CHAPTER 1
INTRODUCTION TO BIOCHEMISTRY

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1.1 WHAT IS BIOCHEMISTRY?

Biochemistry is a hybrid science: Biology is the science of living organisms and chemistry is the science of atoms and molecules, so biochemistry is the science of the atoms and molecules in living organisms. Its domain covers the entire living world with the unifying interest in the chemical structures and reactions that occur in living systems. It cuts across through the disciplines of science, medicine, and agriculture.

A distinction was made between inorganic and organic chemistry in the early nineteenth century, as chemistry became recognized as a scientific discipline. Organic compounds (those containing carbon and hydrogen) were thought to be made only in living systems. However, in 1828, Friedrich Wöhler in Germany heated an inorganic compound, ammonium carbamate, and made an organic compound, urea (**Figure 1.1**), found naturally in animal urine. Wöhler's experiment showed that the chemistries of the living and nonliving worlds are continuous.

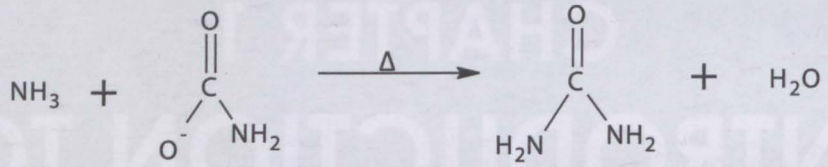

Figure 1.1: Wohler's reaction showing the conversion of ammonium carbamate to urea.

A parallel controversy arose at the end of the nineteenth century, as organic chemists debated whether an intact, living cell was needed to carry out biochemical reactions. Hans Büchner in Germany reproduced the synthesis of ethanol with a cell-free extract of brewer's yeast, showing that reactions of living systems can be reproduced *in vitro* (literally, in glass), that is, away from a living system. Reactions in living cells occur because they are catalyzed by enzymes — the very word *enzyme* is derived from the Greek word for yeast, *zymos*.

Biochemistry became a distinct science in the early twentieth century and present biochemistry can involves around various enzymatic activities of the biomolecules. **A biomolecule can be defined in simple terms as any molecule that is produced by a living organism**.

Biomolecules can include **large polymeric molecules** such as **proteins, polysaccharides, lipids, and nucleic acids.** A polymeric molecule is a relatively light and simple molecule made up from millions of repeated linked units of numerous natural and synthetic compounds of usually high molecular weight.

Biomolecules also include **small molecules** also termed as **biogenic substance**, such as primary metabolites, secondary metabolites, and natural products. **Metabolites** are the intermediates and products of metabolism. The term *metabolite* is usually restricted to small biomolecules.

A **primary metabolite** is directly involved in normal growth, development, and reproduction. Alcohol as an alternative energy source is an example of a primary metabolite produced in large-scale by industrial microbiology.

Secondary metabolites are organic compounds that are not directly involved in the normal growth, development, or reproduction of an organism. Secondary metabolites are often restricted to a narrow set of species within a **phylogenetic** [evolutionary related] group and often play an important role in **plant defence against pests and disease** and other interspecies defences. Humans use secondary metabolites as medicines, flavourings, and recreational drugs.

Natural products are **end products** of secondary metabolism. They are naturally occurring organic compounds often specific for particular organisms and maintain life by regulating biological reactions. Some examples are insect pheromones, plant phenolic compounds, medicines, scents, essential oils, antibiotics etc.

Modern biochemistry can be categorized into three main branches which are:

- **Metabolism** that is defined as the sum of all the biochemical reactions carried out by an organism. It involves primary metabolic pathways that converge into few end products and secondary metabolic pathways that diverge to many products. There are three potential pathways for primary metabolism: the Embden Meyerhof-Parnas Pathway (EMP –produces two molecules of pyruvate via trios-phosphate molecules and is common in plants, animals, fungi and bacteria), the Entner-Doudoroff pathway and the hexose monophosphate (HMP) pathway. Many microorganisms use this pathway mainly for glucose utilization. Yeasts produce alcohol during log phase using anaerobic primary pathway. Secondary metabolism [**anabolism**] synthesizes new compounds. Secondary metabolites are produced when the cell is not operating under optimal growth conditions, such as, depletion of a primary source nutrient. *Streptomyces griseus* and *Bacillus subtilis* through microbial fermentation can produce many different antibiotics that are of high economic importance in the bioprocess industry.