Chapter # 8
Bioenergetics

After studying this chapter, students will be able to:

- Describe the importance of oxidation-reduction reactions.
- Explain ATP as a molecule that is the chief energy currency of all cells.
- Describe photosynthesis.
- State the role of chlorophyll found in chloroplast.
- State the equation (in words or symbols) for photosynthesis.
- Describe respiration.
- Describe anaerobic respiration and state its importance.
- State the equation (in words or symbols) for aerobic respiration.
- Compare aerobic and anaerobic and anaerobic respiration with reference to the amount of energy released.
- List ways in which respiratory energy is used in the body.
- Compare respiration and photosynthesis.

Subject Questions & Answers

8.1 ATP: The Cell's Energy Currency

Q.1: What do you know about Bioenergetics.

Ans. Bioenergetics is the study of how living organisms acquire, convert, store, and utilize energy to fuel their life processes. Organisms obtain energy primarily from their surroundings. Plants capture sunlight through photosynthesis, while animals and other organisms consume food. This energy is then converted into usable chemical energy, stored in molecules like ATP (adenosine triphosphate). ATP act as a ready source of energy. Cells can use ATP whenever they need energy for processes such as growth, movement, repair, and reproduction.

Q.2: Describe the importance of oxidation reduction reactions.

Ans. Oxidation-reduction (redox) reactions are fundamental to the metabolism of organisms. In these reactions, electrons are transferred between molecules. In oxidation, molecule loses electrons and in reduction, it gains electrons. This electron flow is essential for generating energy in the form of ATP during processes like cellular respiration and photosynthesis.

Q.3: Explain ATP as a molecule that is the chief energy currency of all cells.

Ans. ATP The Cell's Energy Currency:

Cells use a special energy currency for their reactions. This currency is a nucleotide called adenosine triphosphate (ATP).

Uses of ATP:

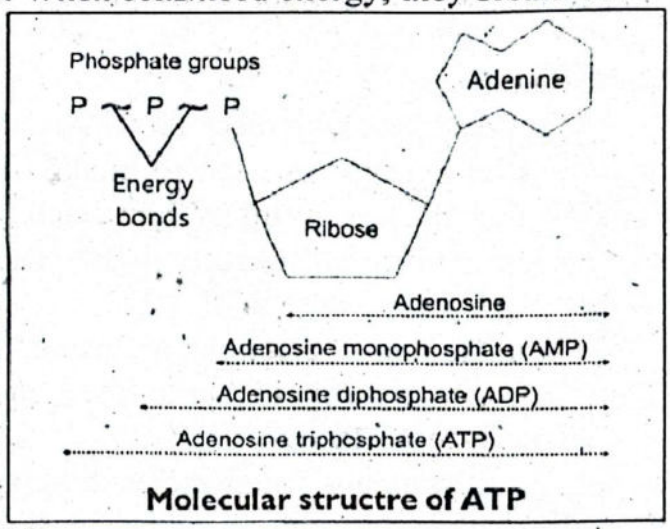
When cells store energy, they make ATP. When cells need energy, they break ATP.

Structure of ATP:

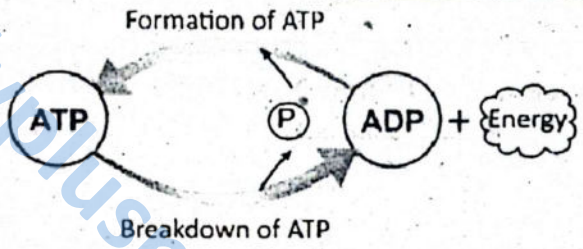
ATP molecule has three subunits

- Adenosine (a nitrogen containing base)
- Ribose (a five- carbon sugar)
- Three phosphate groups.

In the molecule of ATP, the covalent bonds between **two phosphates** are high-energy bonds. When one of these bonds is broken, inorganic phosphate (Pi) separates and energy is released.



Molecular structre of ATP



ATP-ADP Cycle

The breaking of one phosphate bond releases about 7.3 kcal (7,300 calories) per mole of ATP.

$$ATP + H_2O \longrightarrow ADP + Pi + \text{energy (7.3 kcal/mole)}$$

In common energy reactions only the outer P-P high-energy bond breaks. When this happens, ATP becomes ADP (adenosine diphosphate) and one Pi is released. In some cases, ADP is further broken down to AMP (adenosine monophosphate) and Pi:

$$ADP + H_2O \longrightarrow AMP + Pi + \text{energy (7.3 kcal/mole)}$$

Cells get energy from the oxidation of food. They store this energy by combining ADP with Pi to form ATP. So, we can summarize that ATP is made during energy-releasing processes and is broken down during energyconsuming; processes. In this way ATP transfers energy between metabolic reactions.

8.2 Photosynthesis

Q.4: Outline the processes involved in Photosynthesis.

Ans. Photosynthesis:

Photosynthesis is the synthesis of glucose from carbon dioxide and water in the presence of sunlight (and chlorophyll), with oxygen as a by-product.

