# CHAPTER 4

## Cellular Metabolism and Metabolic Disorders

Set by Tewodros Kelemu and Baye Maru

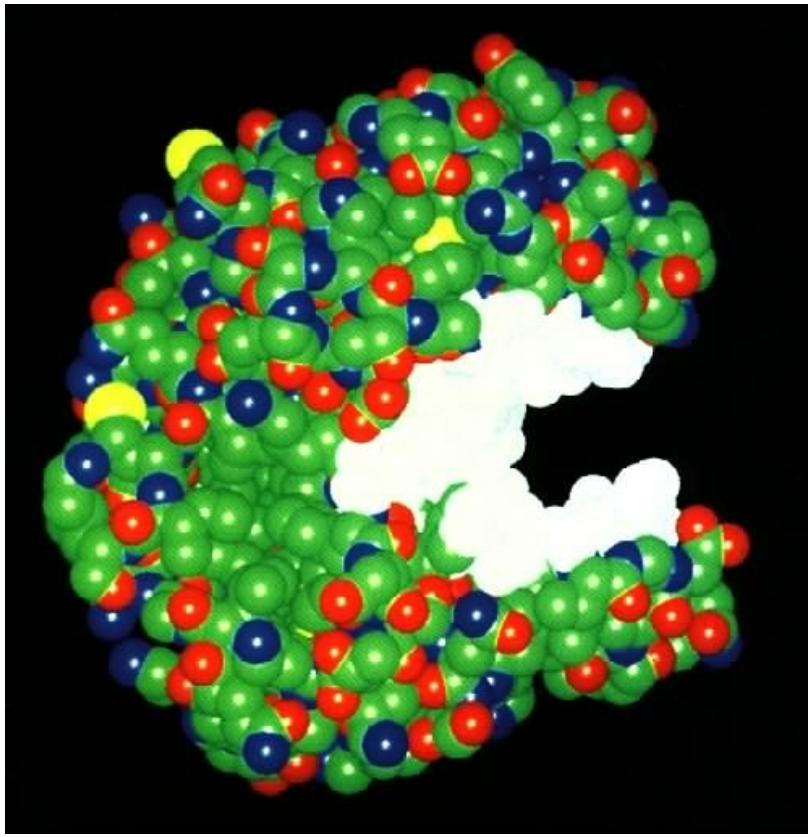
## 4.1 Cellular metabolism

- Metabolism is thus the sum of chemical reactions that takes place within each cell of a living organism and that provides energy for vital processes and synthesizing of new organic materials.
- Broadly, these reactions can be divided into catabolic reactions that convert nutrients to energy and anabolic reactions that lead to the synthesis of larger biomolecules.

# 4.2. Enzymes and their role in metabolism

## *What Are Enzymes?*

- **Most enzymes are Proteins (tertiary and quaternary structures)**
- **Act as Biological Catalyst to accelerates a reaction**
- **Not permanently changed in the process**



# ENZYMES…

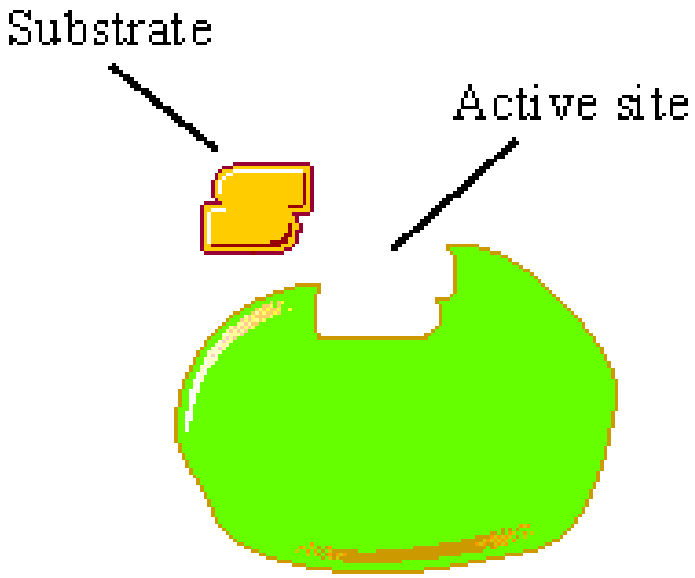
- **Are specific for what they will catalyze**
- **Are Reusable**
- **End in –*ase***

  ***-Sucrase***

  ***-Lactase***

  ***-Maltase***

- Most enzymes are protein in nature.
- Depending on the presence and absence of a **non protein** component with the enzyme, enzymes can exist as simple enzyme



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1. **Simple enzyme**: It is made up of only protein molecules not bound to any non proteins. Example: **Pancreatic Ribonuclease.**

2. **Holo enzyme** is made up o protein groups and non-protein component. 

- The protein component of this holo enzymes is called **apoenzyme** and the non-protein component of the holo enzyme is called a **cofactor**.
- If this cofactor is an organic compound it is called a **coenzyme** and if it is an inorganic groups it is called a**ctivator**. (Fe 2+, Mn 2+, or Zn 2+ ions). If the cofactor is bound so tightly to the apoenzyme and is difficult to remove without damaging the enzyme it is sometimes called a prosthetic group.

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**COENZYMES-**

- Coenzymes are derivatives of **vitamins** without which the enzyme cannot exhibit any reaction.
- One molecule of coenzyme is able to convert a large number of substrate molecules with the help of enzyme. 
- Coenzyme accepts a particular group removed from the substrate or donates a particular group to the substrate 
- Coenzymes are called co substrate because the changes that take place in substrates are complimentary to the changes in coenzymes.
- The coenzyme may participate in forming an intermediate enzyme-substrate complex
- Example: NAD, FAD, Coenzyme A

# Cont'd...

**Metal ions in enzymes**

- Many enzymes require metal ions like

  $ca^{2+}$, $K^{+}$, $Mg^{2+}$, $Fe^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Mn^{2+}$ and $Co^{2+}$

  for their activity.
- Metal-activated enzymes-form only loose and easily dissociable complexes with the metal and can easily release the metal without denaturation.
- Metalloenzymes hold the metal tightly on the molecule and do not release it even during extensive purification.

