

## Overview of Biology Including the Specific Sub-Groups of Molecular and Structural Biology

Purpose: To introduce students interested in the life sciences to certain fields of Biology

Goal: To develop a strong understanding of what each field of Biology is primarily focused on and what kinds of problems can be worked on with each field

In this first module, you will be asked to think critically about Biology as a whole and two specific fields of Biology, Structural and Molecular. A scientist always benefits from understanding which direction they should approach a problem from. You would not necessarily try to build a bookshelf by studying a cookbook. Similarly, we must know what fields are best suited to solve a problem. Having a solid foundational understanding of the various fields of Biology is invaluable when making such decisions. It is also important to understand how the different fields of Biology work in tandem with each other. Research is a collaborative activity and thus one field is almost never used exclusively to work through a research question. Throughout this module, we hope you will learn about each field individually and spend some time thinking about how they might interact with one another.

Biology is the study that helps us understand life. It encompasses virtually all of Earth's organisms, processes, and vitality, which allows for its unique interactions and complexity. It also aims to further our understanding of the role of the human condition in an ever-changing and increasingly bio-diverse world. However, there is more to biology than what meets the eye - in fact, most of biology's intricacies are not even visible to the naked eye. Molecular and Structural Biology are two vital subgroups of Biology that continue to be researched and explored today, from gene therapy to cancer treatments to protein folding. Over the course of this module, you will explore the intricacies of structural and molecular biology as well as how they are being applied in research to solve real world problems.

What is Biology?

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Why is Biology important?

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What is Biology useful for?

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Provide a specific example of a problem that Biology has helped to solve.

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Now that we have a general understanding of the general field of Biology, let us think a little bit more critically about its applications. We have a couple terms that help us to distinguish between different types of organisms. A majority of organisms may be classified as either **Eukaryotic** or **Prokaryotic**. Eukaryotes (like you and me) have the distinct feature of containing membrane-bound organelles, one of which is the mitochondria. The mitochondria is an incredibly unique organelle as it contains its own DNA deemed mitochondrial DNA. You might ask yourself “How did the mitochondria come to have its own DNA?”. Well, scientists in the 1900s had a similar question. The field of Biology helped them to work on this question.

What is a eukaryotic cell?

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What is a prokaryotic cell?

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What is one main difference between the two?

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What is the endosymbiotic theory?

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How is the endosymbiotic theory related to cellular evolution?

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How has the endosymbiotic theory affected our understanding of the past?

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We have learned a little bit about Biology as a whole and explored one problem which it helped to develop a better understanding of. Now, let us talk about a more specific field of Biology. Molecular Biology is a field of Biology which aims to better understand **cellular molecules**. Specifically, this field often looks at molecular composition, structure, and interactions with other molecules. Typically, cellular molecules studied are essential in one way or another to the survival of the cell. For example, we all contain a very special molecule in each of our cells called **Deoxyribonucleic acid**. With DNA being one of the most important biomolecules in biological systems, it would be important for us to know as much as we can about this molecule. Two scientists proposed a model for the structure of DNA in 1953. The information leading to this proposal heavily depended on the field of Molecular Biology.

What is Molecular Biology?

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Why is Molecular Biology important?

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What is Molecular Biology useful for?

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Provide a specific example of a problem that Molecular Biology has helped to solve.

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Who are the two scientists that proposed the structural model of DNA?

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What was the proposed structure of DNA?

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Did these two scientists discover this structure on their own? If not, provide at least two other scientists that were involved in this discovery.

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Let us dive a little deeper into the world of Molecular Biology. You may have heard of a relatively new genome editing tool known as CRISPR. This acronym stands for clustered regularly interspaced short palindromic repeats (a mouthful right?). Let us break this acronym down a bit. For “clustered”, we can think of a group of objects being clustered together or in close proximity to each other. For “regularly interspaced”, we can find this to mean something along the lines of often having space in between. Finally, “short palindromic repeats” describes to us repeated short segments of a nucleic acid sequence which can be read the same forward and backward (racecar is a famous palindromic sequence of letters!). So, in slightly simpler terms CRISPR sequences are small repetitive sequences which are in close proximity to each other and can be read the same forward and backward.

Provide an example of a palindromic sequence of nucleic acids.

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Where did CRISPR sequences originate from?

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Why do we commonly refer to the CRISPR/Cas system as our “molecular scissors”?

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What are the primary components of the CRISPR/Cas9 system?

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What components of the CRISPR/Cas9 system allows for proper recognition of genetic material?

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Now that we have learned a little about Molecular Biology and one of its interesting applications in real-world science, let us take one final look at the field of Biology under a microscope and learn about Structural Biology. Structural Biology is commonly concerned with the structure of biomolecules as well as the study of the **thermodynamics** of **macromolecules**. As you may have already learned, the structure of a protein tends to weigh heavily on the overall function it carries out. Therefore, for us to understand how certain molecules work it is important for us to have a solid understanding of their structure. For example, if we want to develop a new **antibody** to protect against a specific **antigen** we would benefit greatly from understanding the structure of the antigen to ensure our designed antibody is designed effectively.

What is the primary structure in regards to protein structure?

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What is the secondary structure in regards to protein structure?

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What is the tertiary structure in regards to protein structure?

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What is the quaternary structure in regards to protein structure?

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What is thermodynamics?

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What is a macromolecule?

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What is an antibody?

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What is an antigen?

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What is Structural Biology?

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Why is Structural Biology important?

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What is Structural Biology useful for?

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We now have a general understanding of the field of Structural Biology and it is now time for our final case-study where we will critically think on the implications of this field. One important component to the **central dogma** of Biology is the translation of **mRNA** into functional proteins through the activity of the **ribosome**. The Nobel Prize in Chemistry was awarded to three scientists in 2009 for their work on elucidating the ribosomal structure. Such discoveries have allowed us to have a much greater understanding of how protein translation is carried out and why defects in this process can have detrimental effects to an organism.

What is the central dogma of biology?

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What is mRNA?

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What is a ribosome?

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How many subunits is a ribosome composed of?

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Are all subunits of a ribosome catalytically active? If not, which is the catalytic subunit?

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Does the process of protein translation only depend on mRNA and ribosomes? If not, what other molecules are needed for proper translation?

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Describe the structural characteristics of the large ribosomal subunit.

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What is the process of protein translation beginning with mRNA?

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What is a ribozyme?

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What would be one result of a defective ribozyme?

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We here at MoleculeGo hope that you enjoyed learning about Biology and its applications. We also encourage you to take some time exploring other fields of Biology. Below you will find a list of the 25 major fields of Biology. Pick one that interests you and explore how it has helped us understand the world around us!

### 25 Major Fields of Biology

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|------------------|-------------------|---------------------|---------------|
| Anatomy          | Botany            | Taxonomy            | Zoology       |
| Microbiology     | Mycology          | Phycology           | Parasitology  |
| Virology         | Physiology        | Theoretical Biology | Cell Biology  |
| Genetics         | Ecology           | Evolution           | Biochemistry  |
| Biophysics       | Molecular Biology | Structural Biology  | Biotechnology |
| Plant Physiology | Immunology        | Marine Biology      | Photobiology  |
| Radiobiology     |                   |                     |               |