Photosynthesis is carried out by green plants, algae and some bacteria. *It is the most* important metabolic reaction and all life depends on it.

Equation of Photosynthesis: A simple general equation for photosyntehsis is as follows:

Mechanism of Photosynthesis

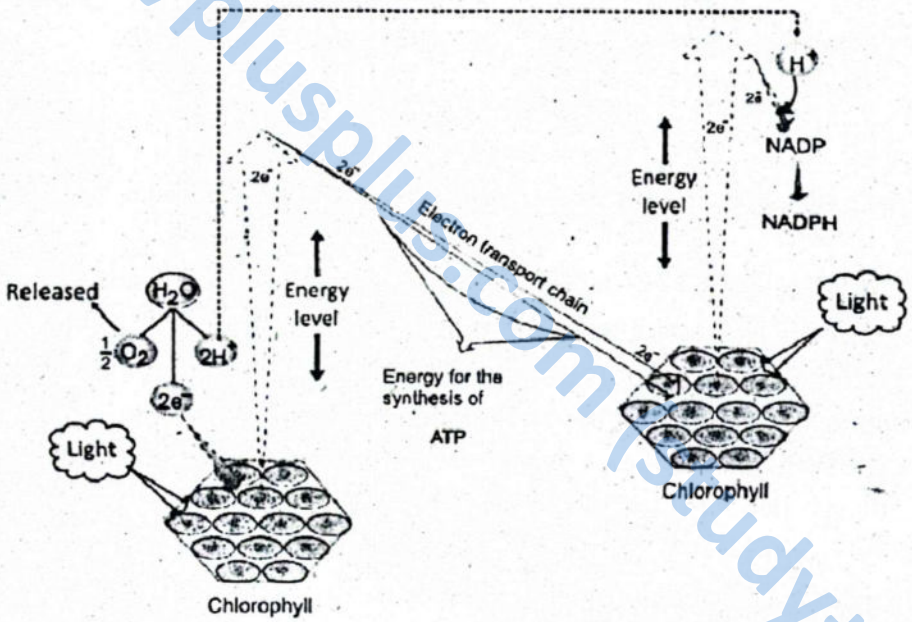
Photosynthesis occurs in two phases:

- Light reactions
- Dark reactions

Light Reactions:

Light reactions take place on the thylakoid membranes of chloroplasts. During light reaction, light energy is used to, make high-energy molecules (ATP and NADPH). Following are the key events of light reactions:

- When chlorophyll absorbs light, reactions start in it. High energy electrons are released from chlorophyll.
- The high energy electrons are passed to an electron transport chain. In this chain, electrons pass from higher to lower energy level. They release energy which is used to produce **ATP.**
- Light also breaks water molecule. **Oxygen** is released while hydrogen atoms give electrons to chlorophyll and become hydrogen ions.
- The electrons of chlorophyll, after the production of ATP, and the hydrogen ions of water are used to reduce a NADP into **NADPH.**

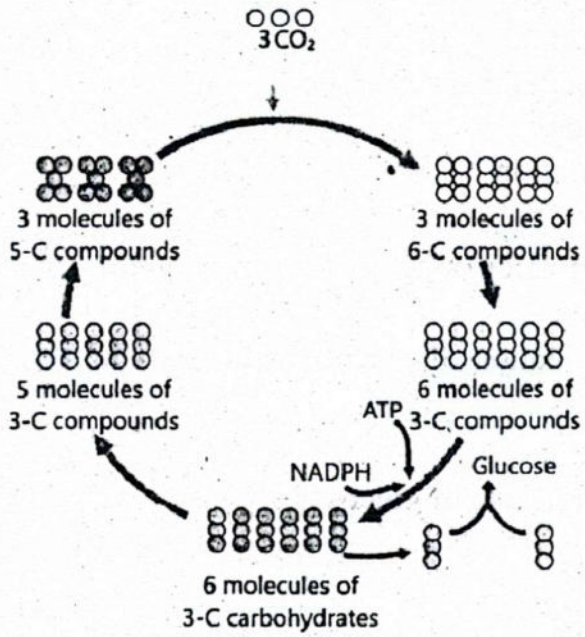


Light reaction of photosynthesis

Dark Reactions:

Dark reactions take place in the stroma of the chloroplasts. During this phase, carbon dioxide is reduced to make glucose. The details of dark reactions were discovered by Melvin Calvin. Following is the summary of dark reactions:

- CO_2 molecules combine, with 5-carbon compounds to form 6-carbon compounds. This 6-carbon compound is unstable and splits into two 3-carbon compounds.
- The 3-carbon compounds are reduced to 3-carbon carbohydrates by using ATP and hydrogen from NADPH. The 3-carbon carbohydrates are used to make glucose.
- The 3-carbon carbohydrates are also used to regenerate the original 5- carbon compounds. This step also utilizes ATP.



Dark reactions of photosynthesis

Q.5: What is the role of chlorophyll in photosynthesis?