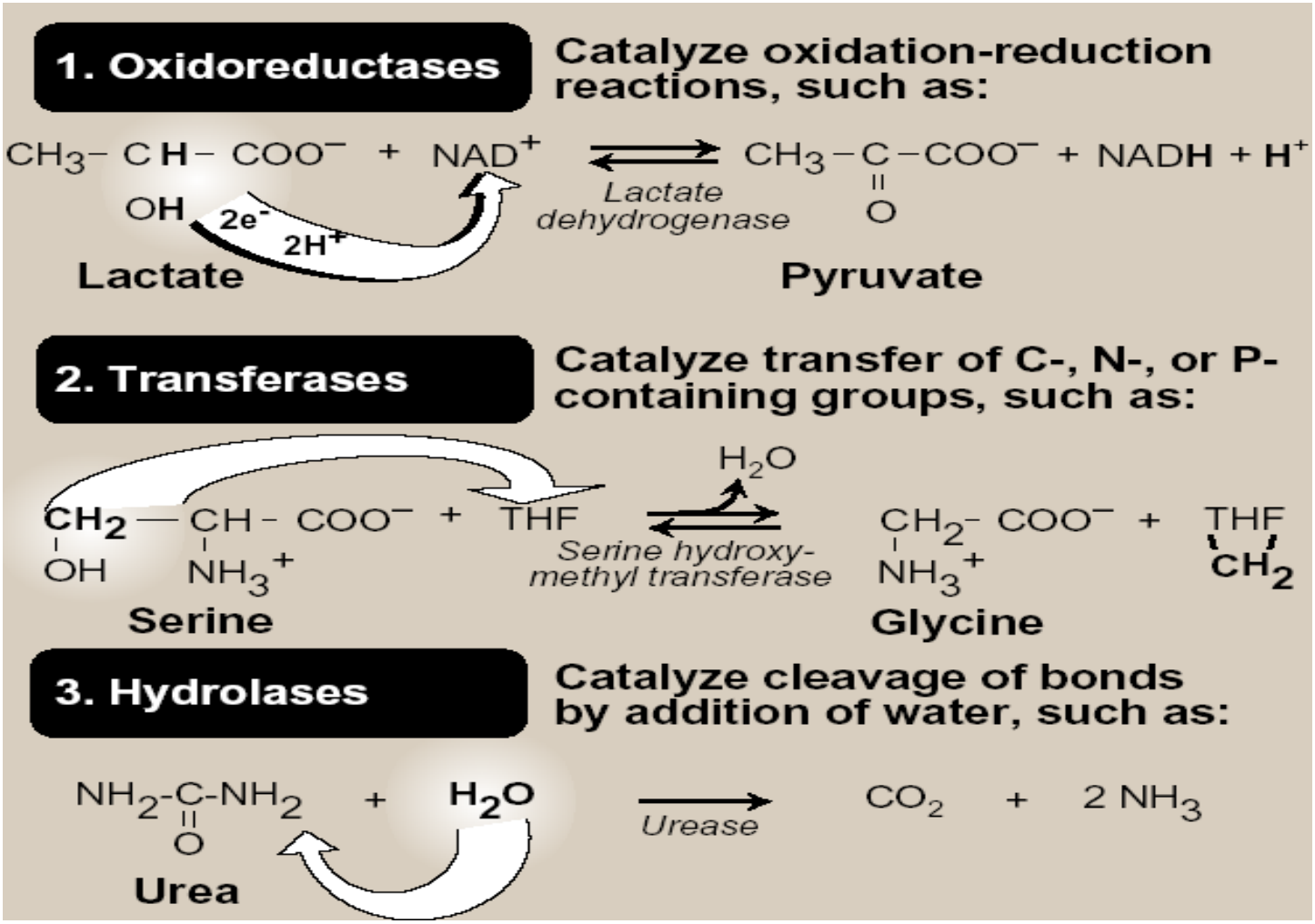
**Properties of Enzymes**

Active site: the active site binds the substrate, forming an enzyme-substrate (ES) complex. ES is converted to enzyme-product (EP); which subsequently dissociates to enzyme and product.

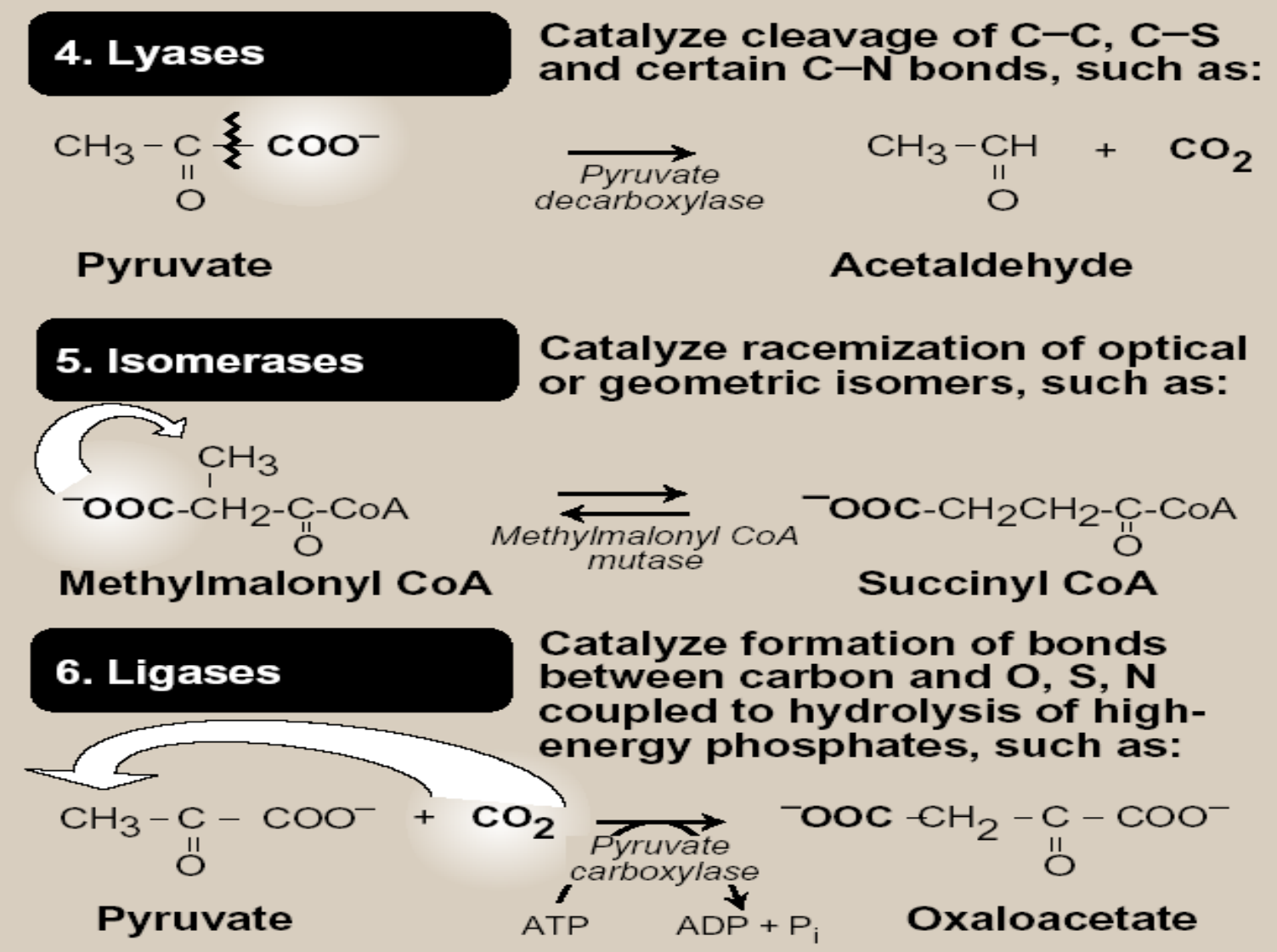
Enzyme turnover number :refers to the amount of substrate converted per unit time

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**Classification of Enzymes** on the basis of the reactions they catalyze



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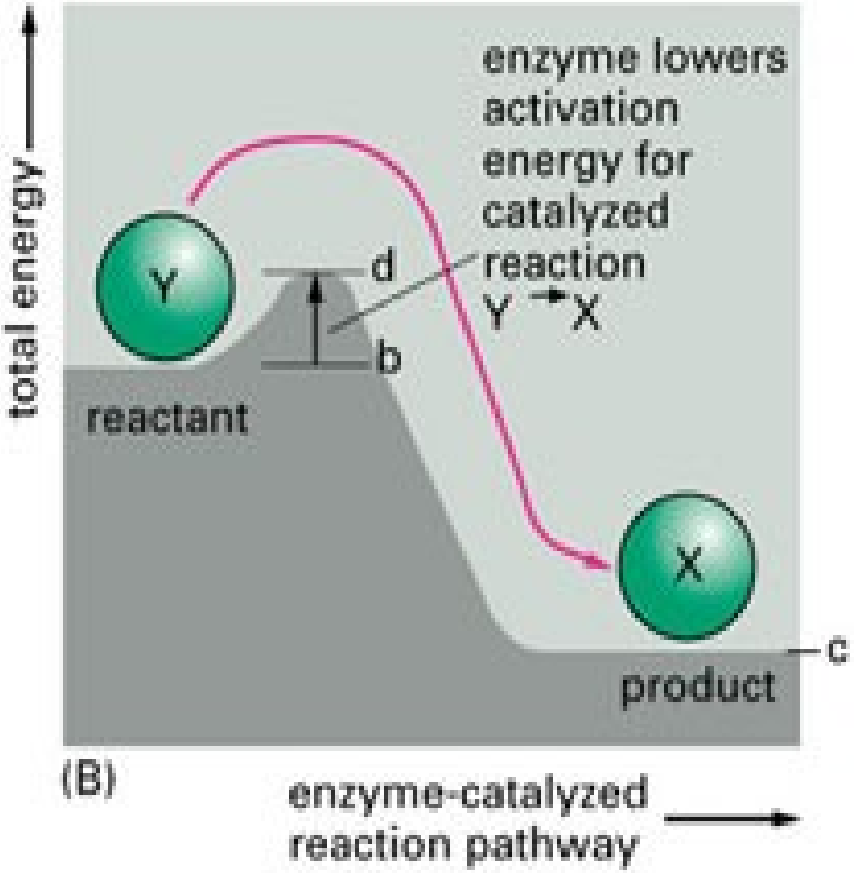

4. Lyases
Catalyze cleavage of C–C, C–S and certain C–N bonds, such as:
CH3 – C – COO⁻
O
Pyruvate
Pyruvate decarboxylase
CH3 – CH + CO2
O
Acetaldehyde
5. Isomerases
Catalyze racemization of optical or geometric isomers, such as:
CH3
⁻OOC-CH2-C-CoA
O
Methylmalonyl CoA
Methylmalonyl CoA mutase
⁻OOC-CH2CH2-C-CoA
O
Succinyl CoA
6. Ligases
Catalyze formation of bonds between carbon and O, S, N coupled to hydrolysis of high-energy phosphates, such as:
CH3 – C – COO⁻ + CO2
O
Pyruvate
Pyruvate carboxylase
ATP
ADP + Pi
⁻OOC – CH2 – C – COO⁻
O
Oxaloacetate

