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# General Biology For Majors I Courseware

## MODULE 1

### THE CHEMISTRY OF LIFE

Learn about the importance of chemistry to biology: from the basics of atoms and chemical bonds to how proteins are assembled and how enzymes function.

**1.1 The Origins of Life**
How did the first life arise on our planet? What is the role of basic biological building blocks, including amino acids, lipids, and nucleic acids?

**1.2 The Chemistry of Life: Building Blocks of Molecules**
What specific types of biological macromolecules do living things require? How are these molecules formed? What functions do they serve?

**1.3** The Chemistry of Life: 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 it.

**1.4 The Chemistry of Life: 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.

**1.5 Macromolecules and Protein Structure and Function**
Learn about the chemical structure of some essential biomolecules: lipids, amino acids, nucleic acids and proteins.

**1.6 Chemical Energy: Reaction Energetics and Enzymes**
Chemical reactions drive the processes of life: from photosynthesis to respiration. Find out about the chemical reaction energetics and the functions of enzymes to facilitate these reactions.

## MODULE 2

### MEMBRANES AND CELLS

Learn about the essential building blocks of life in complex organisms: the different types of cells and their evolution, the structure and function of cells (including membranes and organelles), and how cells talk to one another.

**2.1 Cell Types and the Evolution of the Cell**
Cells come in many forms: from bacteria to animals and plants. What is the relation between cell diversity and evolution? What role did that symbiosis play in creating our own eukaryotic cells?

**2.2 Cell Structure and Function**
At its most basic, the membrane protects the interior of the cell from the outside environment. But membranes do so much more than that.

**2.3 Cell Division**
How does a cell go about dividing? Learn about the important processes of mitosis and meiosis.

**2.4 Cell to Cell Communication**
Cells always exist in a particular environment and their behavior is often strongly influenced by this environment. The ability of cells to sense and respond to this environment is critical for survival.

## MODULE 3

### GENERATING, STORING, AND USING CHEMICAL ENERGY

Learn how cells store and utilize energy: from photosynthesis to cellular respiration.

**3.1 Cellular Respiration**
How do cells produce ATP (the universal energy currency) from simple sugars or other nutrients? Learn about cellular respiration: from glycolysis to the electron transport chain.

**3.2 Photosynthesis**
The process of photosynthesis is essential to most life on earth. How do plants take the energy from photons (from the sun) and convert carbon dioxide into sugars and other carbohydrates?

## MODULE 4

### DNA STRUCTURE AND FUNCTION, REPLICATION, TRANSCRIPTION, AND TRANSLATION

Learn about the flow of genetic information: from DNA to RNA to proteins and beyond. How is our genetic information stored, retrieved, and ultimately expressed in the molecular machines (proteins) that make us who we are?

**4.1 DNA Structure and Replication**
How is hereditary information stored in our cells? Learn about DNA, its structure, function, and replication.

**4.2 Gene Mutations**
Find out about different types of mutations and the mechanisms of repair.

**4.3 Transcription**
How does the information of genes come to be expressed as proteins? Learn about the first step of this process - the transcribing of DNA in messenger RNA.

**4.4 Translation**
How does the information of genes come to be expressed as proteins? Learn about the final step of this process - the translating of messenger RNA into chains of amino acids, the building blocks of proteins.



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## MODULE 5

### GENE REGULATION

Explore regulation of gene expression. How do our bodies (in creatures from bacteria to elephants) know which genes to express at a given time and place? This fundamental question relates to every aspect of life – and determines what we look like and how our bodies function.

**5.1 Gene Regulation in Prokaryotes**
How do organisms like you and me control the expression of our genes? It turns out that we can learn a lot from how bacteria regulate the expression of their genes to break down simple sugars.

**5.2 Gene Regulation in Eukaryotes**
Learn how eukaryotes control gene expression at multiple levels.

**5.3 Evolutionary Developmental Biology**
One of the big questions of biology (since before Darwin) has been development. How do organisms grow their bodies from a single cell into highly structured multicellular life?



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# General Biology For Majors II Courseware

## MODULE 1

### HOW BIOLOGISTS APPLY SCIENCE TO UNDERSTAND LIVING MATTER

Learn how biologists combine models and experiments to understand the diversity and function of life on Earth.

**1.1 Biology's Unifying Principle**
The theory of evolution provided insights that unified all areas of biology and explains the diversity of life.

**1.2 How Science Works**
Biologists combine models and experiments to understand how the living world works.

**1.3 Why Scientists Believe in Evolution**
Since Darwin proposed his theory of evolution, biologists have amassed enough information to remove all doubts.

**1.4 How We Know Earth is Warming**
Earth's climate has warmed progressively during the past century.

**1.5 How Darwinism Almost Went Extinct**
Toward the end of the 19th century, Darwin's theory of evolution was at odds with the leading theory of inheritance.

