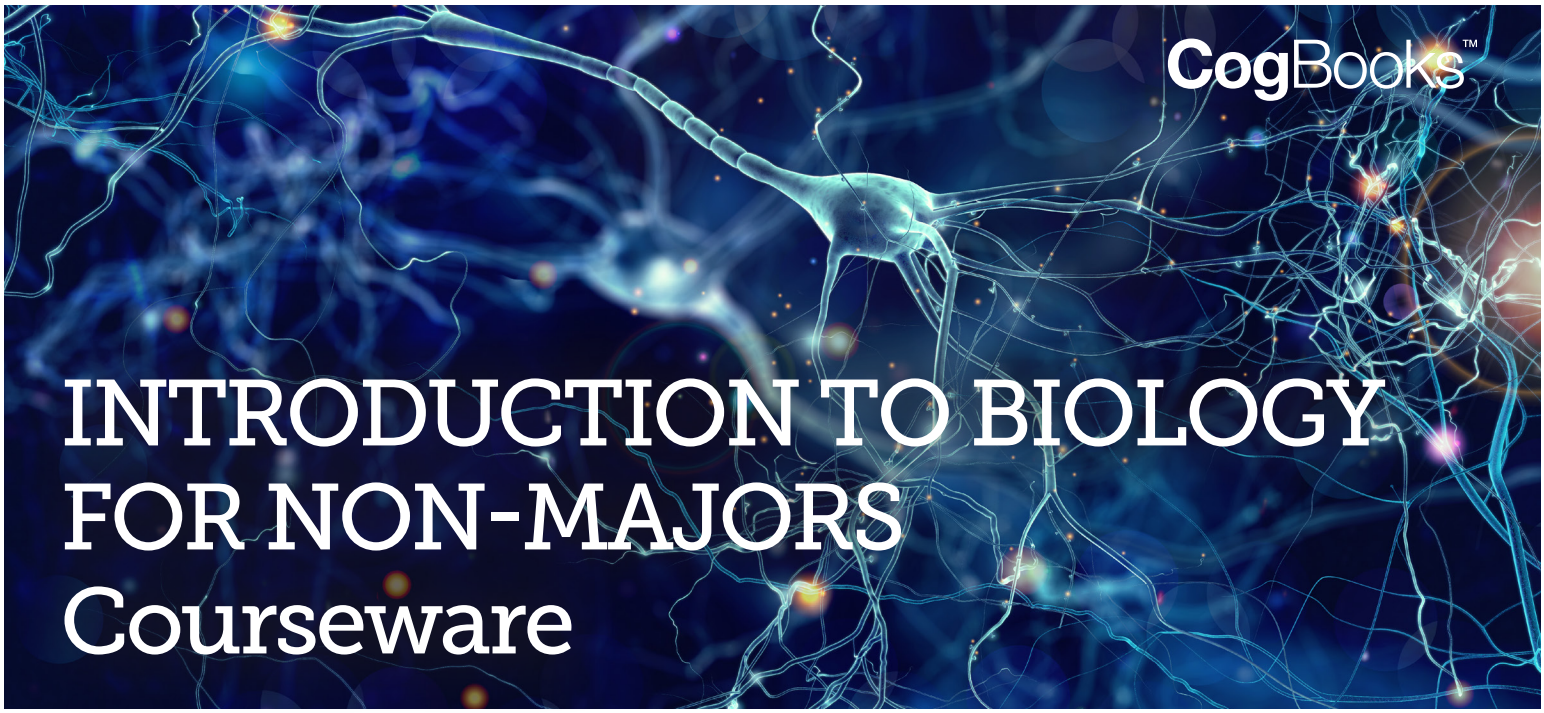

INTRODUCTION TO BIOLOGY FOR NON-MAJORS Courseware

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MODULE 1

OVERVIEW

Biology, the study of life, is a science that gathers knowledge about the natural world. The study and practice of biology is grounded in evolution and the scientific process as well as the everyday applications of these concepts.

1.1 Overview of Biology
The first forms of life on Earth are thought to have been microorganisms that existed for billions of years 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.

1.2 Scientific Method
The methods of science include careful observation, record keeping, logical and mathematical reasoning, experimentation, and submitting conclusions to the scrutiny of others. Science also requires considerable imagination and creativity; a well-designed experiment is commonly described as elegant, or beautiful.