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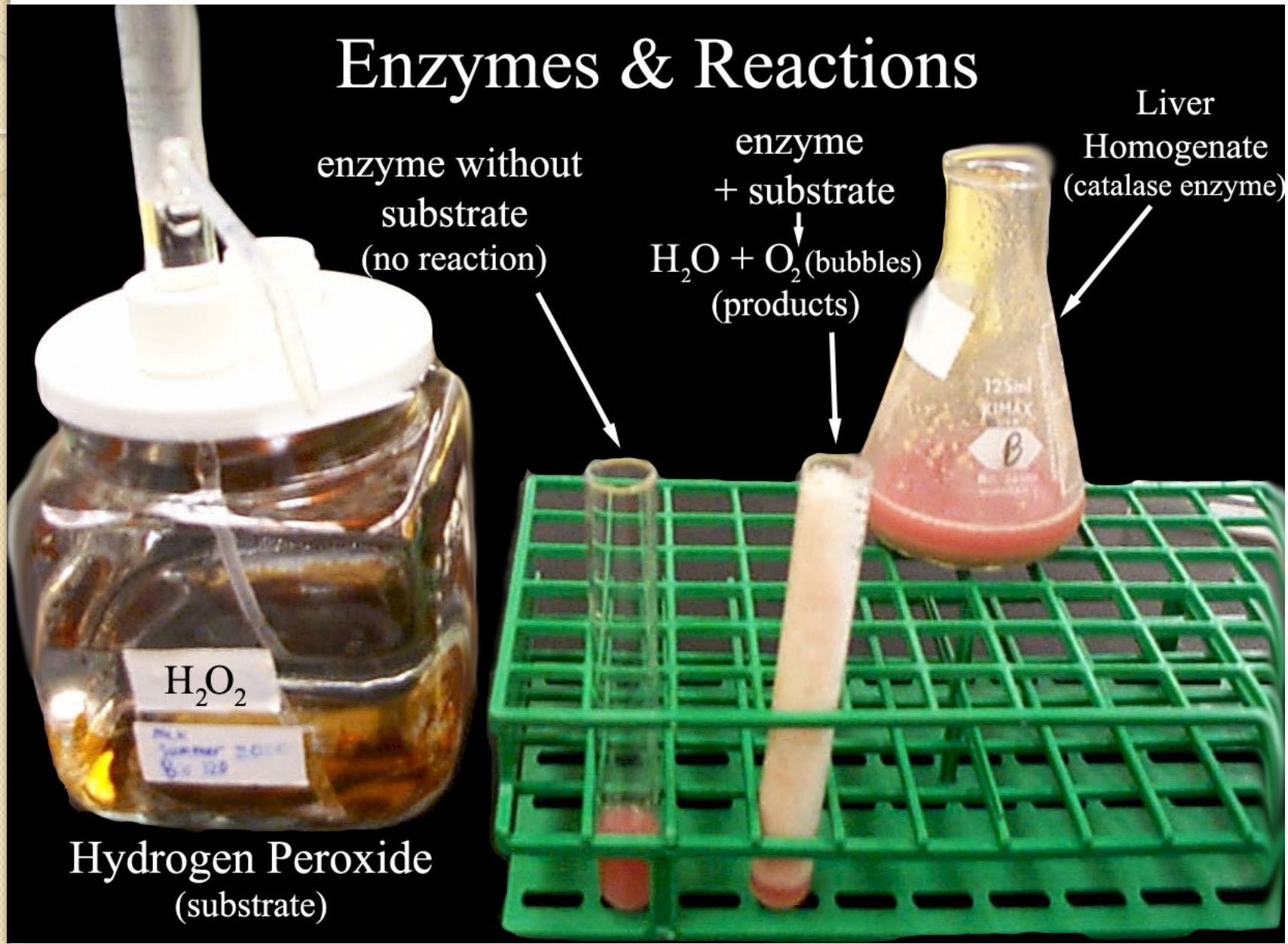
## How do enzymes Work?

**Enzymes work by weakening bonds which lowers activation energy**

- **Activation Energy** is needed to convert **potential energy** into **kinetic energy**.

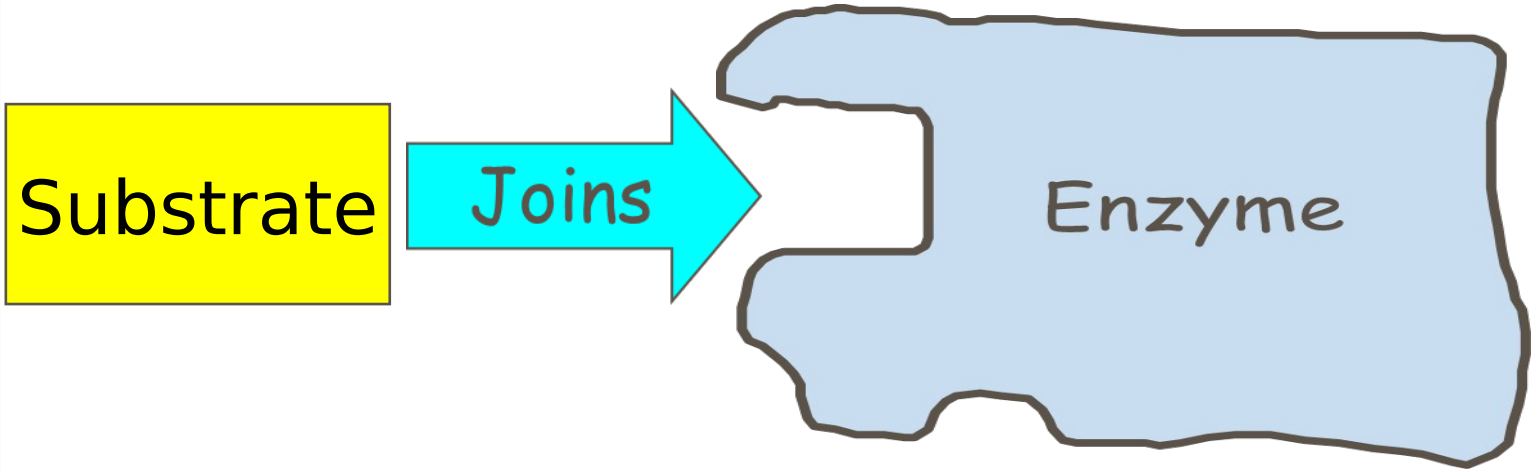


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Enzymes & Reactions
enzyme without substrate (no reaction)
enzyme + substrate
$H_2O + O_2$ (bubbles)
(products)
Liver Homogenate (catalase enzyme)
$H_2O_2$
Hydrogen Peroxide
(substrate)

# Enzyme-Substrate Complex

- The **substance** (reactant) an **enzyme** acts on is the **substrate**

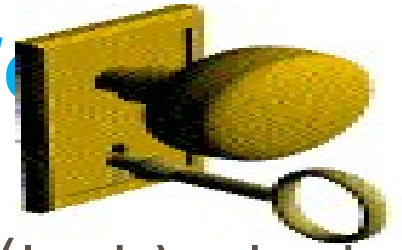



## Active Site

- A **restricted region** of an **enzyme** molecule which **binds** to the **substrate**.

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## Models of How Enzymes W



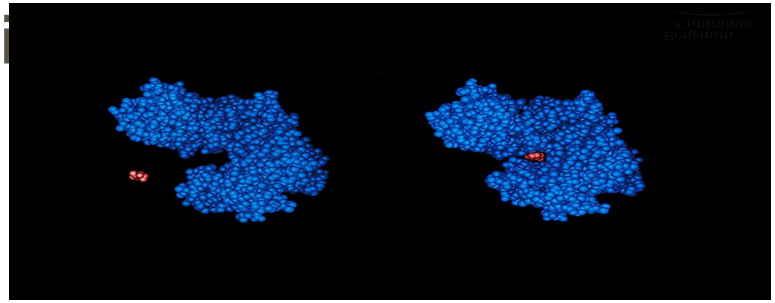
1. **Lock and Key model**

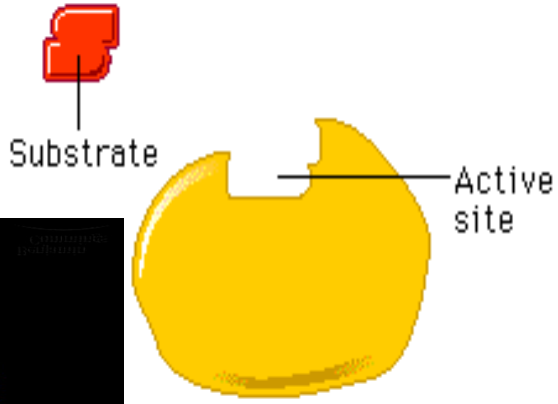
- Substrate (key) fits to the active site (lock) which provides a microenvironment for the specific reaction.

2. **Induced Fit model**

- **A change in the shape of an enzyme's active site**
- **Induced by the substrate**

Substrate "almost" fits into the active site, causing a strain on the chemical bonds, allowi reaction.





