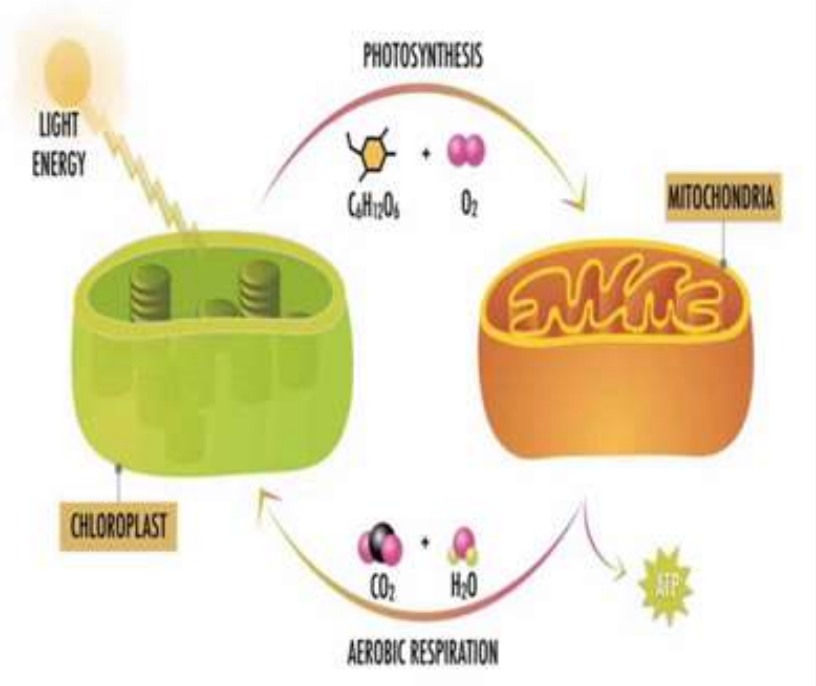
SBI4U
UNIT #2: METABOLIC PROCESSES
LECTURE #2 (THERMO#2)



THERMODYNAMICS AND CELLULAR RESPIRATION

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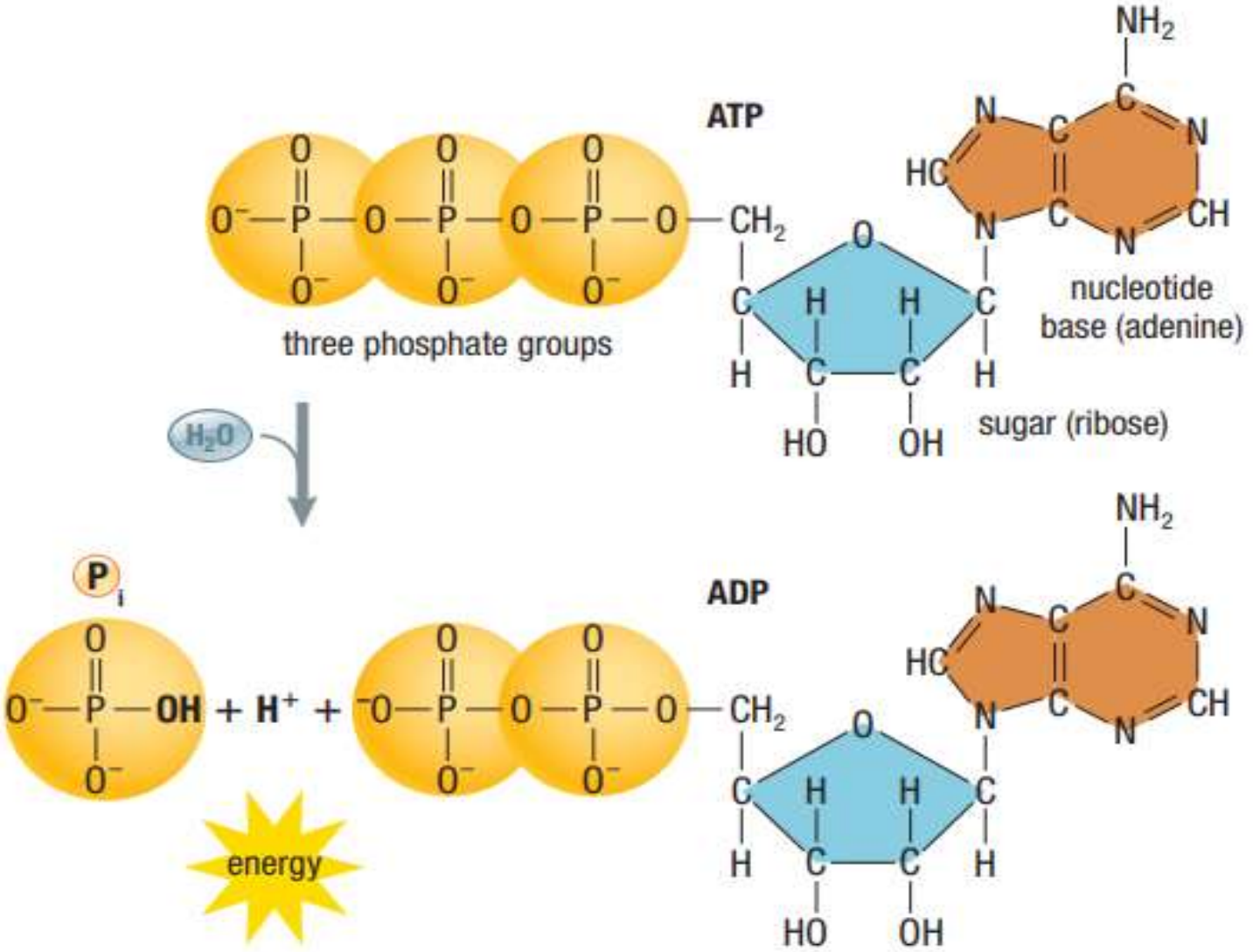
ATP: ENERGY CURRENCY OF THE CELL