Ans. Role of chlorophyll in photosynthesis:

The thylakoid membranes of chloroplasts contain pigments.

Main Pigment: Chlorophyll-a is the main pigment.

Accessory Pigment: Chlorophyll-b and carotenoids are the accessory pigments.

Role of Pigments:

Pigments absorb sunlight and convert it into chemical energy for photosynthesis. Only about 01% of the light falling on the leaf surface is absorbed, the rest is reflected or transmitted. The blue and red lights carry out more photosynthesis.

Different pigments absorb different wavelengths of light.

- Chlorophyll-a absorbs light of blue and red wavelengths.
- Accessory pigments absorb the wavelengths wavelengths which are not absorbed by chlorophyll-a.

Formation of ATP and reduction of NADP to NADPH:

When a pigment absorbs light, reactions occur in it and its electrons are released. The high energy electrons pass through electron transport chain and their energy is used for the formation of ATP and for reducing NADP to NADPH.

8.3 Cellular Respiration

Q.6: What is cellular respiration? Explain its types.

Ans. Cellular Respiration:

Organisms get energy by breaking the C-H bonds of food. For this purpose, they carry out the oxidation of food inside cells. This oxidation of food is called cellular respiration. The most common food used by cells to get energy is glucose.

Types of Cellular Respiration:

There are two types of cellular respiration:

1. Aerobic respiration
2. Anaerobic respiration

1. Aerobic respiration:

Cellular respiration occurring in the presence of oxygen is called aerobic respiration.

It is the complete oxidation of glucose with maximum release of energy. It takes place in two phases:

First Phase:

In the first phase, a molecule of glucose (6-C) is broken down into two molecules of pyruvic acid (3-C).

Second Phase:

In the second phase, the molecules of pyruvic acid are completely oxidized (all C-H bonds are broken) and all energy is released.

2. Anaerobic Respiration (Fermentation)

Cellular respiration that occurs in the absence of oxygen is called anaerobic respiration.

In anaerobic respiration, glucose is incompletely oxidized with less amount of energy released. It takes place in two phases:

First Phase:

Its first phase is exactly similar to that of aerobic respiration. A molecule of glucose is broken down into two molecules of pyruvic acid (3-C).

Second Phase:

In the secohd phase, pyruvic acid may be treated in two ways:

- Alcoholic Fermentation
- Lactic acid Fermentation

Alcoholic Fermentation

During anaerobic respiration in bacteria and yeast, pyruvic acid is further broken down into alcohol (C_2H_5OH) and CO_2. This type of anaerobic respiration is called alcoholic fermentation.

$$\underset{\text{Pyruvic acid}}{2(C_3H_4O_3)} \longrightarrow \underset{\text{Ethyl Alcohol}}{2(C_2H_5OH)} + 2CO_2$$

Lactic acid Fermentation

During anaerobic respiration in the skeletal muscles of humans and other animals, pyruvic acid is converted into lactic acid ($C_2H_6O_3$). This type of anaerobic respiration is called lactic acid fermentation.

$$\underset{\text{Pyruvic acid}}{2(C_3H_4O_3)} + 4H \longrightarrow \underset{\text{Lactic acid}}{2(C_3H_6O_3)}$$

Q.7: Describe Importance of Fermentation (Anaerobic Respiration).

Ans. Importance of Fermentation (Anaerobic Respiration)

1. The environment of Earth did not have free oxygen (O_2) in the early phases of life. The early organisms respired anaerobically and got energy for their life.
2. Even today, some organisms including some bacteria and some fungi get energy from anaerobic respiration and are called anaerobes.
3. When skeletal muscles of humans work hard (during exercise) but oxygen supply is not sufficient to fulfil the demand, the skeletal muscles carry out anaerobic respiration to get energy.
4. Scientists have used fermentation in fungi and bacteria for making useful products for mankind.

Examples:

- Fermentation in bacteria is used for making cheese and yogurt.
- Fermentation in yeasts is used in brewing and baking industries.
- The soy sauce is made through the fermentation by a fungus.

Q.8: Outline the mechanism of aerobic respiration.

Ans. Aerobic Respiration:

Cellular respiration occurring in the presence of oxygen is called aerobic respiration.

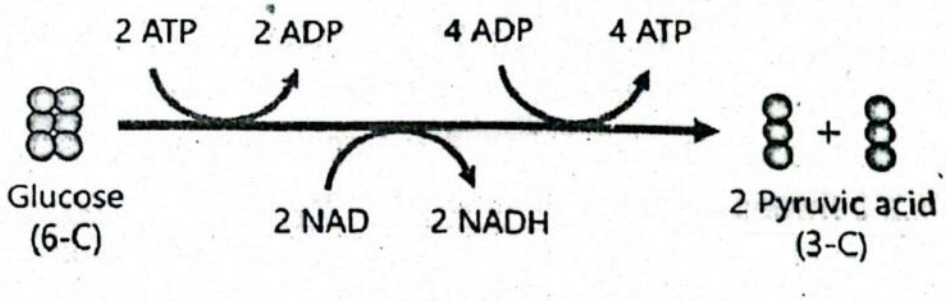
Mechanism of Aerobic Respiration:

There are three main steps of aerobic respiration.