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## Factors that Affect Enzymes

- **Environment (Temperature & pH)**
- **Cofactors**
- **Coenzymes**
- **Inhibitors**
- **Allosteric Sites**

## Environment

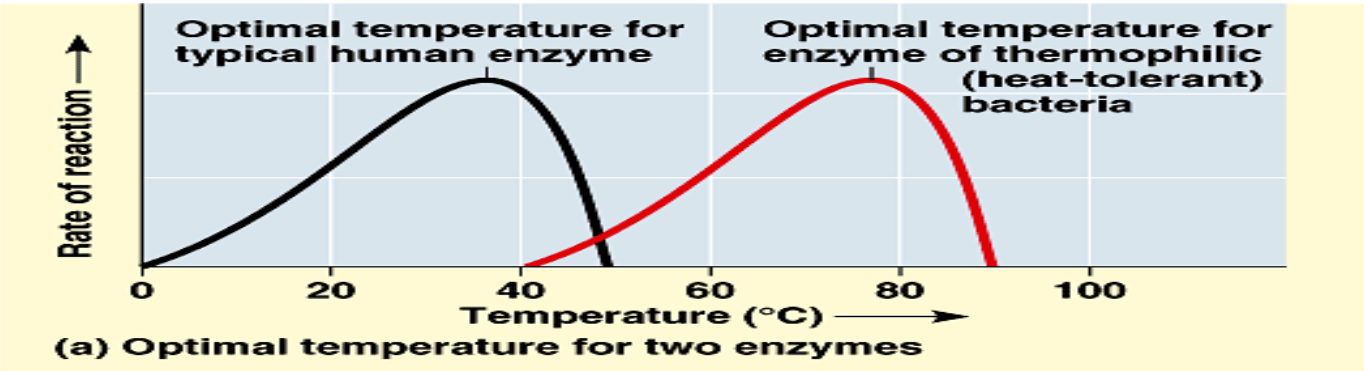
- Factors that change protein structure will affect an enzyme.
- Examples:
  - pH shifts
  - temperature
  - salt concentrations



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## Temperature & pH

- **High temperatures denature enzymes (Most enzymes like normal body temperatures)**
- **Most enzymes function near neutral pH (6 to 8)**




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# Cont'd...

## Cofactors

- Inorganic substances (zinc, iron, copper) are sometimes need for proper enzymatic activity.
- Non-protein helpers can bond to the active site of enzymes to help in reactions
- **Example:**

  **Iron** must be present in the **quaternary structure of hemoglobin** in order for it to pick up oxygen.

## Coenzymes

- Organic molecules that act as cofactors which help enzymes.
- Examples:
  - vitamins

# Cont'd...

## Two examples of Enzyme Inhibitors

a. **Competitive inhibitors:** are chemicals that resemble an enzyme's normal substrate and compete with it for the active site.

b. **Noncompetitive inhibitors:**

Inhibitors that do not enter the active site, but bind to another part of the enzyme causing the enzyme to change its shape, which in turn alters the active site.

## Control of Metabolism

- Is necessary if life is to function.
- Controlled by switching enzyme activity "off" or "on" or separating the enzymes in time or

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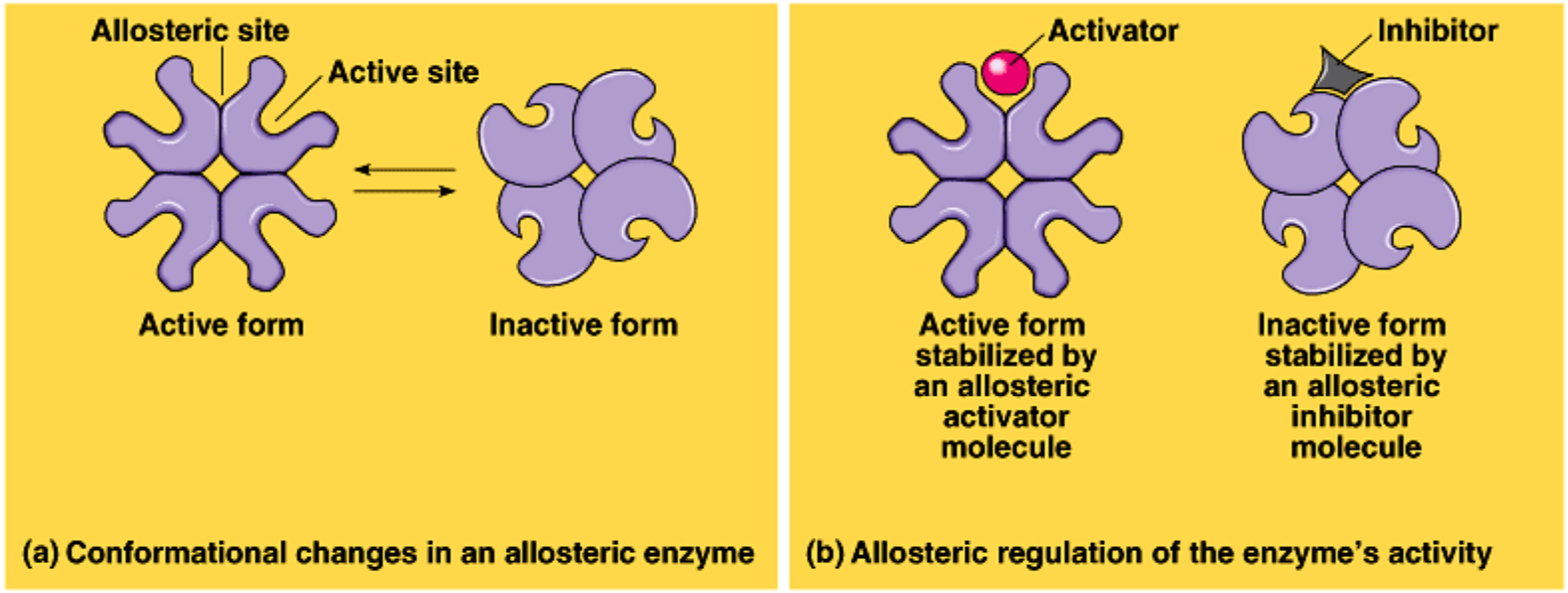
## Types of Control

1. Switching on or off the genes that encode for specific enzyme production
2. Allosteric sites
3. Feedback inhibition
4. cooperativity

## Allosteric Regulation

- The control of an enzyme complex by the binding of a regulatory molecule.
- Regulatory molecule may stimulate or inhibit the enzyme complex.
- Allosteric site is a specific receptor site on some part of the enzyme molecule away from the active site
- When activated, this site changes the shape of the enzyme to inhibit it or to stimulate it

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## Feedback Inhibition

- When a metabolic pathway is switched off by its end-product.
- End-product usually inhibits an enzyme earlier in the pathway.
- Prevents the cell from wasting chemical resources

# 4.3 Bioenergetics and biosynthesis

## 4.3.1. Cellular respiration

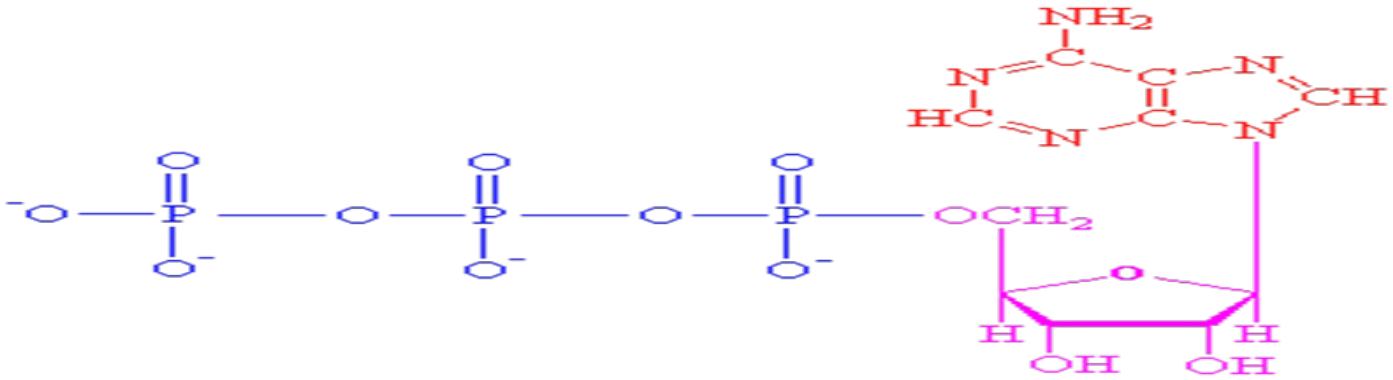
- Most living organisms obtain energy by breaking down organic molecules (catabolism) during cellular respiration.
- This catabolic process can be divided into 3 phases.
- Phase I - Breakdown of large complex biomolecules like polysaccharides, proteins and lipids into their respective building blocks (hydrolysis). The chemical reactions occurring during this stage do not release much energy.
- Phase II - These building blocks are usually oxidized to a common intermediate, acetyl - CoA. Additionally, pyruvate or other citric acid cycle intermediates may also be formed (in glycolysis and other pathways).
- Phase III – This consists of the citric acid cycle (i.e. oxidation of acetyl - CoA to CO2, formation of NADH and FADH2) followed by electron transport and oxidative phosphorylation. Energy released by electron transport to O2 is coupled to ATP synthesis. This cycle is responsible for the release of much energy ( TCA cycle and ETC)

## Molecular structure of ATP

- Adenosine triphosphate (ATP) is a nucleoside triphosphate used in cells as a coenzyme.
- It is often called the "molecular unit of currency" of intracellular energy transfer.
- ATP transports chemical energy within cells for metabolism.
- It is one of the end products of photophosphorylation, cellular respiration, and fermentation and used by enzymes and structural proteins in many cellular processes, including biosynthetic reactions, motility, and cell division.