ATP (Adenosine Triphosphate): the main energy source for all living organism to power up almost every cellular function**.**

Table Types of Work Performed by ATP

Mechanical work	Transport work	Chemical work
• beating of cilia or movement of flagella • contraction of muscle fibres • movement of chromosomes during mitosis/meiosis	• process of pumping substances across membranes against their concentration gradient	• process of supplying chemical potential energy for non-spontaneous, endergonic reactions, including protein synthesis and DNA replication

ATP HYDROLYSIS AND FREE ENERGY



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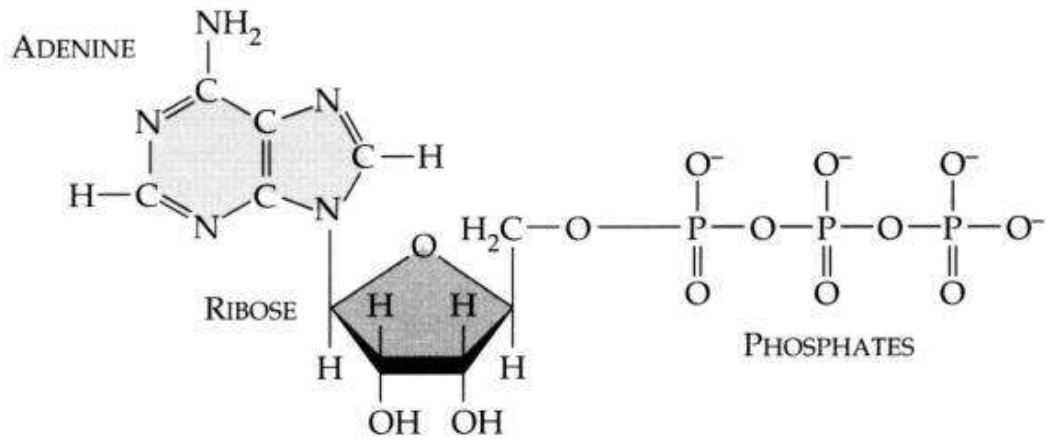
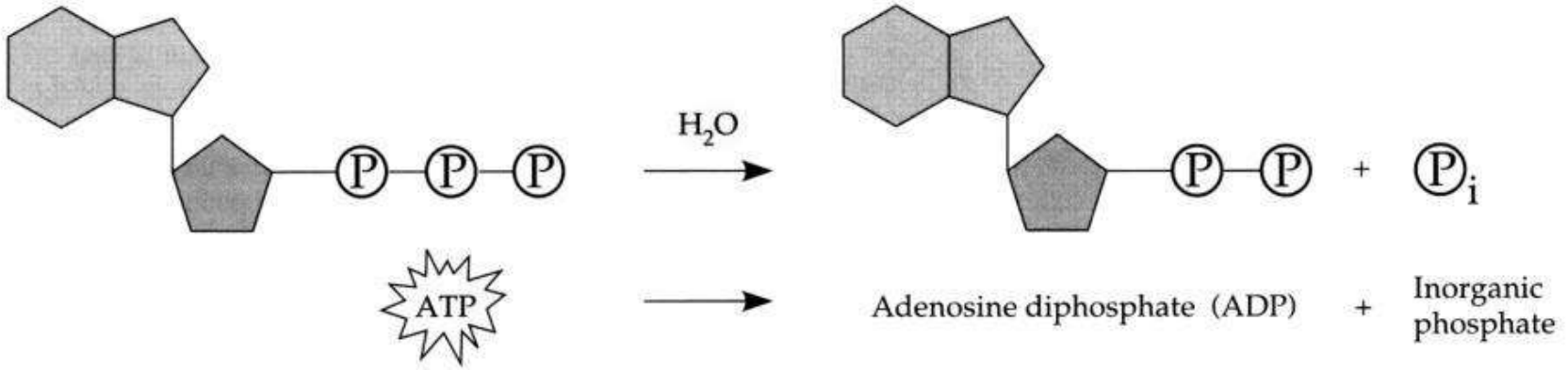


Adenosine triphosphate (ATP)



ATP HYDROLYSIS AND FREE ENERGY

The total free energy is produced from 1 molecule of ATP:

$$ATP + H_2O \rightarrow ADP + P_i \quad \Delta G = -30.5\ kJ/mol$$

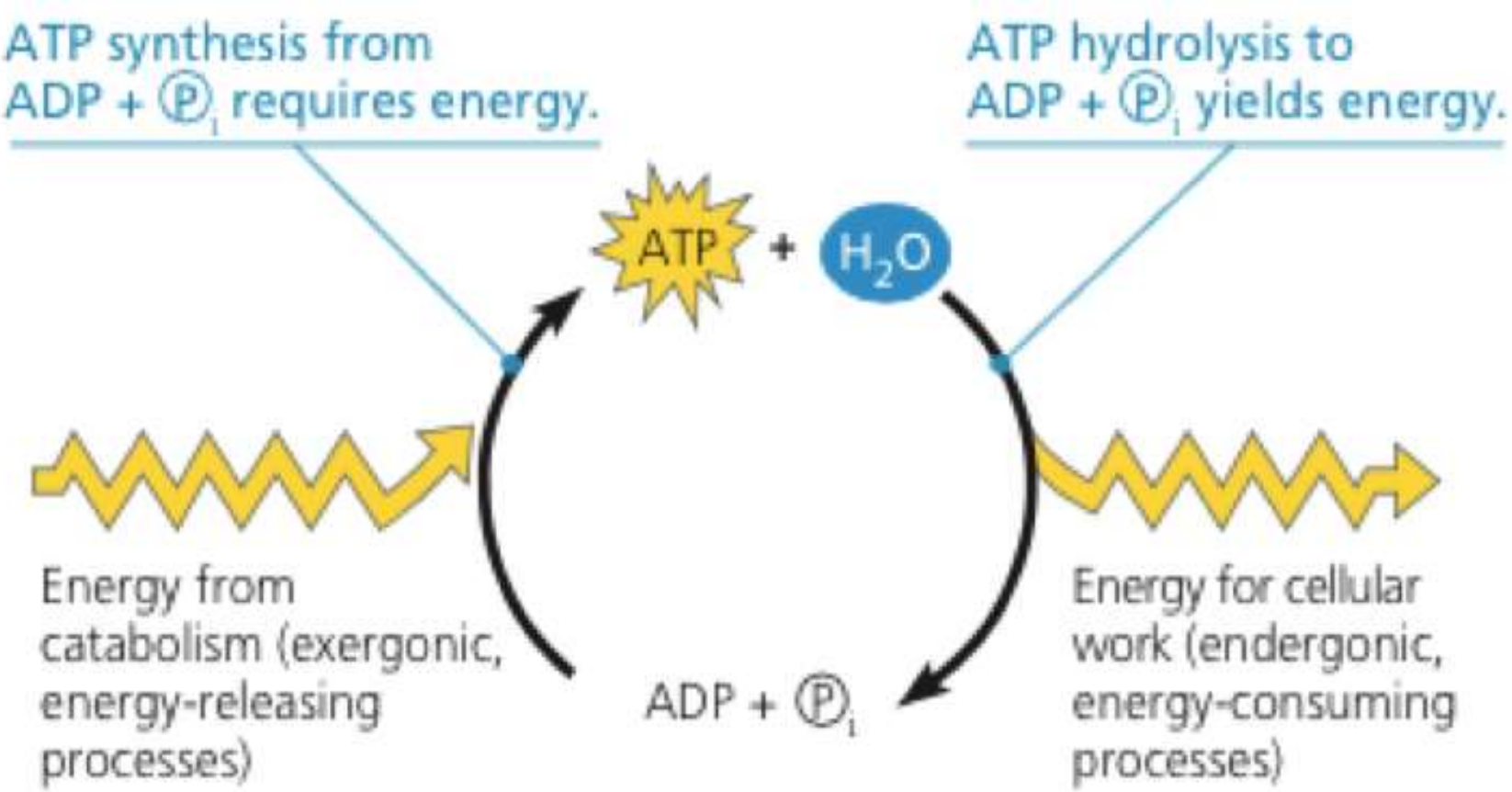
Phosphorylation: is the chemical addition of a phosphoryl group **(PO3-)** to an organic molecule .

The **removal** of a phosphoryl group is called **dephosphorylation.**

Both phosphorylation and dephosphorylation are carried out by enzymes (e.g**., kinases, phosphotransferases**).

REGENERATION OF ATP

ATP cycle: The process of phosphorylating ADP to form **ATP** and removing a phosphate from **ATP** to form ADP in order to store and release energy respectively is known as the **ATP cycle.**



