

## Introduction to Biochemistry

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**Biochemistry is the study of life from a chemical perspective and asks how living organisms arose from biomolecules that are lifeless. These biomolecules can be isolated from organisms and examined individually, and they conform to both the chemical and physical laws that govern inanimate matter. A biochemist studies the properties that organisms have that distinguish them from non-living matter.**



## Diversity and Spread of Life

Inside of any given living organism are **cells** that have a high degree of chemical complexity and microscopic organization. Their intricate internal structures have characteristic sequences of subunits, arranged to produce, for example, **proteins** with unique three-dimensional structures. Each of these unique proteins is highly specific for what types of molecules it will bind and interact with.

Living organisms also have systems for extracting **energy** from the environment, as well as transforming that energy into a usable form. They possess capabilities to replicate their genetic information and reproduce components of the cell, as well as the capacity to precisely regulate the interactions between those components.

This sophistication applies to the **macroscopic structure**, for example, the heart, but also applies to microscopic structures and individual chemical compounds throughout the

organism. The dynamic environments of both the organism and the world outside of it come into contact with each other inevitably. This requires cells, [tissues](#), organs, and organ systems to coordinate and compensate for changes in another. Possessing these abilities allows the whole organism to be greater than the sum of its individual parts.

On the **microscopic scale**, a biochemist sees a collection of molecules carrying out a program, whose result is both program reproduction as well as the self-perpetuation of that collection of individual molecules. In short, the biochemist sees life.

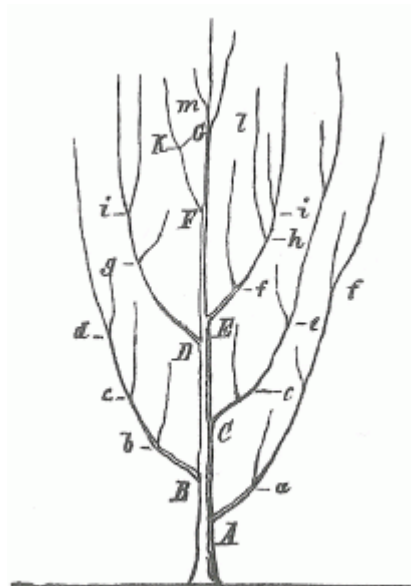


“System of Life. Relation” Image created by Lecturio

## History, Philosophical & Technological Improvement

Throughout history, organisms have changed their strategies to adapt to the changing circumstances on our planet. These changes have passed through [inheritance](#) over eons, and the result of this is the enormous diversity that has evolved. On the outside, a human being looks very different from a mushroom, but fundamentally they are both related to each other through their shared ancestry.

The human and the mushroom do not share every common property, but they do share a common **chemical framework**. This chemical framework is what evolves to allow different organisms to survive in a vast array of habitats, from inside animal intestines to thermal hot springs, from 5000 feet under the ocean surface to the coffee shop where you might be studying today.



Branching tree diagram from Heinrich Georg Bronn's work

Living known living organisms fall into one of the three large domains that define the “branches” of the so-called **evolutionary tree** that shows their course from a common progenitor. There are two groups of prokaryotes that can be distinguished for biochemistry reasons, the **archaebacteria and eubacteria**. Archaebacteria usually live

in extreme environments, whereas eubacteria such as *E. coli* live in the same environments as eukaryotes do.

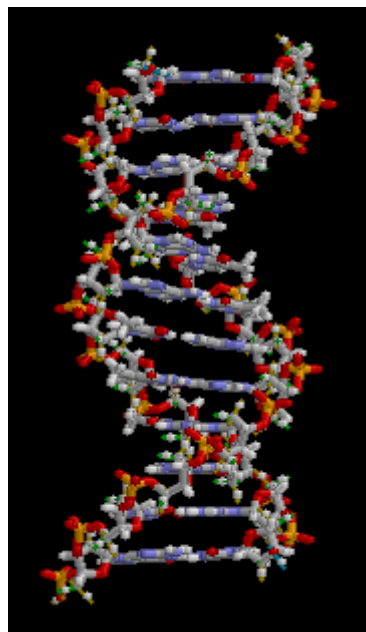
Biochemistry's philosophy and technology have both "Co-Evolved" throughout their course history. Scientists have been asking biochemistry-related questions for hundreds of years, with no definitive start date.

The French nobleman Antoine Lavoisier is known as the "Father of Modern Chemistry", but he began asking some of the first questions of biochemistry in his 1777 studies of how combustion is tied to respiration. Diastase (now called Amylase) was discovered by a French chemist named Anselme Payen in 1833, but most consider the birth of biochemistry as a field of study to have begun when a German chemist named Eduard Bucher described the process of **fermentation** in 1907.

The mid-20th century marked an explosion of technique development for the field of biochemistry, such as **chromatography, X-ray diffraction, NMR, radioisotope labeling, and electron microscopy**. These tools allowed scientists to analyze individual molecules and proteins and deduce metabolic pathways.

American biochemist Kary Mullis won the Nobel Prize in Chemistry (along with Canadian biochemist Michael Smith) for improving the technique of amplifying **DNA** through the **polymerase chain reaction (PCR)** first described by the 1968 Nobel laureate H. Gobind Khorana from India.

The philosophical views of biochemistry have also changed throughout history. The ideas leading to the hypothesis of **Vitalism** began in ancient Egypt, which states "living organisms are fundamentally different from non-living entities because they contain some non-physical element or are governed by different principles that are inanimate things." This idea was widely accepted by many, including Swedish chemist and physician Jöns Jacob Berzelius, who in the early 19th century discovered several of the elements on the periodic table.



Animation of a rotating DNA structure

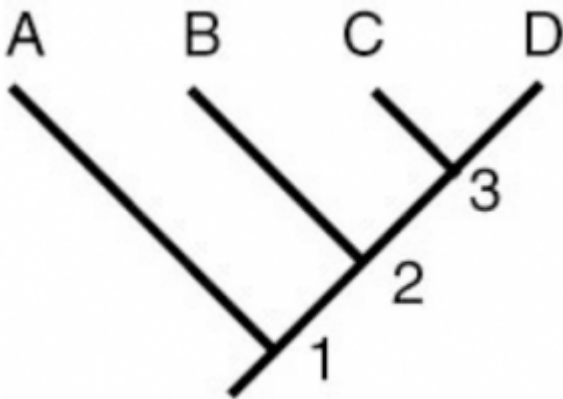
Ultimately Frederick Wöhler disproved this hypothesis by synthesizing urea, a constituent of urine, from ammonium and cyanate in the laboratory without the use of a cell. Philosophical views of biochemistry have co-evolved the development of technology, for

example, Frederick Miescher's isolation of DNA in the early 1900's.

The **Avery-Macleod-McCarty Experiment** demonstrated in 1944 that DNA is the substance that causes bacterial transformation, leading to the 1953 determination of DNA structure by Francis Watson and James Crick using X-Ray diffraction. This experimental evidence allowed for the development of the **Central Dogma of Molecular Biology** in the 1960's, which states that genetic information flows from DNA to RNA, and then to Protein.

## Review Questions

The answers are below the references.



**1. In the above cladogram, which node occurred earliest in time?**

- A. 1
- B. 2
- C. 3
- D. 4

**2. In the cladogram for question 1, which node represents the most recent common ancestor of terminal taxa B and C?**

- A. 1
- B. 2
- C. 3
- D. 4

**3. In the cladogram for question 1, which node represents the most recent common ancestor of terminal taxa A and B?**

- A. 1
- B. 2
- C. 3
- D. 4

## References

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**Correct answers:** 1A, 2B, 3A

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