last 2.5 million years, and only in the last 200,000 years have humans started looking like we do today.

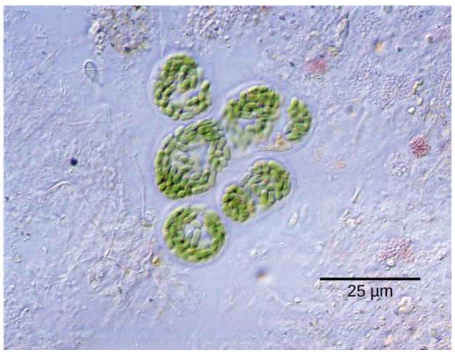

Figure 1: Cyanobacteria, shown here at 300x magnification under a light microscope, are some of Earth's oldest life forms.

BIOLOGY:

Biology is derived from two Greek words: Bios and Logos meaning Life and Study respectively. In other terms, **Biology** is the study of living organisms and their interactions with one another and their environments. This is a very broad definition because, the scope of biology is vast. Biologists may study anything from the microscopic structures such as bacteria or DNA or submicroscopic view of a cell to ecosystems and the whole living planet (**Figure 1**). Listening to the daily news, you will quickly realize how many aspects of biology are discussed every day. For example, recent news topics include a research that fathers can pass Mitochondrial DNA to children. Other subjects include efforts toward finding a cure for AIDS, Alzheimer's disease, and cancer. On a global scale, many researchers are committed to finding ways to protect the planet, solve environmental issues, and reduce the effects of climate change. All of these diverse endeavors are related to different facets of the discipline of **biology**.

Studying living things, called organisms, takes us all around the world, from the most productive tropical rain forests to the hostile lands of Antarctica or the deepest oceanic basins. Although our knowledge of the world around us is constantly changing, there are a few basic principles of biology that should hopefully remain useful for many years to come. Most biological study is built on the foundations of five universally recognized truths. These are:

1. **Cells** are the basic unit of life.
2. **Genes** are the basic units for passing traits from parent to offspring.
3. **Evolution** by natural selection is the process that has led to the great diversity of species on Earth.
4. **Living things** maintain the environment within their cells and bodies.
5. **Living things** have the ability to acquire and transform energy.

As you can imagine and may very well know, biology is a massive field of study. It is constantly developing as biologists around the world are completing research and taking our understanding of life to new levels. Every minute, new research are published in different fields of biology and it is near on impossible for one person to keep up-to-date with every topic related to biology. However, everyone has to start somewhere and studying biology can enlighten your understanding of the world around you. Biology in the 21st century has moved from just studying it but applying its knowledge in solving various problems. Therefore it is important to train the future biologist how researches are conducted in this field to equip them for future discoveries.

Scientific Methods:

Biology is a science, but what exactly is science? **Science** (from the Latin *scientia*, meaning "knowledge") can be defined as knowledge that covers general truths or the operation of general laws, especially when acquired and tested by the scientific method. It becomes clear from this definition that the application of the scientific method plays a major role in science. The **scientific method** is a method of research with defined steps that include experiments and careful observation. Biologists study the living world by posing questions about it and seeking science-based responses. This approach is common to other sciences as well and is often referred to as the scientific method. The scientific method was used even in ancient times, but it was first documented by England's **Sir Francis Bacon (1561–1626)** (**Figure 2**), who set up inductive methods for scientific inquiry. The scientific method is not exclusively used by biologists but can be applied to almost all fields of study as a logical, rational problem-solving method.

The scientific process typically starts as follows:

- **Observation** (often a problem to be solved). For ***Example***, "One Monday morning, a student arrives at class and quickly discovers that the classroom is too warm. That is an observation that also describes a problem: the classroom is too warm." That leads to
- **A question**: this deals with asking oneself why? It's a condition where one seeks answers to natural phenomenon identified. For ***Example***, The student then asks a question: "Why is the classroom so warm?"
- **Proposing a Hypothesis:** Recall that a hypothesis is a suggested explanation that can be tested. To solve a problem, several hypotheses may be proposed. For example, one hypothesis might be, "The classroom is warm because no one turned on the air conditioning." But there could be other responses to the question, and therefore other hypotheses may be proposed. A second hypothesis might be, "The classroom is warm because there is a power failure, and so the air conditioning doesn't work." Once a hypothesis has been selected, the student can make a prediction. A prediction is similar to a hypothesis but it typically has the format "If . . . then . . . ." For ***Example***, the prediction for the first hypothesis might be, "*If* the student turns on the air conditioning, *then* the classroom will no longer be too warm."
- **Testing a Hypothesis:** A valid hypothesis must be testable. It should also be **falsifiable**, meaning that it can be disproven by experimental results. Importantly, science does not claim to "prove" anything because scientific understandings are always subject to modification with further information.

A researcher can conduct one or more experiments designed to eliminate one or more of the hypotheses. Each experiment will have one or more variables and one or more controls. A **variable** is any part of the experiment that can vary or change during the experiment. The **control group** contains the way the situation is under normal condition. Therefore, if the results of the experimental group differ from the control group, the difference must be due to the hypothesized manipulation, rather than some outside factor.

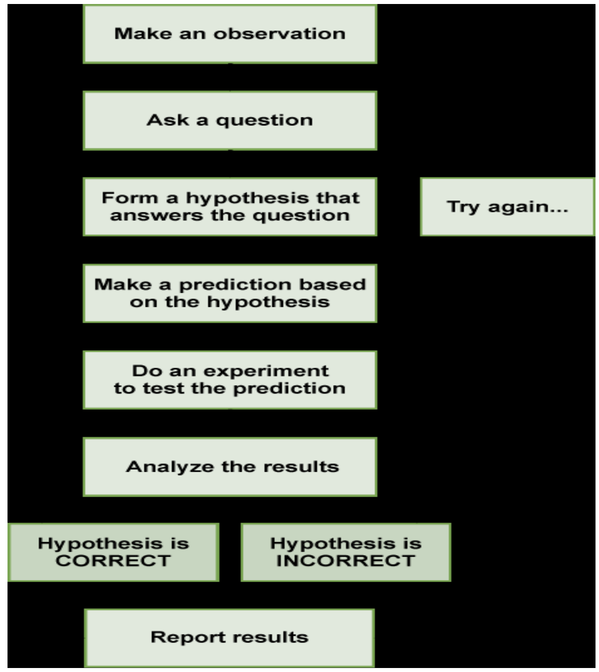

Figure 2 **Figure 3**

Figure 2: Sir Francis Bacon (1561–1626) is credited with being the first to define the scientific method. (credit: Paul van Somer).
Figure 3: The scientific method hierarch.

LIFE:

Life is a phenomenon existing (as far as we know) only on Earth. 'Life' is the title given to separate the things that are able to function by themselves from material objects such as rocks and water. All of the living things on Earth are collectively known as organisms. There are a range of functions that are essential for something to be considered an organism. These include movement, respiration, sensitivity, growth, reproduction, the release of wastes and the consumption of food. Life has evolved into an incredible array of shapes and forms. Humans belong to the most advanced group of organisms, the animals. Other higher-level organisms include plants and fungi. More primitive life forms include microscopic groups such as bacteria and archaea. Viruses are an unusual group because they are unable to reproduce without the use of a host cell. As such, viruses are classed by some biologists to be living and by others to be not.


Figure 4 and 5: To depict Life.

CELLS:

All living things are built from microscopic structures called cells. One cell has the potential to sustain life and is the simplest structure capable of doing so. Although life evolved into multi-cellular organisms a long time ago, the majority of life on Earth still remains as single-celled organisms. Bacteria, archaea, protists, and many fungi have only one cell and are able to survive and reproduce in a huge array of ways that puts plants and animals to shame.

Cells are typically divided into two main categories: **prokaryotic cells** and **eukaryotic cells**. **Prokaryotic cells** are found only in microscopic organisms such as **bacteria** and **archaea**. Eukaryotic cells are found in more advanced organisms such as **animals, plants,** and **fungi.**

The main difference between the two types of cells is that eukaryotic cells have a **nucleus which contains the cell's DNA** and has specialized structures called organelles. Organelles perform specific functions such as photosynthesis and protein production. In prokaryotic cells, the **DNA isn't encapsulated within a nucleus and organelles are missing**. The cells from one organism to the next always varies but they do often have many similarities. Almost all cells contain DNA, are surrounded by a membrane, and perform similar functions such as respiration and the production of proteins.