REGENERATION OF ATP

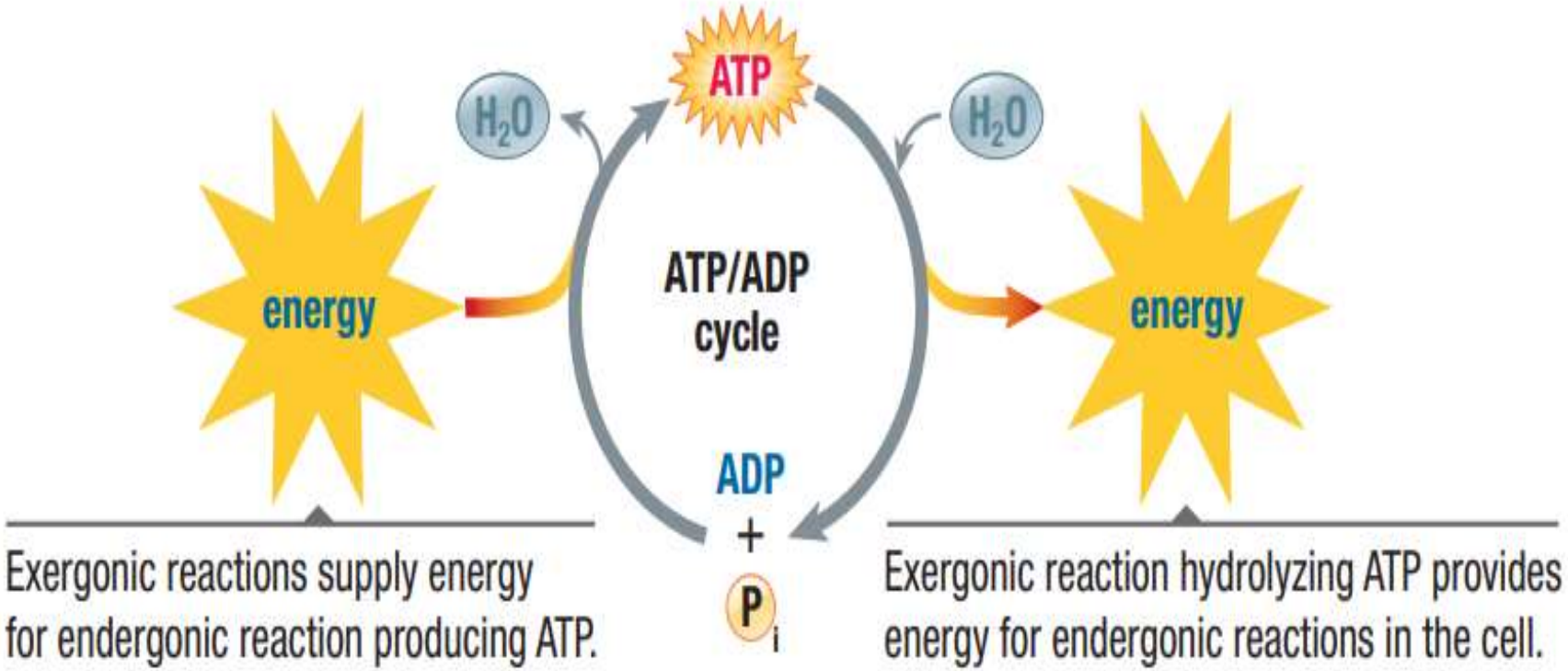


Figure The ATP cycle couples reactions that release free energy (exergonic) to reactions that require free energy (endergonic).

ENZYMES AND ACTIVATION ENERGY

Enzymes as Catalysts: Enzymes are biological catalysts that speed up or slows the chemical reaction and remained unchanged at the end of the chemical reaction.

Maud Menten: A Canadian scientist who explained the fundamental role of enzymes and developed a mathematical equation to estimate the rate enzyme reaction (Enzyme kinetic).

Naming: the name of the enzyme comes from the name of the substrate that the enzyme works on and ends in the suffix ***–ase.*** *E.g: Maltose (substrate) ; maltase (enzyme)*

ENZYMES

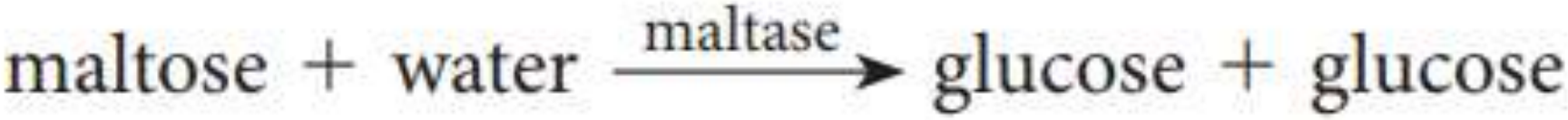
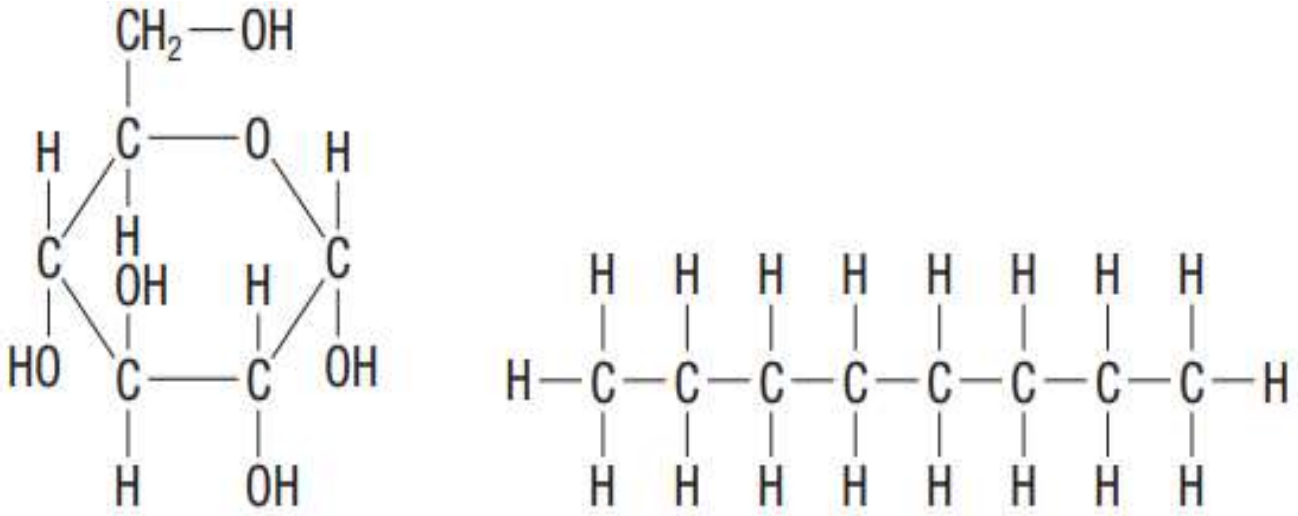


Table 1 Characteristics of Enzymes

Enzymes DO	• lower the activation energy of a reaction • increase the rate of a spontaneous (exergonic) reaction
Enzymes DO NOT	• alter the products of a reaction • supply free energy (ΔG) to a reaction • make an endergonic reaction proceed spontaneously

FOOD AS FUEL

Glucose is like gasoline: they have a common feature: C-H bonds. They have a great deal of potential energy because of their structure and bond type.