MODULE 2

CHEMISTRY OF LIFE

The elements - carbon, hydrogen, nitrogen, oxygen, sulfur, and phosphorus - are the key building blocks of the chemicals found in living things. They form the carbohydrates, nucleic acids, proteins, and lipids that are the fundamental molecular components of all organisms.

2.1 The Building Blocks of Molecules
What specific types of biological macromolecules do living things require? How are these molecules formed? What functions do they serve?

2.2 Water
Water is one of the most abundant molecules in living cells and most critical to life. Approximately, 60–70% of our body is made up of water. Life would not exist without water.

2.3 Biological Molecules
Biological macromolecules are organic - they contain carbon. In addition, they may contain hydrogen, oxygen, nitrogen, phosphorus, or sulfur. There are four major classes of biological macromolecules: carbohydrates, lipids, proteins, and nucleic acids.

MODULE 3

CELLULAR BIOLOGY

Cells, the building blocks of your body and all other living things on earth, play a vital role during the growth, development, and day-to-day maintenance of an organism. In spite of their enormous variety, however, all cells share certain fundamental characteristics, such as, for example, the ability to use chemical energy.

3.1 Cells
The human body is constructed from many cell types. Life begins for multicellular organism as a fertilized egg, or zygote. Trillions of cell divisions subsequently occur in a controlled manner to produce a complex, multicellular human. All multicellular organisms use cell division for growth, and in most cases, the maintenance and repair of cells and tissues.

3.2 Energy
Virtually every task performed by living organisms requires energy. Nutrients and other molecules must be imported, metabolized (broken down) and possibly synthesized into new molecules, modified if needed, and distributed to the entire organism. All of this requires a steady supply of energy.

3.3 Photosynthesis
The process of photosynthesis is essential to most life on earth. Through photosynthesis, certain organisms convert solar energy (sunlight) into chemical energy, which is then used to build carbohydrate molecules. The energy enters the ecosystems of our planet continuously and is transferred from one organism to another.

3.4 Carbon Cycle
Energy flows directionally through ecosystems, entering as sunlight and leaving as heat during the transfers between trophic levels. The matter that makes up living organisms is conserved and recycled. The six most common elements associated with organic molecules--carbon, nitrogen, hydrogen, oxygen, phosphorus, and sulfur--take a variety of chemical forms and may exist for long periods in the atmosphere, on land, in water, or beneath Earth's surface. Geologic processes, such as weathering, erosion, water drainage, and the subduction of the continental plates, all play a role in the cycling of elements on Earth.

MODULE 4

GENETICS AND EVOLUTION

From the foundations of cellular reproduction to the experiments that revealed the basis of genetics and laws of inheritance. In addition, the core concepts of evolution are discussed with examples illustrating evolutionary processes.

4.1 Mendelian Genetics
Genetics is the study of heredity. Johann Gregor Mendel set the framework long before chromosomes or genes had been identified, at a time when meiosis was not well understood. Mendel selected a simple biological system and conducted methodical, quantitative analyses using large sample sizes.

4.2 DNA
DNA is the genetic material passed from parent to offspring for all life on Earth. With the exception of identical twins, each person's DNA is unique and it is possible to detect differences between human beings on the basis of their unique DNA sequence. DNA analysis has many practical applications: tracing genealogy, identifying pathogens, new vaccine development, and cancer therapy – among others. It is now possible to determine predisposition to many diseases by analyzing genes.

4.3 Evolution
All species of living organisms—from the bacteria on our skin, to the trees in our yards, to the birds outside—evolved at some point from a different species. Evolution is the process through which the characteristics of species change and through which new species arise.

4.4 New Species
Although all life on earth shares various genetic similarities, only certain organisms combine genetic information by sexual reproduction and have offspring that can then successfully reproduce. Scientists call such organisms members of the same biological species.

4.5 Behavior
Behaviors are responses to stimuli. They can either be instinctual/innate behaviors, which are not influenced by the environment, or learned behaviors, which are influenced by environmental changes.

4.6 Mating Systems
Not all animals reproduce sexually, but many that do have the same challenge: they need to find a suitable mate and often have to compete with other individuals to obtain one.