1. Glycolysis
2. Krebs cycle
3. Electron transport chain

1. Glycolysis:

In the first step, the glucose (6C) molecule is broken. It results in two molecules of pyruvic acid (3C) with 2 ATPs and 2 molecules NADH. This process is called glycolysis and it occurs in cytoplasm. Oxygen is not required for glycolysis. That is why, it also occurs in anaerobic respiration.

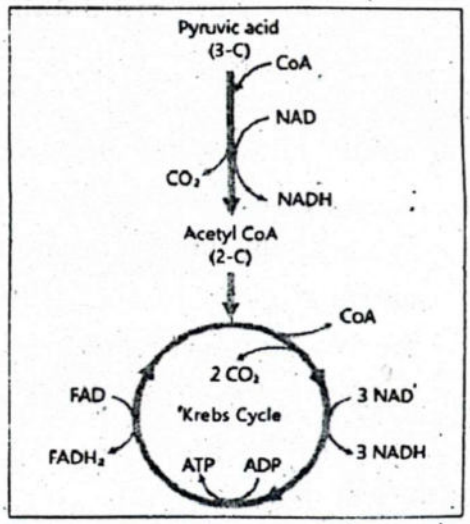


Summary of Glycolysis

2. Krebs Cycle

When oxygen is available, the molecules of pyruvic acid move from cytoplasm to the matrix of mitochondria. Here, a series of reaction called Krebs cycle (discovered by a British scientist Sir Hans Krebs) occurs. Before Krebs cycle, each pyruvic acid is converted into **acetyl coenzyme-A,** carbon dioxide and NADH.

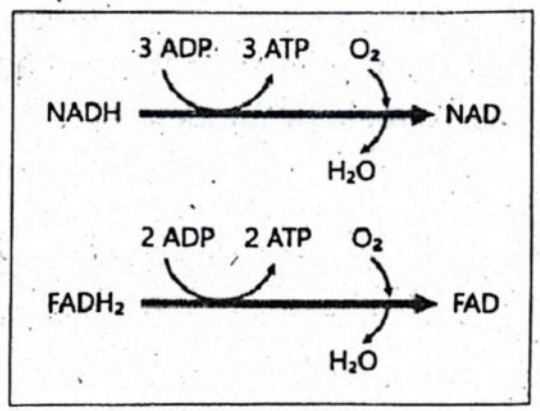
In Krebs cycle, the acetyl coenzyme-A is completely oxidized to carbon dioxide. It results in the formation of ATP and energy-rich compounds i.e. NADH and $FADH_2$ (Flavin Adenine Dinucleotide - reduced).



Summary or Krebs cycle

3. Electron Transport Chain

This step occurs on the membranes of mitochondria. During it, NADH and $FADH_2$ change back to NAD and FAD by releasing electrons and ' hydrogen ions. The released electrons pass through an electron transport chain and release energy. This energy is used to make ATP. At the end of chain, electrons and hydrogen ions combine with oxygen and form water.



Electron transport chain

Q.9: Discuss the use of respiratory energy in the body.

Ans. Use of respiratory energy in the body:

Respiratory energy (ATP), produced during cellular respiration is used in various ways:

1. Muscle contractions and movement
2. Active transport of substances
3. Synthesis of biomolecules
4. Replication of DNA and mitosis
5. Transmission of nerve impulse
6. Maintenance of body temperature
7. Break down and elimination of toxins from the body.

Q.10: Give difference between aerobic and anaerobic respiration.

Ans. Difference between aerobic and anaerobic respiration.

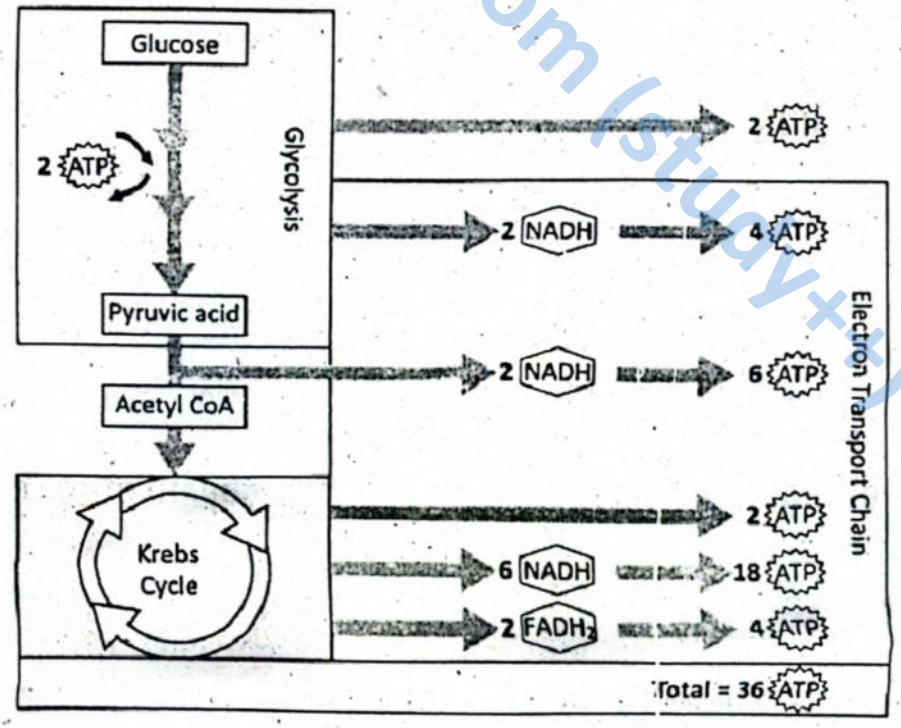
	Aerobic respiration	Anaerobic respiration
Presence of Oxygen	Yes	No