(a) glucose **(b)** octane

Figure (a) Glucose and (b) octane (a component of gasoline) are valuable fuels due to the presence of easily accessible carbon-hydrogen (C–H) bonds.

ENERGY AT DIFFERENT ENERGY LEVEL

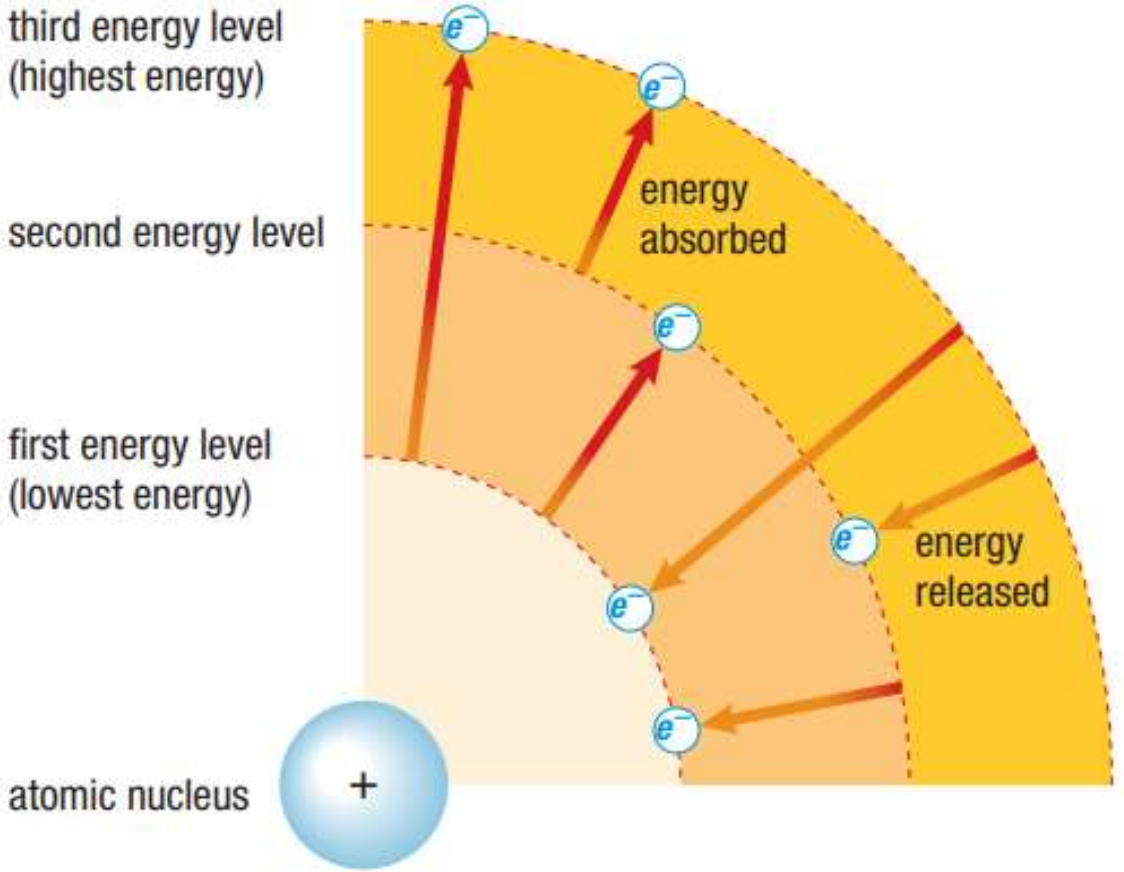


Figure Electrons that absorb energy move to a higher energy level, which is farther away from the nucleus. Electrons that release energy move closer to the nucleus. Electrons can only exist in discrete energy states.