## MODULE 2

### WHY OFFSPRING (USUALLY) RESEMBLE THEIR PARENTS

Learn how the properties of organisms pass from parents to offspring in a way that sustains evolution by natural selection.

**2.1 How the Church Saved Darwin's Theory**
Gregor Mendel's discovered the rules of inheritance by experimenting with pea plants.

**2.2 How to Predict Phenotypes**
A Mendelian model of inheritance predicts the probability of offspring inheriting certain alleles.

**2.3:**
Most Traits Don't Follow Mendel's Model

Most traits vary continuously because phenotypes result from the cumulative effect of many genes.

**2.4 Where Alleles Come From**
A new allele arises when a cell copies its DNA imperfectly.

## MODULE 3

### HOW SPECIES EVOLVE

Learn how populations evolve by natural selection, genetic drift, and random mutation—processes that can even generate new species.

**3.1 How Nature Selects**
Natural selection can change the mean or variance of a trait depending on the environment.

**3.2 Why Sex Feels Good**
Sexual reproduction enables a species to adapt rapidly to a changing environment faster than asexual reproduction does.

**3.3 Evolution Doesn't Mean Progress**
In small populations, the frequency of an allele changes randomly through a process called genetic drift.

**3.4 Where Species Come From**
When a population becomes divided by a geographic barrier, natural selection or genetic drift can cause the subpopulations to form new species.

## MODULE 4

### HOW ORGANISMS SURVIVE AND REPRODUCE

Learn how organisms survive stress and find resources, which ultimately enables them to grow and reproduce.

**4.1 Every Organism Has a Niche**
Each species must remain within a certain range of environmental conditions to survive and reproduce.

**4.2 How Organisms Survive through Plasticity**
Organisms shift their phenotype over time to reduce negative effects of environmental stress.

**4.3 How Organisms Survive through Homeostasis**
Organisms exert energy to keep their internal conditions stable while environmental conditions change.

**4.4 How Organisms Find Resources**
Organisms behave in way that maximize the resources gained for the amount of time or energy invested in foraging.

**4.5 How Organisms Use Energy**
Organisms use the energy in food for maintain cells, fuel movement, grow tissues, and produce offspring.



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## MODULE 5

### HOW ORGANISMS INTERACT

Learn how interactions between organisms—such as competition, predation, and mutualism—influence the ecology and evolution of populations.

**5.1 How Populations Grow**
A population grows through birth, death, and migration—processes that depend on the density of individuals.

**5.2 How Competing Species Coexist**
Two species can coexist only when their niches differ sufficiently to enable each species to acquire sufficient resources.

**5.3 How Species Coevolve**
When species interact, adaptation of one species imposes a selective pressure on another species.

**5.4 How Interactions Shape Communities**
Each species has direct and indirect effects on other species in its community, resulting in complex responses when a species enters or leaves a community.

## MODULE 6

### HOW GLOBAL CHANGE SHAPES BIODIVERSITY

Learn how interactions between organisms and their environments generate patterns over vast regions, or even the entire planet.

**6.1 Why the Tropics Hold so Many Species**
The majority of species occur in the tropics possibly because the stable temperatures of the tropics promote speciation.

**6.2 How People Impacted the Carbon Cycle**
Human activities since the industrial revolution greatly disrupted the fluxes of carbon among soils, plants, the atmosphere, and the ocean.

**6.3 How will Species Respond to Climate Change?**
Depending on its niche, a species will either adapt, move, or go extinct as Earth's climate continues to change rapidly.

**6.4 Can we stop a Mass Extinction?**
Human nature potentially limits our ability to deal with the problem of climate change, and other problems caused by our growing consumption of resources.



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# General Biology For Majors – Additional Modules
(optional, additional content)

## MODULE 1

### HUMAN BODY

Start exploring anatomy and physiology – from body tissue to some key body systems. This understanding is fundamental and can serve you well in many aspects of your life and benefit your own health.

**1.1 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.

**1.2 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.

**1.3 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.

**1.4 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.

**1.5 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.

**1.6 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.

**1.7 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.

**1.8 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.

**1.9 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.

## MODULE 2

### GENETICS AND EVOLUTION

Why do organisms resemble their parents? How are these traits passed along between generations? How has our planet been populated by such diverse life forms? Learn how evolution through natural selection explains the origins of earth's biodiversity.

**2.1 Transmission Genetics**
Transmission genetics deals with the manner in which genetic differences among individuals are passed from generation to generation.

**2.2 Sex-linked Traits**
Why do organisms resemble their parents? How are these traits passed along between generations?

**2.3 Natural Selection and Evolution**
The discovery of Charles Darwin and Alfred Russell Wallace, the theory of evolution by natural selection, gives us a proven framework to understand the origins of biodiversity on earth, including our own origins.

**2.4 Evolution in Populations**
Explore how evolution can shape populations.

**2.5 The Tree of Life**
Learn about efforts to organize a 'tree' of life: the fields of taxonomy and phylogenetics.