Number of ATP as net profit	36	02
Final Products	CO_2; H_2O	Lactic acid of Ethanol + CO_2
Site of occurrence	Cytoplasm and Mitochondria	Cytoplasm
Importance	Major source of energy for most organism	• Source of energy for anaerobic organisms. • Source of energy for aerobic organisms in short supply of O_2. • Source of useful products (ethanol cheese)

Q.11: Compare the processes of respiration and photosynthesis.

Ans. Difference between Photosynthesis and Respiration

Characteristics	Photosynthesis	Respiration
Type of metabolism	Anabolic process	Catabolic process
Energy investment/ production	Energy is store in the form of bond energy	Bond energy of food is transformed into ATP
Organism (capable of performing this process)	Some bacterial all algae and all plants.	All organism
Site of occurrence	Chloroplasts in green parts only	In cytoplasm and mitrochondria in all cells
Time of occurrence	In daytime only in the presence of light.	All the time



An overview of number of ATPs reduced by the aerobic oxidation of glucoss

1. Electrons can be a source of energy release. Explain with an example.

Ans. Electron transport chain is the final step of cellular respiration. In electron transport chain NADH and $FADH_2$ release electrons and hydrogen ions. These electrons are taken up by a series of electron carriers. When electrons move through the series of electron carriers they lose energy, which is used to synthesize ATP molecules. At the end of the chain, electrons and hydrogen ions combine with molecules oxygen and form water.

2. Discuss energy budget of aerobic and anaerobic respiration.

Ans. Energy Budget of Aerobic Respiration:

Each NADH molecule produces three ATP molecules in electron transport chain. While each NADH generated in glycolysis gives profit of two ATP molecules because it has to be transported across the mitochondrial membrane and it costs one ATP. Each $FADH_2$ molecules produces two ATP molecules.

Energy Budget of Anaerobic Respiration:

During anaerobic oxidation of a glucose molecule only 2 ATP molecules are gained as the net profit. It is because there is no krebs cycle and electron transport chain in anaerobic respiration.

3. Describe the three usage of respiration energy in the body of organisms.

Ans. Usage of Respiratory Energy in the body of organisms:

Number of processes requires energy in the body of an organism. Body provides it from respiratory energy

Following are processes which utilize respiratory energy.

- **Synthesis of molecules:**
  Formation of different molecules as well. as large molecules from small molecules requires energy.
- **Cell division:**
  During cell division formation of large molecules like DNA and protein takes place which require energy as well as movement. of chromosomes also require energy.
- **Movements:**
  In animals, energy is needed to make muscles contract. While in plants, energy is needed for transport of substances in the phloem.

4. What is energy currency of cell? Describe chemical process of energy transmission.

***Ans. Energy Currency* of cell:**

ATP (adenosine triphosphate) is the energy currency of the cell. In living organisms, energy is stored in ATP. In organisms, energy is liberated during an oxidation reaction. This energy is utilized by molecules called ADP (adenosine

diphosphate) to form a bond with phosphate (P). As a result ADP become ATP, energy of oxidation is now stored in ATP.

Energy stored in ATP:

The amount of energy stored is 7.3 Kcal/ mole. This stored energy in ATP will be utilized by living organism for performing any types of work e.g; transport of molecules against the concentration gradient. The energy is now become free (liberated) by breaking ATP molecule.

ATP → ADP + P + Energy (7.3 kcal/mole) so, the formation of ATP is energy consuming process and breakdown of ATP is energy releasing process.

5. What would happen if Krebs cycle stops?

Ans. If the Krebs cycle stops, it can lead to a number of problems including:

Cell death:

An unbalanced Krebs cycle can cause severe changes to mitochondria and lead to cell death.

Toxic buildup:

A deficiency in the enzymes involved in the Krebs cycle can lead to build up of toxic substances.

Decreased energy production:

A deficiency in the enzymes involved in the Krebs cycle can lead to a decreased ability of the body to produce energy.