- Substrate level phosphorylation, oxidative phosphorylation in cellular respiration, and photophosphorylation in photosynthesis are three major mechanisms of ATP biosynthesis.
- Metabolic processes that use ATP as an energy source convert it back into its precursors.
- ATP is therefore continuously recycled in organisms.

- One molecule of ATP contains three phosphate groups, and it is produced by a wide variety of enzymes, including ATP synthase, from adenosine diphosphate (ADP) or adenosine monophosphate (AMP) and various phosphate group donors.



ATP consists of a base, in this case adenine (red), a ribose (magenta) and a phosphate chain (blue).

## 4.3.1.1 Anaerobic respiration

- Anaerobic respiration is a form of respiration using electron acceptors other than oxygen.
- Anaerobic metabolic processes do not require oxygen.

### Glycolysis

- Glycolysis (from glycose, an older term for glucose + -lysis degradation) is the metabolic pathway that converts glucose $C_6H_{12}O_6$, into pyruvate, $CH_3COCOO^- + H^+$.
- The free energy released in this process is used to form the high-energy compounds ATP (adenosine triphosphate) and NADH (reduced nicotinamide adenine dinucleotide).

- Glycolysis does not require or consume oxygen.
- The terms "aerobic glycolysis" and "anaerobic glycolysis" refer to glycolysis in the presence or absence of oxygen, respectively.
- Glycolysis occurs, with variations, in nearly all organisms, both aerobic and anaerobic.
- The wide occurrence of glycolysis indicates that it is one of the most ancient known metabolic pathways.
- It occurs in the cytosol of the cell.

The entire glycolysis pathway can be separated into two phases:

1. The Preparatory Phase – in which ATP is consumed and is hence also known as the investment phase

- The first five steps are regarded as the preparatory (or investment) phase, since they consume energy to convert the glucose into two three-carbon sugar phosphates (G3P).

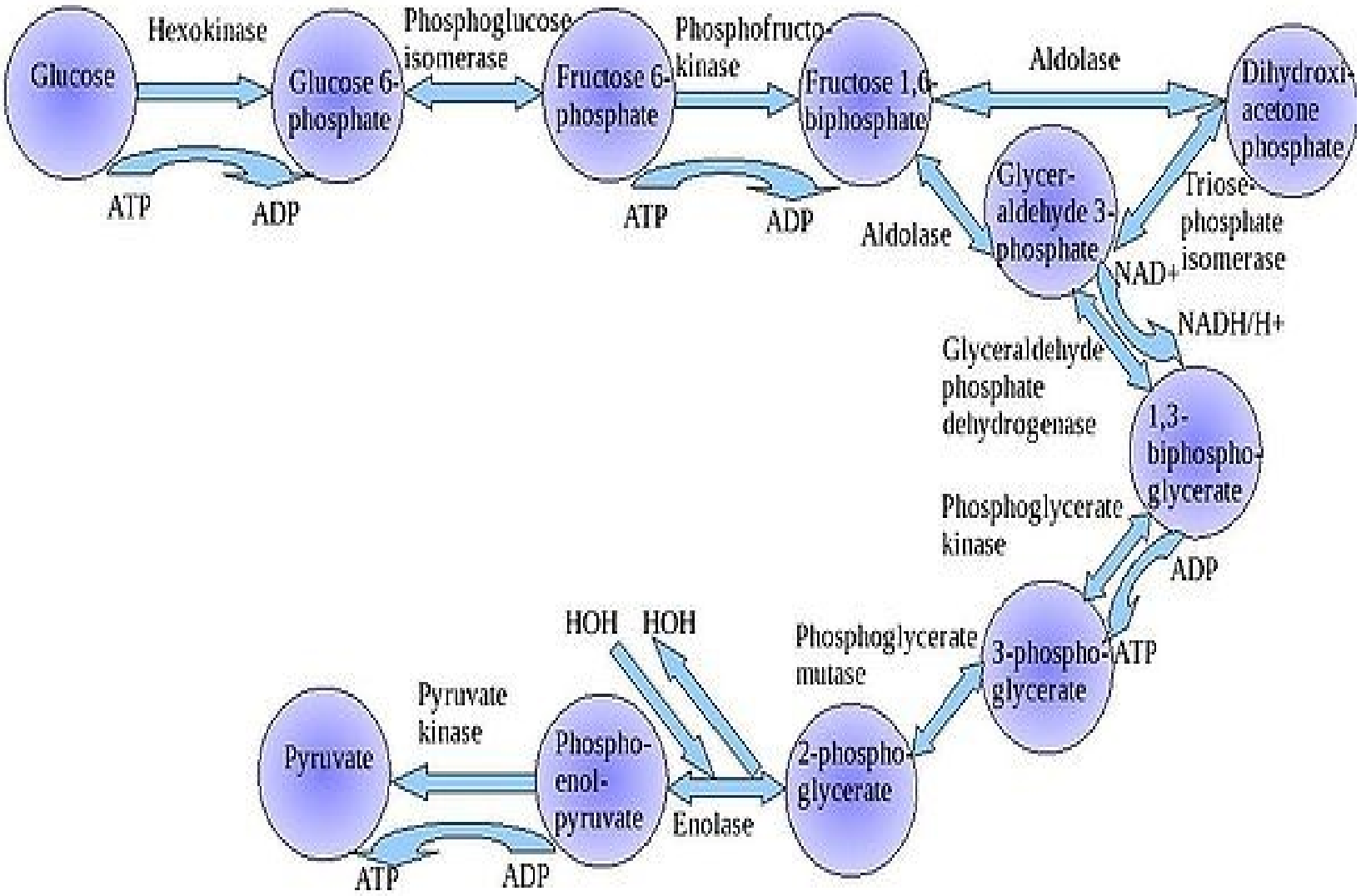
2. The Pay Off Phase – in which ATP is produced.

- Characterized by a net gain of the energy-rich molecules ATP and NADH.
- This yields 2 NADH molecules and 4 ATP molecules, leading to a net gain of 2 NADH molecules and 2 ATP molecules from the glycolytic pathway per glucose.
- Substrate-level phosphorylation is the mechanism to produce ATP during glycolysis.

## Biochemical logic for the presence of regulatory steps

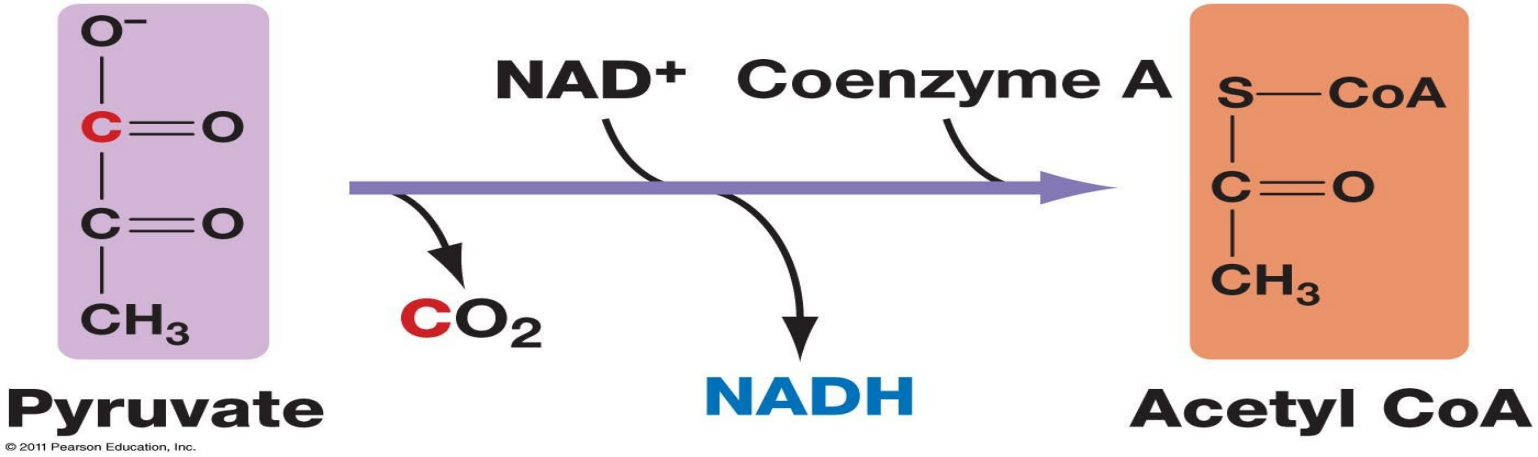
- The existence of more than one point of regulation indicates that intermediates between those points enter and leave the glycolysis pathway by other processes.
- For example, in the first regulated step, hexokinase converts glucose into glucose-6-phosphate. Instead of continuing through the glycolysis pathway, this intermediate can be converted into glucose storage molecules, such as glycogen or starch.

