INTRODUCTION TO METABOLISM

Metabolism is a biochemical process that allows an organism to live, grow, reproduce, heal, and adapt to its environment. A **metabolic pathway** (or metabolic map) constitutes a series of enzymatic reactions to produce specific products. The term **metabolite** is applied to a substrate or an intermediate or a product in the metabolic reactions.

Types of metabolic reactions

The biochemical reactions are mainly of four types:-

1. Oxidation-reduction.

2. Group transfer.

3. Rearrangement and isomerization

4. Make and break of carbon-carbon bonds. These reactions are catalysed by specific enzymes—more than 2,000 known so far

Metabolism is broadly divided into two categories (Fig.1.1).

1. **Catabolism** : The **degradative processes** concerned with the breakdown of complex molecules to simpler ones, with a concomitant release of energy.

2. **Anabolism :** The **biosynthetic reactions** involving the formation of complex molecules from simple precursors.

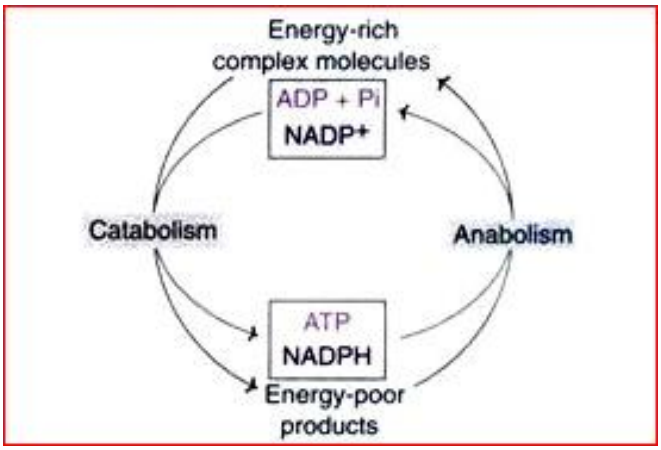
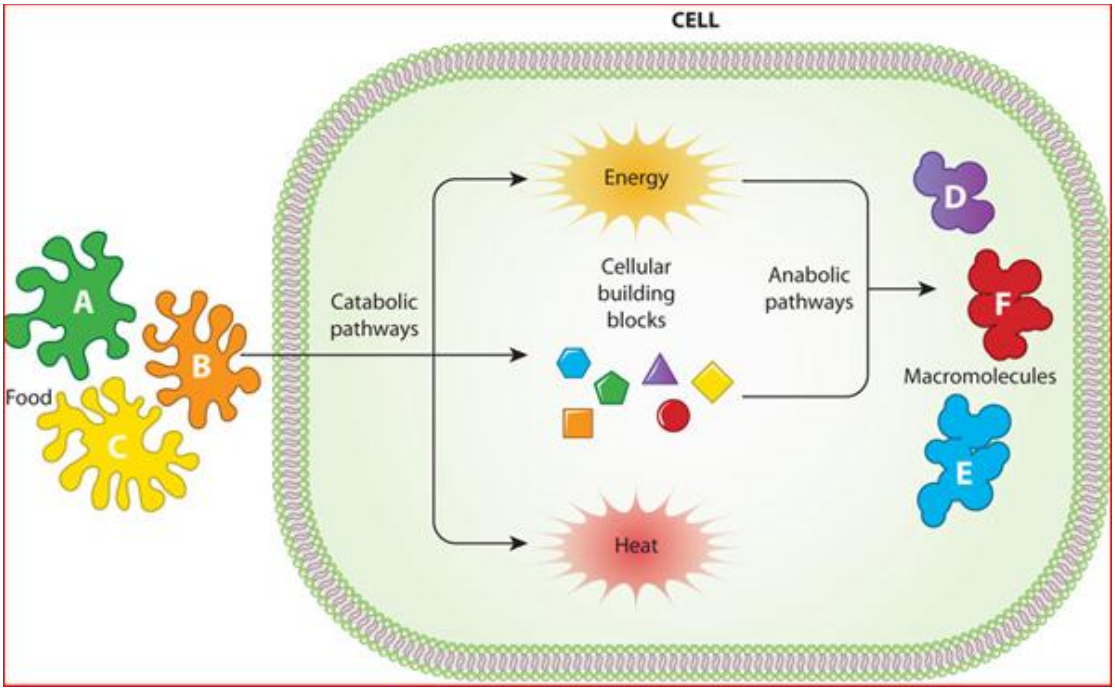