Collapse of energy:

If NAD is not generated for the Krebs cycle, the total energy obtained from the break down of fats, proteins and carbohydrates will collapse.

Information

In 1941, the Nobel prize winner, Fritz Lipmann proposed that ATP is the main energy-transfer molecule in the cell.

Nicotinamide adenine dinucleotide (NAD):
It is a coenzyme. One form of this coenzyme also carries phosphate. It is called NADP.

Pigments are the substances that absorb visible light. Different pigments absorb light of different wavelengths (colours).

In anaerobic -process, many *C-H* bonds of food are left unbroken.

Yeast and bacteria can ferment sugars of berries to alcohol. Birds eating these berries can become quite drunk, as is obvious from their flight pattern.

Key Points

- In oxidation-reduction (redox) reactions, electrons are transferred between molecules.
- In oxidation, molecule loses electrons.
- In reduction, it gains electrons.
- Electron flow (oxidation-reduction) is essential for generating energy.
- ATP is the energy currency of the cells.
- In photosynthesis, water and carbon dioxide combine in the presence of light and chlorophyll and carbohydrates and oxygen are produced.
- During light reactions of photosynthesis chlorophyll captures sunlight and makes ATP.
- During dark reactions carbon dioxide is reduced to make glucose.
- Anaerobic respiration is the incomplete oxidation of glucose in the absence of oxygen while aerobic respiration is the complete oxidation of glucose in the presence of oxygen.
- During glycolysis, glucose is broken down two molecules of pyruvic-acid.
- During Krebs cycle, pyruvic acid molecule is completely broken down into hydrogen ions, high energy electrons and carbon-dioxide.
- During electron transport chain, electrons travel on a series of electron carriers and emit energy, which is utilized to convert ADP into ATP.

Additional MCQs

8.1 ATP: The Cell's Energy Currency

1. The lose of electron from an atom is called:

(a) Reduction (b) Oxidation (c) Metabolism (d) Glycolysis

2. The molecules gain electrons in:

(a) Glycolysis (b) Photosynthesis (c) Reduction (d) Oxidation

3. The energy currency of all cells is:

(a) ATP (b) ADP (c) NADP (d) NADPH

4. It is the study of energy transformation in living organisms.

(a) Glycolysis (b) Histology (c) Physiology (d) Bioenergetics

5. **Fritz Lipmann proposed that ATP is the main energy transfer molecule in the cell in:**
(a) 1939 (b) 1940 (c) 1941 (d) 1942

6. **When cells store energy, they make:**
(a) ADP (b) NADPH (c) ATP (d) NADP

7. **When cells need energy, they break.**
(a) NADP (b) ATP (c) ADP (d) NADPH

8. **Each ATP molecules has subunits:**
(a) 1 (b) 2 (c) 3 (d) 4

9. **The breaking of one phosphate bond releases about Kcal per mole of ATP.**
(a) 7.1 (b) 7.2 (c) 7.3 (d) 7.4

10. **When only the outer P-P high energy bond breaks ATP becomes:**
(a) ADP (b) AMP (c) NADP (d) NADPH

11. **What released when ATP becomes ADP?**
(a) One Pi (b) Two Pi (c) Three Pi (d) Four Pi

12. **ATP stands for:**
(a) Adenosine triphosphate (b) Adenosine diphosphate
(c) Adenosine monophate (d) None of these

13. **During energy releasing process:**
(a) ATP is made (b) ATP is broken down
(c) AMP is made (d) ADP is broken down

14. **It is broken down during energy consuming processes.**
(a) ADP (b) ATP (c) AMP (d) NADP

15. **7.3 Kcal per mole energy is equal to:**
(a) 73 Calories (b) 730 cal (c) 7,300 calories (d) 7,3000 calories

16. **Number of phosphate groups in ATP molecule is:**
(a) 1 (b) 2 (c) 3 (d) 4

17. **It is a nitrogen containing base:**
(a) Ribose (b) Phosphate (c) Adenine (d) Adenosine

18. **In Ribose sugar, number of carbon atom is:**
(a) 4 (b) 5 (c) 6 (d) 7

19. **In one ATP molecule, there are _____ phosphate groups.**
(a) 2 (b) 3 (c) 4 (d) 5

20. **Between two phosphates in one molecule of ATP, there are:**
(a) Ionic bonds (b) Double covalent bonds
(c) Covalent bonds (d) None of these

21. **In some cases, ADP is further broken down to:**
(a) ATP (b) NADP (c) AMP (d) NADPH

22. **In the molecule of ATP, there are covalent bands between:**
(a) 2 phosphates (b) 3 phosphate (c) 4 phosphates (d) 5 phosphate