# Glycolysis involves ten enzymatic reactions as described below



# 4.3.1.2 TCA cycle and ETC: Aerobic respiration

- One fate of pyruvate is that it enters to TCA cycle for complete oxidation. But there are intermediate processes: **The Oxidation of Pyruvate to form Acetyl CoA for Entry Into the Krebs Cycle**
- 2 NADH's are generated (1 per pyruvate)
- 2 $CO_2$ are released (1 per pyruvate)

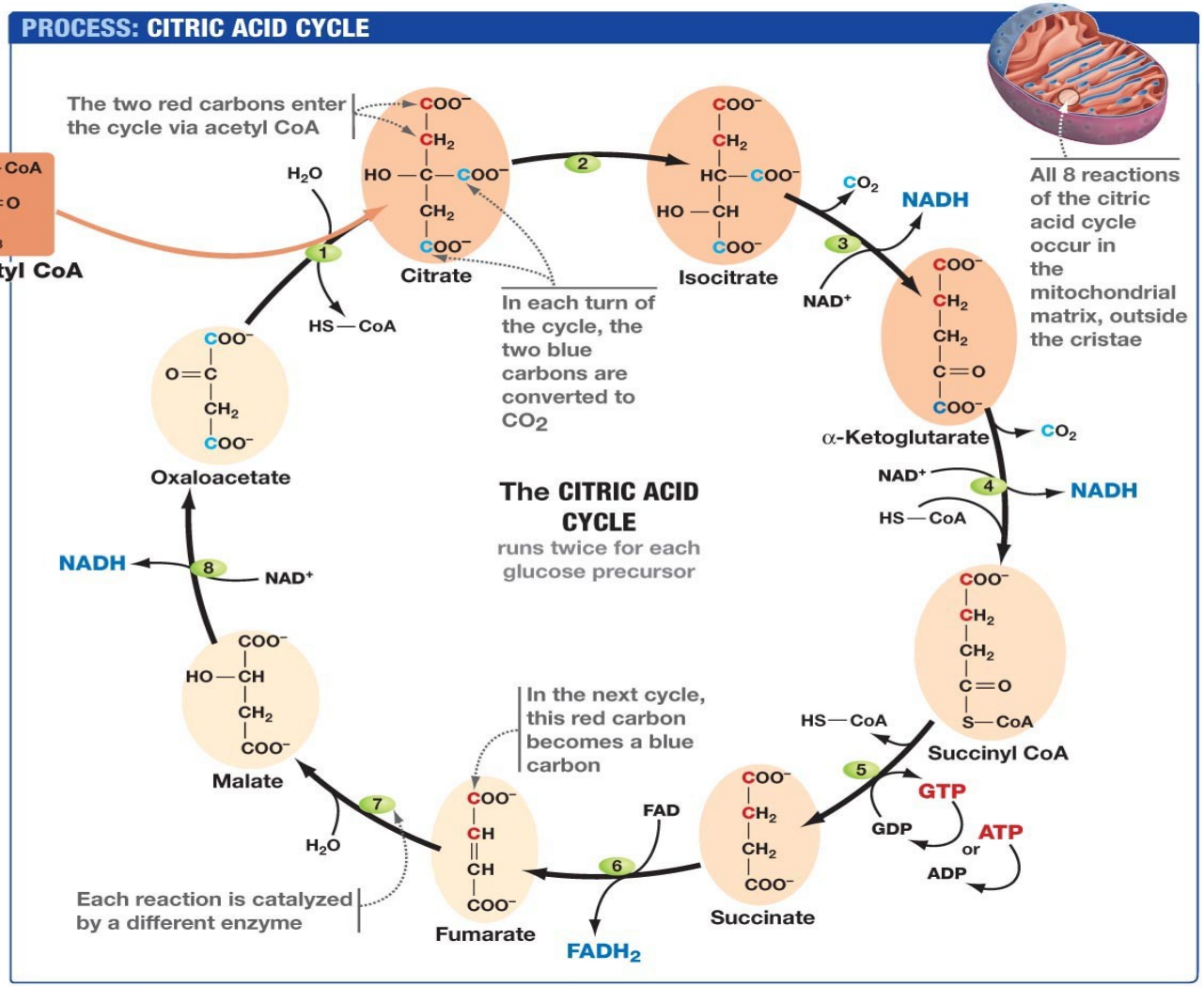


- **The Krebs Cycle (citric acid cycle, TCA cycle)**
  - is considered as central pathway of aerobic metabolism, as it serves two purposes- bioenergetics and biosynthesis

1. **Bioenergetics:** The cycle carries out complex degradation of acetyl group in acetyl - CoA to $CO_2$, resulting in release of energy (ATP or GTP) and reducing power (NADH and $FADH_2$).
2. **Biosynthesis:** It supplies precursors for several biosynthetic pathways of amino acids, pyrimidines, purines etc

Example:- α-ketoglutarate and oxaloacetate are used for synthesis of a number of amino acids like glutamic acid, asparatic acid etc

- Acetyl - CoA is the starting material for fatty acid biosynthesis.

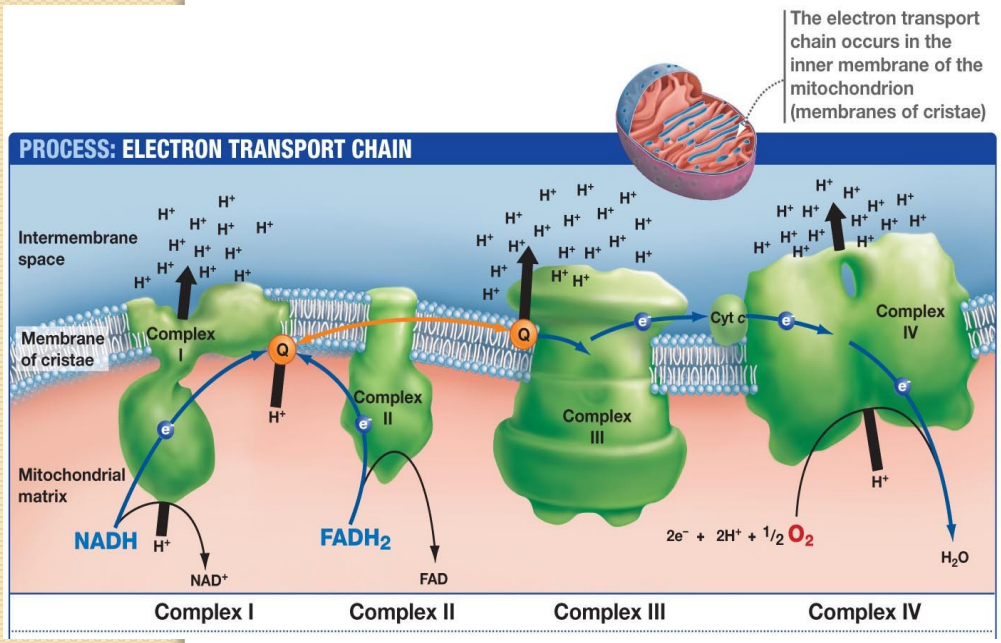


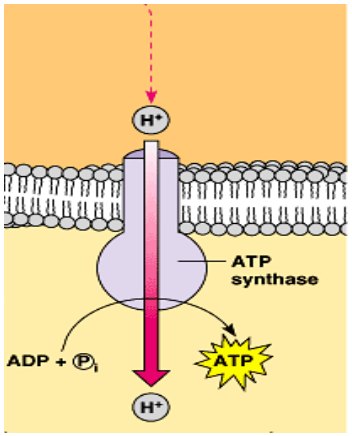

- 6 NADH's are generated (3 per Acetyl CoA that enters)
- 2 FADH2 is generated (1 per Acetyl CoA that enters)
- 2 ATP are generated (1 per Acetyl CoA that enters)

Therefore, the total numbers of molecules generated in the Oxidation of Pyruvate and the Krebs Cycle is: 8 NADH, 2 FADH2, 2 ATP and 6 CO2

# 7.3.2 Electron transport chain

- In aerobic respiration, electron transport is the final step in the break-down of glucose.
- It also is the point at which most of the ATP is produced. High-energy electrons and hydrogen ions from NADH and FADH2 produced in the Krebs cycle are used to convert ADP to ATP.