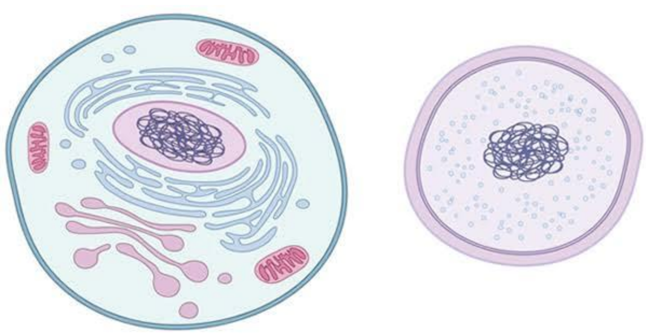

Figure 6: Cell Structure.

GENES:

Genes are the basic unit for heredity. They contain all the information required to keep an organism alive. When organisms reproduce, the information from genes is passed from parent to offspring. The genes that are passed from parent to offspring then provide the information to cells to keep the new organism alive. Genes are the reason why children look similar to their parents.

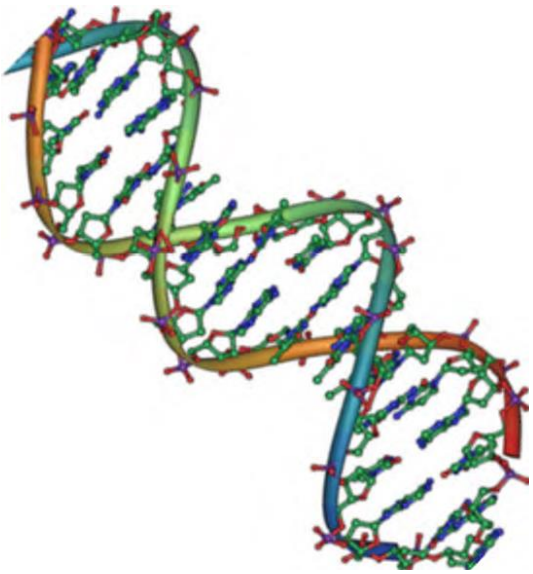

Figure 7: Native DNA

EVOLUTION:

The theory of evolution by natural selection gives by far the best explanation for the huge diversity of species on Earth. The process of natural selection has been sculpting life for over 4 billion years and is the cornerstone of modern biology. The natural selection of useful traits from generation to generation drives the evolution of species over long periods of time. With the help of genetic mutations, evolution has driven the development of life, capable of thriving in almost any environment on Earth. The process of evolution is visible in all aspects of life. Obvious similarities in structure and function of different species are hard to ignore and the collection of evidence supporting the theory of evolution has become undeniable.

HOMEOSTASIS:

Homeostasis is the act of maintaining a relatively constant internal environment within an organism’s cells. Cells function most efficiently in a certain range of conditions and as the environment changes around them, they constantly work to keep their internal environment in an optimal condition. Cells are working to maintain factors such as the concentrations of water, salt and sugar, the temperature within the cell, and oxygen concentrations.

FIELDS OF BIOLOGY:

There is a huge array of sub-disciplines or branches of biology; all up more than 60. Many have been around for hundreds of years, whilst others are far newer and are often developing very rapidly. Fields of study such as evolution, ecology, and genetics are themselves very broad topics and contain many specializations within each field. For example, an ecologist, who looks at how organisms interact with each other and the environment, might specialize in marine ecology, population ecology, plant ecology or freshwater ecology. As biology is such a broad field of study, the work from one biologist to another may be completely different. An agriculturalist for example, who is interested in the production of crops, will focus on very different content to that of an ethologist, who studies the behaviour of animals. In order to be a well-rounded biologist, however, it is good to have an understanding of the basics of the broad fields within biology.