ENERGY CHANGES DURING OXIDATION

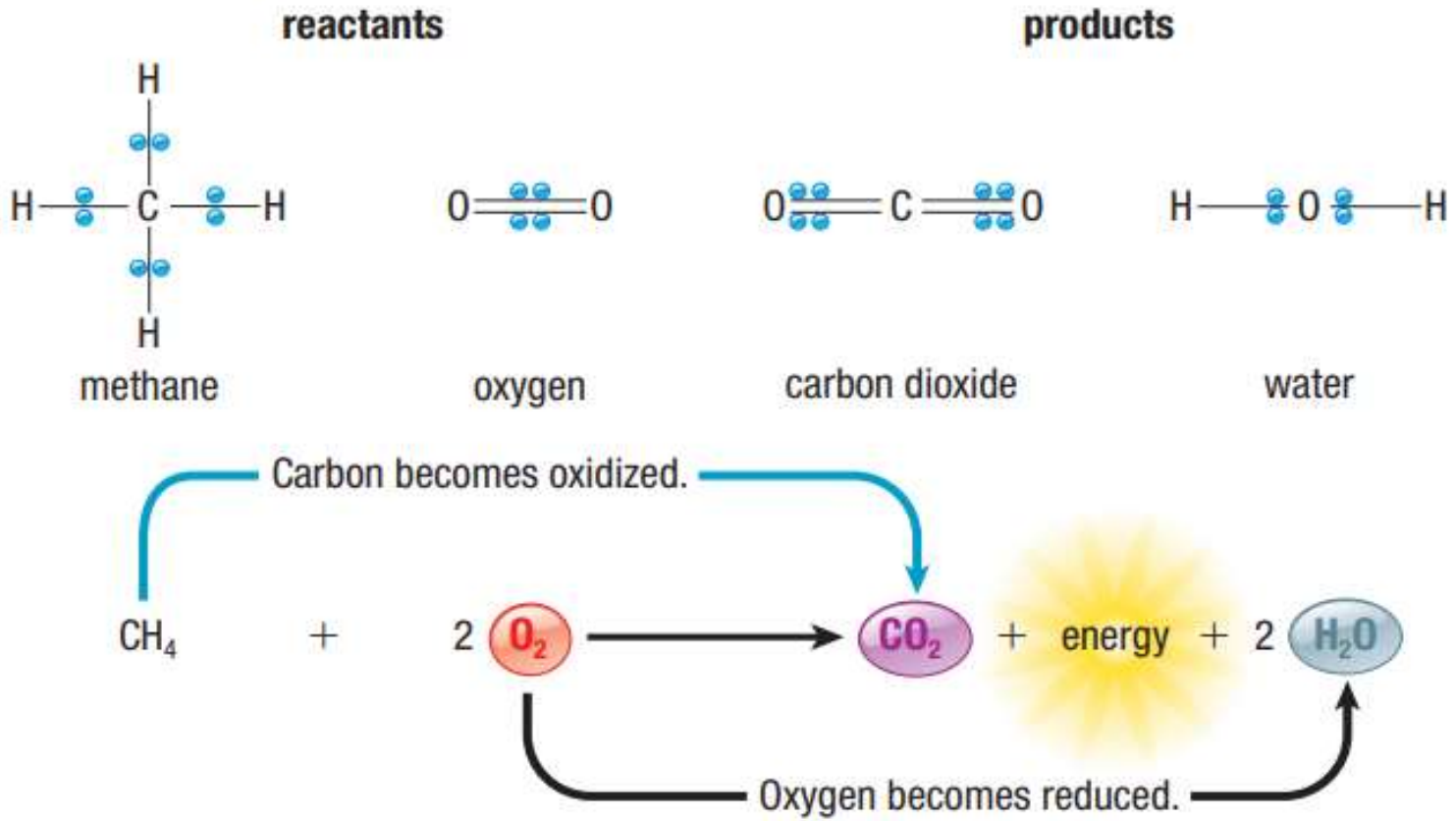


Figure This diagram shows the relative loss and gain of electrons in a redox reaction in which methane reacts with oxygen. The carbon in the methane molecule is oxidized, and the oxygen is reduced. The dots indicate the positions of the electrons that are involved in the covalent bonds of the reactants and products.