**The maximum net Energy Production from Aerobic Respiration is 36-38.**

# Biosynthesis

- **Biosynthesis** is a multi-step, enzyme-catalyzed process where substrates are converted into more complex products in living organisms.
- In biosynthesis, simple compounds are modified, converted into other compounds, or joined together to form macromolecules.
- This process often consists of metabolic pathways.
- Some of these biosynthetic pathways are located within a single cellular organelle, while others involve enzymes that are located within multiple cellular organelles.
- Examples of these biosynthetic pathways include the **production of lipid membrane components** and **nucleotide**.

# Cont'd...

- The prerequisite elements for biosynthesis include: precursor compounds, chemical energy (e.g. ATP), and catalytic enzymes which may require coenzymes (e.g.NADH, NADPH).
- These elements create monomers, the building blocks for macromolecules.
- Some important biological macromolecules include: **proteins**, which are composed of amino acid monomers joined via peptide bonds, and
- **DNA** molecules, which are composed of nucleotides joined via phosphodiester bonds.

# Requirements of Biosynthesis

## I. Photosynthesis

- Energy is transformed all around us every day.
- Batteries convert chemical energy into electric energy, and radios convert electric energy into the energy carried by sound waves.
- Similarly, some **autotrophs** convert light energy into chemical energy through **photosynthesis.**

**The importance of photosynthesis**

- The processes of all organisms, from **bacteria** to **humans** require energy and to get this energy, many organisms access stored energy by eating food.
- Carnivores eat other animals and herbivores eat plants. **But where does the stored energy in food originate?**

# Cont'd…

- All of this energy can be traced back to the process of **photosynthesis** and **light energy** from the sun.
- Photosynthesis is essential to all life on earth.
- It is the only biological process that captures energy from outer space (sunlight) and converts it into chemical energy in the form of **Glyceraldehyde3-phosphate** (G3P), which in turn can be made into sugars and other organic compounds such as **proteins**, **lipids**, and **nucleic acids**.
- **Plants** use these compounds in all of their metabolic processes.
- Unlike plants, **animals** need to consume other organisms to consume the molecules they need for their metabolic processes.

# The process of photosynthesis

- During photosynthesis, molecules in leaves capture sunlight and energize electrons, which are then stored in the covalent bonds of carbohydrate molecules.
- That energy within those covalent bonds will be released when they are broken during cell respiration.
- **How long lasting and stable are those covalent bonds?**
- The energy extracted today by the burning of coal and petroleum products represents sunlight energy captured and stored by **photosynthesis** almost 200 million years ago.

➢ **Photoautotrophs**

✓ Are organisms(plants, algae, and some bacteria) which have a capability of performing photosynthesis and they use light to manufacture their own food.

# Cont'd…

- **Heterotrophs**: are organisms, such as animals, fungi, and most other bacteria, they must rely on the **sugars** produced by photosynthetic organisms for their energy needs.
- **Chemoautotrophs**: are very interesting group **of bacteria** synthesize sugars, not by using sunlight's energy, but by extracting energy from inorganic chemical compounds.
- The importance of photosynthesis is not just that it can capture sunlight's energy.
- A lizard sunning itself on a cold day can use the sun's energy to warm up.
- Photosynthesis is vital because it evolved as a way to store the energy in solar radiation (the photo part) as high energy electrons in the carbon-carbon bonds of carbohydrate molecules (the ''synthesis'' part).

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## Other variant of photosynthesis

- Commonly known photosynthetic processes is the one known as **oxygenic photosynthesis**.
- The other type is termed as **anoxygenic photosynthesis**.
- The general principles of anoxygenic and oxygenic photosynthesis are very similar,
- But oxygenic photosynthesis is the most common and is seen in **plants, algae** and **cyanobacteria**.
- During **oxygenic photosynthesis**, light energy transfers electrons from water ($H_2O$) to carbon dioxide ($CO_2$), to produce carbohydrates.
- In this transfer, the $CO_2$ is "reduced," or receives electrons, and the water becomes "oxidized," or loses electrons. Ultimately, oxygen is produced along with carbohydrates.

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- On the other hand, anoxygenic photosynthesis uses electron donors other than **water**.
- The process typically occurs in bacteria such as **purple bacteria** and **green sulfur bacteria**, which are primarily found in various aquatic habitats.

**The photosynthetic apparatus**

- **Plastids**
  - Photosynthetic eukaryotic organisms contain organelles called **plastids** in their cytoplasm.
  - Plastids generally contain pigments or can store nutrients.
  - Colorless and nonpigmented **leucoplasts** store fats and starch, while **chromoplasts** contain

# Cont'd…

- Photosynthesis occurs in the chloroplasts; specifically, in the **grana** and **stroma** regions.
- The **grana** is the innermost portion of the organelle; a collection of disc-shaped membranes, stacked into columns like plates.
- The individual discs are called **thylakoids**. It is here that the transfer of electrons takes place.
- Chloroplasts are similar to mitochondria, the energy centers of cells, in that they have their own genome, or collection of genes, contained within circular DNA

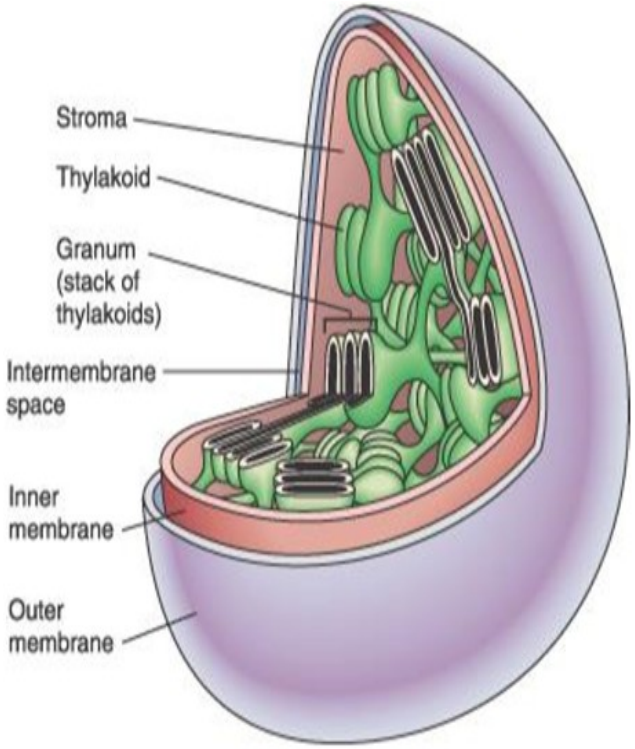



Fig: 4.4. structure of chloroplast

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## Pigments

- **Pigments** are molecules that bestow color on plants, algae and bacteria, but they are also responsible for effectively trapping sunlight.
- Pigments of different colors absorb different wavelengths of light. There are 3 main group of pigments.

### 1. Chlorophylls

- These green-colored pigments are capable of trapping blue and red light.
- Chlorophylls have three subtypes, **dubbed chlorophyll a**, **chlorophyll b** and **chlorophyll c**.
- There is also a bacterial variant aptly named bacteriochlorophyll, which absorbs infrared light.
- This pigment is mainly seen in purple and green bacteria, which perform anoxygenic photosynthesis.

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**2.Carotenoids:** these red, orange or yellow-coloured pigments absorb bluish-green light. Examples of carotenoids are **xanthophyll (yellow)** and **carotene** (orange) from which carrots get their color**.**

**3.Phycobilins:** these red or blue pigments absorb wavelengths of light that are not as well absorbed by chlorophylls and carotenoids. They are seen in **cyanobacteria** and **red algae.**

**Antennae**

- Pigment molecules are associated with **proteins**, which allow them the flexibility to move toward light and toward one another.
- A large collection of 100 to 5,000 pigment molecules constitutes antennae. These structures effectively capture light energy from the sun, in the form of photons.

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**Reaction centers:** the pigments and proteins, which convert light energy to chemical energy and begin the process of electron transfer, are known as **reaction centers**.

**The photosynthetic process**

- The reactions of plant photosynthesis are divided into those that require the presence of sunlight and those that do not.
- Both types of reactions take place in **chloroplasts**: light dependent reactions in the thylakoid and light-independent reactions in the stroma**.**
- **Light-dependent reactions :**When a photon of light hits the reaction center, a pigment molecule such as chlorophyll releases an electron.
- The released electron manages to escape by traveling through an electron transport chain, which generates the energy needed to produce **ATP** (adenosine triphosphate, a source of chemical energy for cells) and **NADPH**.
- The "electron hole" in the original chlorophyll pigment is filled by taking an electron from water. As a result, oxygen is released into the atmosphere.