8.2 Photosynthesis

23. **Which of the following organisms use inorganic raw materials to prepare their organic food?**
(a) Plants (b) Algae (c) Some bacteria (d) All of these
24. **The organic food of autotrophic organisms is in the form of:**
(a) Protein (b) Lipids (c) Fats (d) Carbohydrates
25. **_____ is a by product of photosynthesis?**
(a) Nitrogen (b) Oxygen
(c) Carbon monoxide (d) Carbon dioxide
26. **Photosynthesis occurs in:**
(a) Two phases (b) Three phases (c) Four phases (d) Five phases
27. **_____ is released while hydrogen atoms give electrons to chlorophyll and become hydrogen ions.**
(a) Hydrogen (b) Carbon dioxide (c) Oxygen (d) Nitrogen
28. **The electrons of chlorophyll are used to reduce a NADP into:**
(a) AMP (b) NADPH (c) ATP (d) ADP
29. **Light reactions take place on the:**
(a) Thylakoid (b) Cytosol (c) Mitochondria (d) Stroma
30. **Dark reactions take place in:**
(a) Thylakoid (b) Mitochondria (c) Stroma (d) Ribosome
31. **Nicotinamide adenine dinucleotide is a:**
(a) Enzyme (b) Co-factor (c) Factor (d) Co-enzyme
32. **During light reaction, light energy is used to make:**
(a) ATP and ADP (b) ADP and NADPH
(c) ATP and NADPH (d) NADPH and NADP
33. **During dark reaction, carbon dioxide is reduced to make:**
(a) Oxygen (b) Water (c) Protein (d) Glucose
34. **The details of dark reaction were discovered by:**
(a) Melvin Calvin (b) Fritz Lipmann
(c) Robert Whittaker (d) Ernst Hackle
35. **CO_2 molecules combine with 5 carbon compounds to form:**
(a) 4-carbon compounds (b) 5-carbon compounds
(c) 6-carbon compounds (d) None of these
36. **Each 6-carbon compound splits into:**
(a) Two 3-carbon compounds (b) Three 2-carbon compounds
(c) One 1-carbon and five 5-carbon compounds
(d) None of these

37. **Dark reactions is also known as:**
(a) Glycolysis (b) Calvin cycle
(c) Cell cycle (d) Biogeochemical cycle

38. **The 3-carbon compounds are reduced to 3 carbon carbohydrates by using hydrogen and:**
(a) ADP (b) ATP (c) AMP (d) NADP

39. **During dark reactions the 3-carbon compounds are reduced to _____ carbon carbohydrates.**
(a) 1 (b) 2 (c) 3 (d) 4

40. **The 3-carbon carbohydrates are also used to regenerate the original _____ carbon Compounds.**
(a) 2 (b) 3 (c) 4 (d) 5

41. **It is the main pigment:**
(a) Chlorophyll-a (b) Chlorophyll-b (c) Carotenoids (d) All of these

42. **Only about _____ of the light falling on the leaf surface is absorbed.**
(a) 01 % (b) 02% (c) 03% (d) 04%

43. **Chlorophyll a absorbs light of blue and:**
(a) Coreen wavelengths (b) Violet wavelengths
(c) Red wavelengths (d) Yellow wavelengths

44. **It absorbs light of blue and red wavelengths.**
(a) Chlorophyll-b (b) Carotenoid (c) Chlorophyll-a (d) None of these

8.3 Cellular Respiration

45. **The most common food used by cells to get energy is:**
(a) Protein (b) Glucose (c) Fat (d) Lipid

46. **It is necessary for aerobic respiration.**
(a) Nitrogen (b) Carbo dioxide (c) Carbon monoxide (d) Oxygen

47. **Number of carbon atom in glucose is:**
(a) 2 (b) 4 (c) 6 (d) 8

48. **Number of carbon atom in pyruvic acid is:**
(a) 2 (b) 3 (c) 4 (d) 5

49. **In bacteria and yeast, pyruvic acid is further broken down into alcohol and:**
(a) Carbon dioxide (b) Oxygen (c) Nitrogen (d) Hydrogen

50. **In humans and animals, pyruvic acid is converted into:**
(a) Alcohol (b) Carbon dioxide (c) Lactic acid (d) Oxygen

51. **Soy sauce is made through the fermentation by a:**
(a) Fungus (b) Yeast (c) Bacteria (d) None of these

52. **Its fermentation is used for making cheese and yogurt.**
(a) Yeast (b) Bacteria (c) Fungus (d) a and b both

53. **Fermentation in yeasts is used in:**
(a) Making cheese and yogurt (b) Brewing and baking industries
(c) Soy Sauce (d) Cheese and Soy sauce

54. **The glucose (6c) molecule is broken during.**
(a) Glycolysis (b) Krebs cycle
(c) Electron transport chain (d) Light reaction

55. **Glycolysis occurs in:**
(a) Mitochondria (b) Cytoplasm (c) Ribosome (d) Nucleus

56. **Sir Hans Krebs discovered the:**
(a) Light reaction (b) Dark reaction (c) Glycolysis (d) Krebs cycle

57. **Before Krebs cycle, each pyruvic acid is converted into:**
(a) Acetyl coenzyme A (b) Carbon dioxide
(c) NADH (d) All of these