Fig. 1.1 : An outline of catabolism and anabolism



Catabolism

The very purpose of catabolism is to trap the energy of the biomolecules in the form of ATP and to generate the substances (precursors required for the synthesis of complex molecules.

Purpose	Breaking down complex molecules into simpler ones
Energetics	Releases energy when bonds are broken *(exergonic)*
Mechanism	Typically involves oxidation reactions
Examples	Glycolysis

Catabolism occurs in three stages (fig. 1.2)

1. Hydrolysis of complex molecules: In the first stage, complex molecules are broken down into their component building blocks. For example, proteins are degraded to amino acids, polysaccharides to monosaccharides, and fats (triacylglycerols) to free fatty acids and glycerol.

2. Conversion of building blocks to simple intermediates: In the second stage, these diverse building blocks are further degraded to acetyl coenzyme A (CoA) and a few other simple molecules. Some energy is captured as ATP, but the amount is small compared with the energy produced during the third stage of catabolism.

3. Oxidation of acetyl coenzyme A: The tricarboxylic acid (TCA) cycle is the final common pathway in the oxidation of fuel molecules that produce acetyl CoA. Oxidation of acetyl CoA generates large amounts of ATP via oxidative phosphorylation as electrons flow from NADH and flavin adenine dinucleotide (FADH2) to oxygen