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- **light-independent reactions** (also called dark reactions and known as the **Calvin cycle**): Light reactions produce ATP and NADPH, which are the rich energy sources that drive dark reactions.
- Although **NADPH** and **ATP** provide cells with large amounts of energy, these molecules are not stable enough to store chemical energy for long periods of time.
- Thus, there is a second phase of photosynthesis called the Calvin cycle in which energy is stored in organic molecules such as glucose.

Three chemical reaction steps make up the Calvin cycle:

- **Carbon fixation**,
- **Reduction** and
- **Regeneration**.

# Cont’d…

- These reactions use **water and catalysts**.
- The carbon atoms from carbon dioxide are ''fixed,'' when they are built into organic molecules that ultimately form three-carbon sugars. These sugars are then used to make glucose or are recycled to initiate the Calvin cycle again.

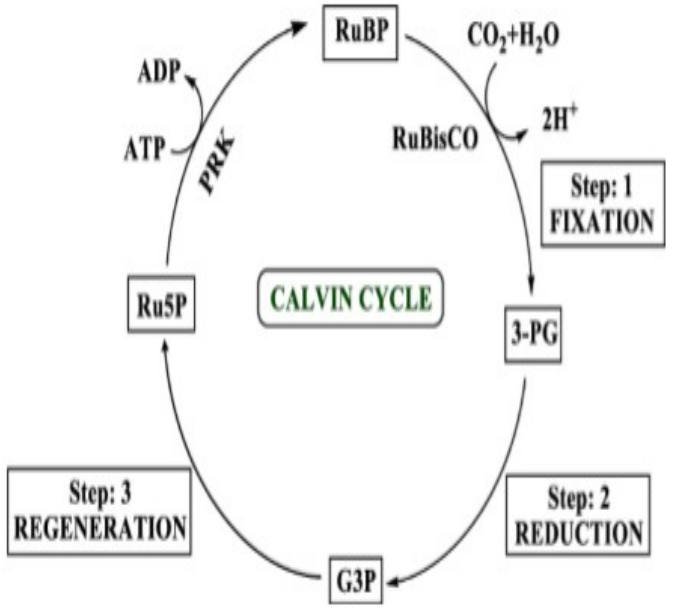



Fig:4.6. Calvin cycle

# Cont’d…

## Alternative Pathways

- The environment in which an organism lives can impact the organism's ability to carry out **photosynthesis**.
- Environments in which the amount of **water** or **carbon dioxide** available is insufficient can decrease the ability of a photosynthetic organism to convert **light energy** into **chemical energy**.
- For example, plants in hot, dry environments are subject to excessive water loss that can lead to decreased photosynthesis.
- Many plants in extreme climates have altered native photosynthesis pathways to **maximize energy conversion**.

# Cont'd...

- C4 plants one adaptive pathway that helps plants maintain photosynthesis While minimizing water loss is called the C4 pathway.
- **The C4 pathway** occurs in plants such as sugar cane and corn and these plants are called C4 plants because **they fix carbon dioxide into four-carbon compounds instead of three-carbon molecules during the Calvin cycle**.
- C4 plants also have significant structural modifications in the arrangement of cells in the leaves.
- In general, C4 plants keep their stomata closed during hot days, while the four carbon compounds are transferred to special cells where CO2 enters the Calvin cycle.
- This allows for sufficient carbon dioxide uptake, while simultaneously minimizing water loss.

# Cont'd…

- CAM plants Another adaptive pathway used by some plants to maximize photosynthetic activity is called crassulacean acid metabolism (CAM photosynthesis).
- **The CAM pathway** occurs in water conserving plants that live in deserts, salt marshes, and other environments where access to water is limited.
- CAM plants, such as **cacti**, **orchids**, and **the pineapple** allow carbon dioxide to enter The leaves only at night, when the atmosphere is cooler and more humid.
- At night, these plants fix **carbon dioxide** into **organic compounds.**
- During the day, carbon dioxide is released from these compounds and enters the Calvin cycle.
- This pathway Also allows for sufficient carbon dioxide uptake, while minimizing water loss.

# 4.4. Metabolic disorders, diagnosis and treatments

- **Metabolism** is the breaking down of food to its simpler components: **proteins**, **carbohydrates** (or sugars), and **fats**.
- Metabolic disorders occur when these normal processes become disrupted.
- **Disorders in metabolism** can be ***inherited***, in which case they are also known as inborn errors of metabolism, or they may be acquired during your lifetime.

**Inherited metabolic disorders**

- They are one cause of metabolic disorders, and occur when a **defective gene** causes an enzyme deficiency.
- These diseases, of which there are many subtypes, are known as ***inborn errors of metabolism***.
- Metabolic diseases can also occur when the liver or pancreas do not function properly.

# Cont'd…

- There are numerous examples of inherited metabolic disorders, classified based on the type of food-related building block that they affect, including **amino acids**, **carbohydrates**, and **fatty acids.**
- **Inherited causes of metabolic disorders** include:
  - **Carbohydrate disorders**; examples include Diabetes insipidus, hereditary fructose intolerance, galactosemia, pyruvate metabolism disorders, von Gierke‟s disease, McArdle disease, Pompes disease, and Forbes‟ disease.
  - **Fatty acid oxidation defects**; examples include Gaucher‟s disease, Niemann-Pick disease, Fabry‟s disease, and medium-chain acyl-coenzyme A dehydrogenase (MCAD) deficiency .
  - **Amino acid disorders**; examples include Tay-Sachs disease, phenylketonuria, tyrosinemia, maple syrup urine disease, and homocystinuria.

# Cont'd…

## Other causes of metabolic disorders

- Metabolic disorders can be due to other factors, such as a combination of ***inherited*** and ***environmental factors***.
- Some of the conditions that can cause metabolic disorders include:
- Alcohol abuse, Diabetes (chronic disease that affects your body's ability to use sugar for energy)
- *Diuretic abuse*, Gout (type of arthritis caused by a buildup of uric acid in the joints)
- Ingestion of poison or toxins, including excessive aspirin, bicarbonate, alkali, ethylene glycol, or methanol
- Kidney failure, Pneumonia, respiratory failure, or collapsed lung
- ***Sepsis*** (life-threatening bacterial blood infection) .

# Cont'd…

## *Risk factors of metabolic disorders*

- A number of factors increase the risk of developing metabolic disorders.
- Not all people with risk factors will get metabolic disorders.
- **Risk factors for metabolic disorders include**:
  - *certain chronic medical conditions, such as lung or kidney disease and Diabetes*.
  - *Family history of genetic metabolic disorder*
  - Age- the risk of metabolic syndrome increases with age.
  - *Obesity and lack of exercise*.
  - *Hormone imbalance*
  - *Insulin resistance: a situation in which a body cannot use insulin properly.*

# Cont'd…

## Diagnosis of metabolic disorders

- Metabolic syndrome is more effectively diagnosed by testing different blood markers (specific markers of insulin resistance), **obesity** (especially abdominal obesity), **high blood pressure**, and **lipid abnormalities**.
- **Specifically, metabolic syndrome is diagnosed if any three of the following five markers are present**:

- Elevated waist circumference: 40 inches or more for men; 35 inches or more for women
- Elevated triglycerides: 150 mg/dL or higher
- Reduced high-density lipoprotein (HDL) levels (AKA ''good'' cholesterol): less than 40 mg/dL in men; less than 50 mg/dL in women
- Elevated blood pressure: 130/85 mm Hg or higher or are already taking blood pressure medications
- Elevated fasting glucose: 100 mg/dL or higher or are already taking glucose-lowering medications .

# Cont'd…

- The treatment approach for metabolic disorders depends on the specific disorder.
- Inborn errors of metabolism (inherited metabolic disorders) are often treated with nutritional counselling and support, periodic assessment, physical therapy, and other supportive care options.
- Multiple treatment options are available for inherited metabolic disorders and examples include:
  - bone marrow transplantation,
  - enzyme replacement therapy in selected patients,
  - gene therapy in selected patients,
  - medications to reduce symptoms, such as pain or low blood sugar, mineral supplementation, nutritional counselling, surgery to relieve pain or symptoms, vitamin supplementation and etc.

# Cont'd…

**Potential complications of metabolic disorders**

- Complications of untreated metabolic disorders can be serious, even life threatening in some cases.
- The risk of serious complications can be minimized following the treatment plan designed by health care professional.
- **Complications of metabolic disorders include:**
  - **organ failure/dysfunction**,
  - **seizures and tremors**, and
  - **unconsciousness and coma**.

# THANK YOU