RAPID COMBUSTION AND CONTROLLED OXIDATION

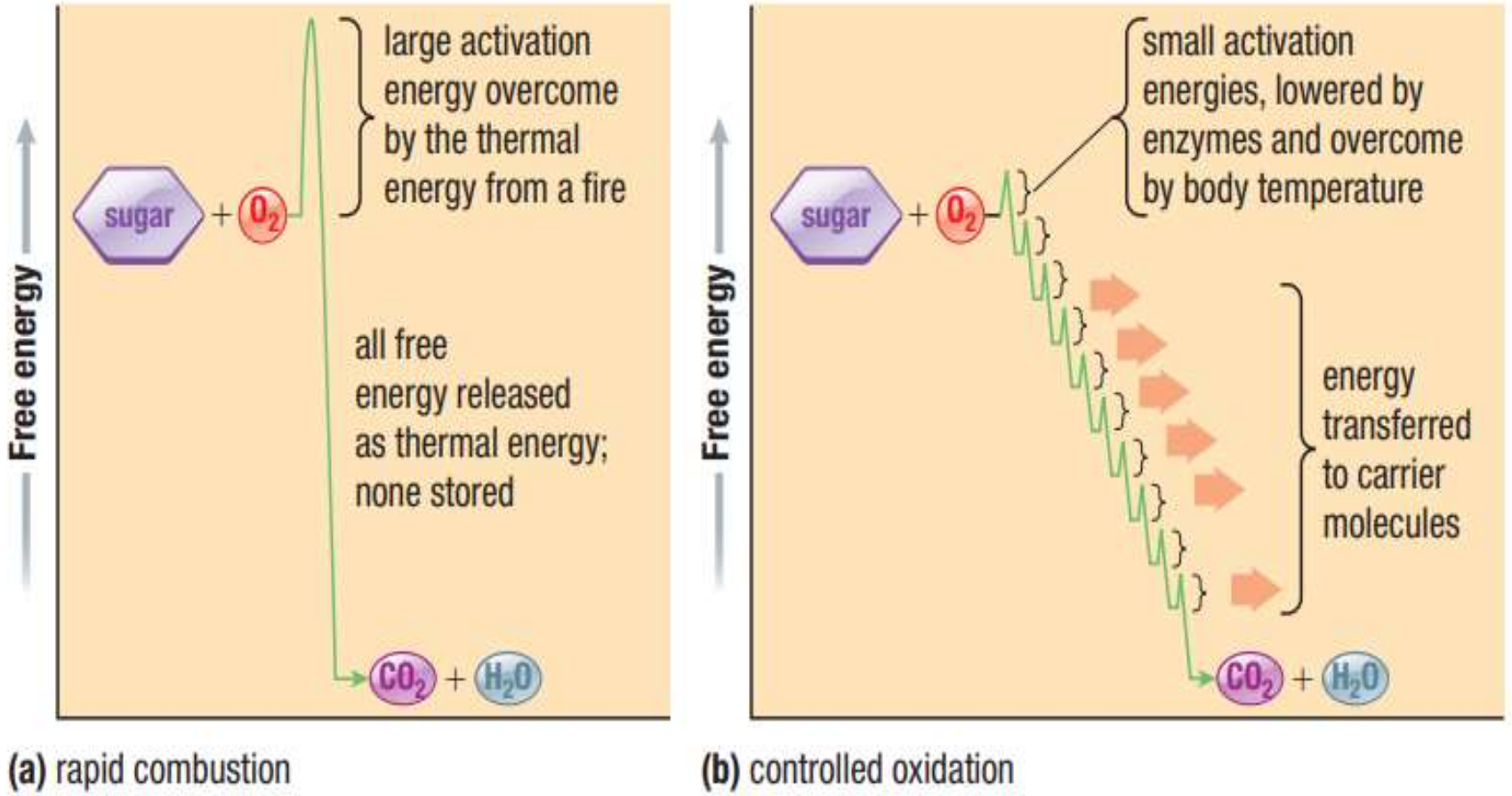
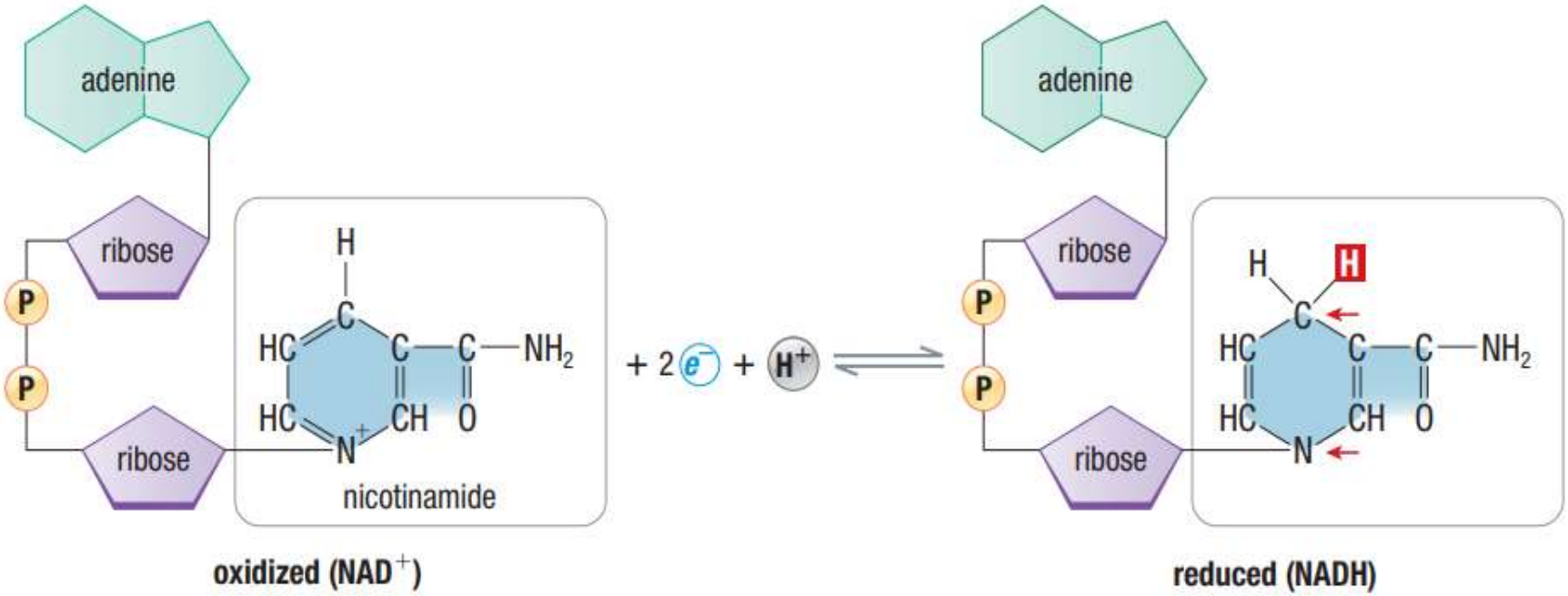


Figure A comparison of the oxidation of glucose by (a) rapid combustion (burning) and (b) controlled oxidation

ENERGY CARRIERS

Dehydrogenase: an enzyme that oxidizes a substrate and transfers hydrogen ions to an accepter. E.g coenzyme NAD^+ (nicotinamide adenine dinuleotide)



$$NAD^+ + 2e^- + H^+ \underset{\text{oxidation of NADH}}{\overset{\text{reduction of } NAD^+}{\rightleftharpoons}} NADH$$

Figure Structure of the electron carrier NAD^+ and its fully reduced form, NADH

ACTIVITY

Chapter# 3:
Self quiz (q.1-20)
Pg#159

CELLULAR RESPIRATION

A catabolic metabolism to produce energy from food in living cells (plant and animal).

Cellular respiration is a set of metabolic reactions and processes that take place in the cells of organisms to convert biochemical energy from nutrients into adenosine triphosphate (ATP), and then release waste products.