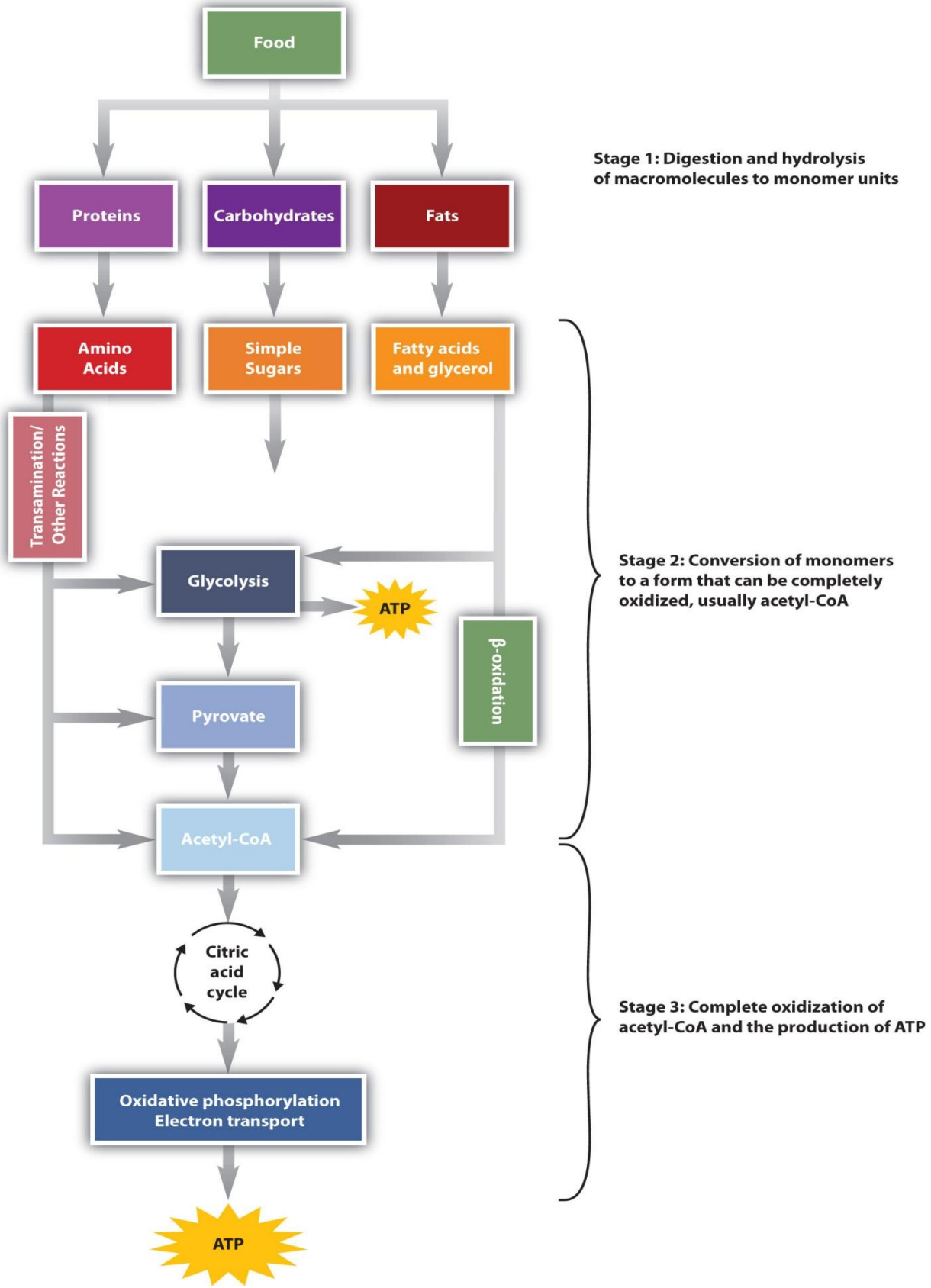

Food
Proteins
Carbohydrates
Fats
Amino Acids
Simple Sugars
Fatty acids and glycerol
Transamination/ Other Reactions
Glycolysis
ATP
β-oxidation
Pyrovate
Acetyl-CoA
Citric acid cycle
Oxidative phosphorylation Electron transport
ATP
Stage 1: Digestion and hydrolysis of macromolecules to monomer units
Stage 2: Conversion of monomers to a form that can be completely oxidized, usually acetyl-CoA
Stage 3: Complete oxidization of acetyl-CoA and the production of ATP

Fig. 1.2 : The three stages of catabolism (ETC–Electron transport chain)

Anabolic pathways

Anabolic reactions combine small molecules, such as amino acids, to form complex molecules such as proteins . Anabolic reactions require energy which is generally provided by the hydrolysis of ATP to adenosine diphosphate (ADP) and inorganic phosphate (Pi). Anabolic reactions often involve chemical reductions in which the reducing power is most frequently provided by the electron donor NADPH .

Purpose	Synthesizing complex molecules from simpler ones
Energetics	Uses energy to construct new bonds *(endergonic)*
Mechanism	Typically involves reduction reactions
Examples	Gluconeogenesis

Stages of anabolism

There are three basic stages of anabolism :-

1. Production of precursors such as amino acids, monosaccharides and nucleotides.
2. Use energy from ATP to turn the precursors into reactive form.
3. The assembly of these activated precursors into complex molecules such as proteins, polysaccharides, lipids and nucleic acids.

Comparison of catabolic and anabolic pathways

	Anabolism	Catabolism
Introduction	Metabolic process that builds molecules the body needs.	Metabolic process that breaks down large molecules into smaller molecules.
Energy	Requires energy	Releases energy
Hormones	Estrogen, testosterone, insulin, growth hormone.	Adrenaline, cortisol, glucagon, cytokines.
Effects on Exercise	Anabolic exercises, which are often anaerobic in nature, generally build muscle mass.	Catabolic exercises are usually aerobic and good at burning fat and calories.
Example	amino acids becoming polypeptides (proteins), glucose becoming glycogen, fatty acids becoming triglycerides.	proteins becoming amino acids, proteins becoming glucose, glycogen becoming glucose, or triglycerides becoming fatty acids.