ISBN: 978-1-913014-11-7

MODULE 5

EVOLUTIONARY PROCESSES

The theory of evolution is the unifying theory of biology, meaning it is the framework within which biologists ask questions about the living world. Its power is that it provides direction for predictions about living things that are borne out in experiment after experiment.

5.1 Evolution of Populations
All life on Earth is related. Evolutionary theory states that humans, beetles, plants, and bacteria all share a common ancestor, but that millions of years of evolution have shaped each of these organisms into the forms seen today.

Natural selection acts to promote traits and behaviors that increase an organism's chances of survival and reproduction, while eliminating those traits and behaviors that are to the organism's detriment.

5.2 Phylogenies and the History of Life
A phylogeny describes the relationships of an organism, such as from which organisms it is thought to have evolved, to which species it is most closely related, and so forth. Phylogenetic relationships provide information on shared ancestry but not necessarily on how organisms are similar or different.

MODULE 6

BIOLOGICAL DIVERSITY

Biodiversity refers to the variety and variability of life on Earth. It typically measures variation at the genetic, the species, and the ecosystem level with a focus on taxonomic, ecological, morphological, and functional diversity.

6.1 Viruses
Viruses are diverse entities. They vary in their structure, their replication methods, and in their target hosts. While most biological diversity can be understood through evolutionary history, much about virus origins and evolution remains unknown.

6.2 Prokaryotes: Archaea & Bacteria
Scientists grouped living things into five kingdoms—animals, plants, fungi, protists, and prokaryotes—based on several criteria. Some proposed that all life on Earth evolved along three lineages, called domains—Bacteria, Archaea, and Eukarya. Two of the three domains—Bacteria and Archaea—are prokaryotic. Prokaryotes were the first inhabitants on Earth, appearing 3.5 to 3.8 billion years ago.

6.3 Protists
Protist is a diverse group of eukaryotes. Most protists are microscopic, unicellular organisms that are abundant in soil, freshwater, brackish, and marine environments. They are also common in the digestive tracts of animals and in the vascular tissues of plants.

6.4 Fungi
The kingdom Fungi includes an enormous variety of living organisms collectively referred to as Eucomycota, or true Fungi. Fungi have many commercial applications. The food industry uses yeasts in baking, brewing, and cheese and wine making. Many industrial compounds are byproducts of fungal fermentation. Fungi are the source of many commercial enzymes and antibiotics.

6.5 Plant Diversity
There are more than 300,000 species of catalogued plants. The first plants to colonize land were most likely closely related to modern day mosses (bryophytes) and are thought to have appeared about 500 million years ago.

6.6 Animal Diversity
Animal evolution began in the ocean over 600 million years ago. The animal classification system characterizes animals based on their anatomy, morphology, evolutionary history, features of embryological development, and genetic makeup.

6.7 Invertebrates
Invertebrate animals are those without a cranium and defined vertebral column or spine. In addition, most invertebrates also lack an endoskeleton. Invertebrates, a large number of which are aquatic, form nearly 97 percent of the animal kingdom.

6.8 Vertebrates
Vertebrates are among the most recognizable organisms of the animal kingdom. More than 62,000 vertebrate species have been identified. The vertebrate species now living represent only a small portion of the vertebrates that have existed. The best-known extinct vertebrates are the dinosaurs.

ISBN: 978-1-913014-11-7

MODULE 7

PLANT STRUCTURE AND FUNCTION

Plants are as essential to human existence as land, water, and air. From providing oxygen, food, and shelter to serving as a source of medicines, oils, perfumes, and industrial products, plants provide humans with numerous valuable resources.

7.1 Plant Form and Physiology
Plants have tissues that conduct food and water, and they have seeds. Seed plants are divided into gymnosperms and angiosperms.

7.2 Soil and Plant Nutrition
In order to grow and develop into mature, fruit-bearing plants, many requirements must be met and events must be coordinated. Seeds must germinate under the right conditions in the soil; therefore, temperature, moisture, and soil quality are key factors that play a role in germination and seedling development. Soil quality and climate are significant to plant distribution and growth.

7.3 Plant Reproduction
Plants have evolved different reproductive strategies for the continuation of their species. Some plants reproduce sexually, and others asexually. Plant sexual reproduction usually depends on pollinating agents, while asexual reproduction is independent of these agents.