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O \qquad \Delta G = -2870\ \text{kJ/mol}$$

a glucose molecule is gradually broken down into carbon dioxide and water. Along the way, some ATP is produced directly in the reactions that transform glucose. Much more ATP, however, is produced later in a process called oxidative phosphorylation.

Total energy produced from I mol. Of glucose is: -2870 kJ/mol

Types of cellular respiration

Aerobic

- Occurs in the presence of oxygen
- Maximizes ATP output
- Each cycle through aerobic respiration makes 36 ATP molecules.

Anaerobic

- Happens without oxygen
- Minimal ATP output (since it occurs without additional oxygen)
- Each cycle through anaerobic respiration makes 2 ATP molecules.

https://www.youtube.com/watch?v=n0uABIlfj44

https://www.youtube.com/watch?v=NN5Y57NbnrU

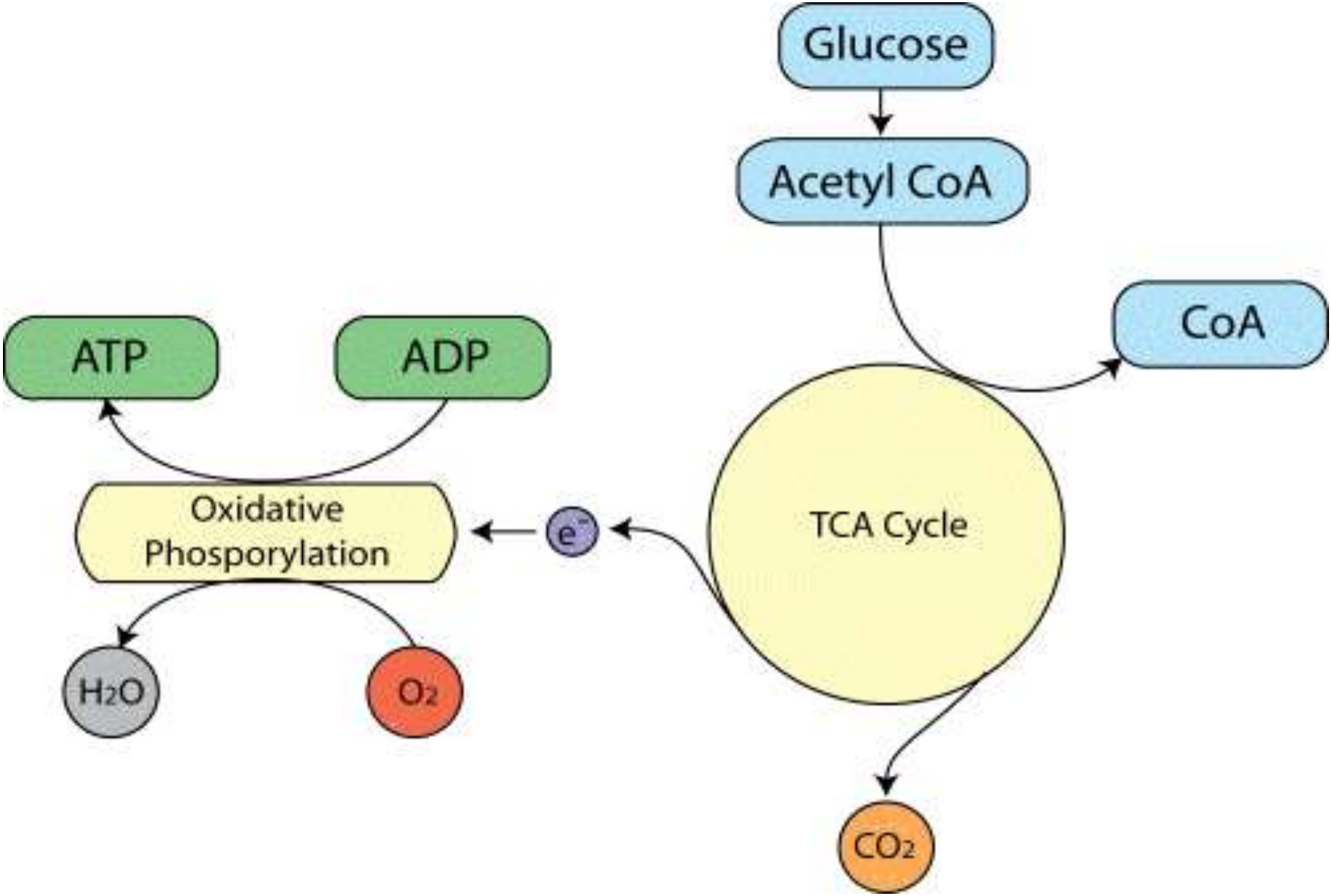
OVERVIEW OF RESPIRATION

Overall, cellular respiration can be broken down into three main stages:

A. glycolysis- the anaerobic (absence of oxygen) stage where a small amount of ATP is produced along with the molecule pyruvate which moves on to the next part of the process

B. pyruvate oxidation and the Krebs cycle- this begins the aerobic portion where the pyruvate molecule is first altered and then enters a cyclical pathway which generates some ATP along with the high energy molecules of NADH

C. electron transport chain and chemiosmosis- the high energy NADH molecules are used to generate ATP in a process called oxidative phosphorylation


Glucose
Acetyl CoA
CoA
ATP
ADP
Oxidative Phosporylation
e⁻
TCA Cycle
H2O
O2
CO2


THE END