MODULE 8

HUMAN BODY

The understanding of anatomy and physiology – from body tissue to key body systems - is fundamental and can serve you well in many aspects of your life as well as benefit your health.

8.1 Homeostasis
Homeostasis refers to the relatively stable state inside the body of an animal. Animal organs and organ systems constantly adjust to internal and external changes in order to maintain this steady state.

8.2 Body Tissues
The different types of cells are not randomly distributed throughout the body; rather they occur in organized layers, a level of organization referred to as tissue. The variety in shape reflects the many different roles that cells fulfill in your body.

8.3 Digestion and Nutrition
The ability to digest food is essential to an organism's survival. Humans have a highly specialized digestive system which allows selective absorption of a wide range of nutrients. The body utilizes these nutrients to produce energy. Excess and waste materials are excreted.

8.4 Respiratory System
Animals are complex multicellular organisms that require a mechanism for transporting nutrients throughout their bodies and removing wastes. The human circulatory system has a complex network of blood vessels that reach all parts of the body. This extensive network supplies the cells, tissues, and organs with oxygen and nutrients, and removes carbon dioxide and waste compounds.

8.5 Circulatory System
The mammalian circulatory system is a closed system with double circulation passing through the lungs and the body. It consists of a network of vessels containing blood that circulates because of pressure differences generated by the heart.

8.6 Immune System
Organisms have a wide array of adaptations for preventing attacks of parasites and diseases. The vertebrate defense systems, including those of humans, are complex and multilayered, with defenses unique to vertebrates. These unique vertebrate defenses interact with other defense systems inherited from ancestral lineages, and include complex and specific pathogen recognition and memory mechanisms.

8.7 Musculoskeletal and Nervous Systems
The muscular and skeletal systems provide support to the body and allow for movement. The central nervous system and associated nerve cells transmit electrochemical signals to and from the musculoskeletal system. These signals initiate a broad range of responses, including movement.

8.8 Endocrine System
The endocrine system produces hormones that function to control and regulate many different body processes. The endocrine system coordinates with the nervous system.

8.9 Reproductive System
In the animal kingdom, each species has its unique adaptations for reproduction. Humans reproduce by sexual reproduction. A male sperm combines with a female egg to form genetically unique offspring. Male and female anatomies are adapted to produce sperm or egg respectively. Sperm and egg maturation is tightly regulated by hormonal signals.

8.10 Osmotic Regulation and Excretion
The daily intake recommendation for human water consumption is eight to ten glasses of water. In order to achieve a healthy balance, the human body should excrete the eight to ten glasses of water every day. This occurs via the processes of urination, defecation, sweating and, to a small extent, respiration.

ISBN: 978-1-913014-11-7

MODULE 9

ECOLOGY

Ecology is the study of how organisms relate to each other and their physical surroundings. Across the globe different biomes exist that support different communities of life. Communities include all the different species living in a given area. The variety of these species is referred to as biodiversity. Organisms within a community coexist in a variety of ways, displaying competition, mutualism, predation, as well as parasitism. All organisms will either be a decomposer, producer, or consumer, and all trophic levels are important for a healthy ecosystem. The biggest impact people are having is through land use change and the altering of the global climate.

9.1 Introduction to Ecology
The number of species occupying the same habitat and their relative abundance is known as the diversity of the community. Scientists study ecology at the community level to understand how species interact with each other and compete for the same resources.

9.2 World Biomes
Many abiotic forces influence where life can exist and the types of organisms found in different parts of the world. These abiotic factors influence the distribution of biomes: large areas of land with similar climate, flora, and fauna.

9.3 Weather and Climate
Weather refers to the conditions of the atmosphere during a short period of time. Weather forecasts are usually made for 48-hour cycles. Long-range weather forecasts are available but can be unreliable. In contrast, climate refers to the long-term, predictable atmospheric conditions of a specific area. Climate can be considered “average” weather.

9.4 Climate Change
Global climate change is the term used to describe altered global weather patterns, including a worldwide increase in temperature, due largely to rising levels of atmospheric carbon dioxide.

9.5 Conservation
The current high rates of species extinctions will cause a precipitous decline in the biodiversity of the planet in the next century or two. The losses will include many species we know today.

ISBN: 978-1-913014-11-7