58. **The first step of aerobic respiration is:**
(a) Krebs cycle (b) Dark reaction
(c) Glycolysis (d) Electron transport chain

59. **It is the last step of aerobic respiration:**
(a) Glycolysis (b) Krebs cycle
(c) Electron transport chain (d) Light reaction

60. **The chemical formula of pyruvic acid is:**
(a) $C_2H_3O_1$ (b) $C_2H_4O_6$ (c) $C_3H_4O_3$ (d) $C_2H_{12}O_6$

61. **The chemical formula of ethyl alcohol is:**
(a) $2(C_2H_5OH)$ (b) $2(CH_4)$ (c) $2(C_3H_6O_3)$ (d) $C_6H_{12}O_6$

62. **The chemical formula of lactic acid is:**
(a) $C_2H_6O_2$ (b) $2(C_3H_6O_3)$ (c) $2(C_2H_4O_3)$ (d) $C_4H_2O_6$

63. **The chemical formula of glucose is:**
(a) $C_6H_{12}O_6$ (b) $C_3H_6O_3$ (c) C_2H_5OH (d) CH_3COOH

64. **Krebs cycle results in the formation of:**
(a) ATP (b) NADH (c) $FADH_2$ (d) All of these

65. **It occurs in the matrix of mitochondria.**
(a) Krebs cycle (b) Glycolysis (c) Light reaction (d) Photosynthesis

66. **This step occurs on the membrane of mitochondria.**
(a) Electron transport chain (b) Glycolysis
(c) Fermentation (d) Photosynthesis

67. **ATP's produced during anaerobic respiration is:**
(a) 18 (b) 2 (c) 36 (d) 24

68. **Number of ATP as net profit during aerobic respiration is:**
(a) 32 (b) 34 (c) 36 (d) 38

69. **Each $FADH_2$ produces ATP:**
(a) 2 (b) 4 (c) 6 (d) 8

70. **Each NADH produces ATP.**
(a) 2 (b) 3 (c) 4 (d) 5

ANSWERS:

1.	(b)	2.	(c)	3.	(a)	4.	(d)	5.	(c)	6.	(c)	7.	(b)
8.	(c)	9.	(c)	10.	(a)	11.	(a)	12.	(a)	13.	(b)	14.	(b)
15.	(c)	16.	(c)	17.	(c)	18.	(b)	19.	(b)	20.	(c)	21.	(c)
22.	(a)	23.	(d)	24.	(d)	25.	(b)	26.	(a)	27.	(c)	28.	(b)
29.	(a)	30.	(c)	31.	(d)	32.	(c)	33.	(d)	34.	(a)	35.	(c)
36.	(a)	37.	(b)	38.	(b)	39.	(c)	40.	(d)	41.	(a)	42.	(a)
43.	(c)	44.	(c)	45.	(b)	46.	(d)	47.	(c)	48.	(b)	49.	(a)
50.	(c)	51.	(a)	52.	(b)	53.	(a)	54.	(a)	55.	(b)	56.	(d)
57.	(d)	58.	(c)	59.	(c)	60.	(c)	61.	(a)	62.	(b)	63.	(a)
64.	(d)	65.	(a)	66.	(a)	67.	(b)	68.	(c)	69.	(a)	70.	(b)

Conceptual MCQs

1. **Through which process organisms get energy?**
(a) Photosynthesis (b) Respiration (c) Transpiration (d) Evaporation

2. **Aerobic respiration occurs in:**
(a) Cytoskeleton (b) Mitochondria (c) Lysosomes (d) Plastids

3. **In cellular respiration food is oxidized to:**
(a) O_2 (b) CO_2 (c) H_2 (d) H_2O

4. **In which process oxygen is released as a by product?**
(a) Photosynthesis (b) Respiration (c) Fermentation (d) Reproduction

5. **The main photosynthetic pigment is:**
(a) Chlorophyll-a (b) Chlorophyll-b (c) Carotenoid (d) a and b both

ANSWERS:

1.	(b)	2.	(b)	3.	(b)	4.	(a)	5.	(a)

Additional Short Questions

8.1 ATP: The Cell's Energy Currency

1. **What is bioenergetics?**

Ans. The study of energy transformation in living organisms is called bioenergetics.

2. Who proposed that ATP is the main energy transfer molecule in the cell?

Ans. Fritz Lipmann proposed that ATP is the main energy transfer molecule in the cell.

3. Differentiate between oxidation and reduction.

Ans. Oxidation:

The loss of electrons is called oxidation.

Reduction:

The gain of electrons is called reduction.

4. Describe the molecular structure of ATP.

Ans. Each ATP molecule has three sub units.

(a) Adenine (a double ringed nitrogen containing base)

(b) Ribose (a five-Carbon sugar)

(c) Three phosphate groups.

5. What does ATP stand for?

Ans. ATP stands for adenosine triphosphate.

6. What does ADP stand for?

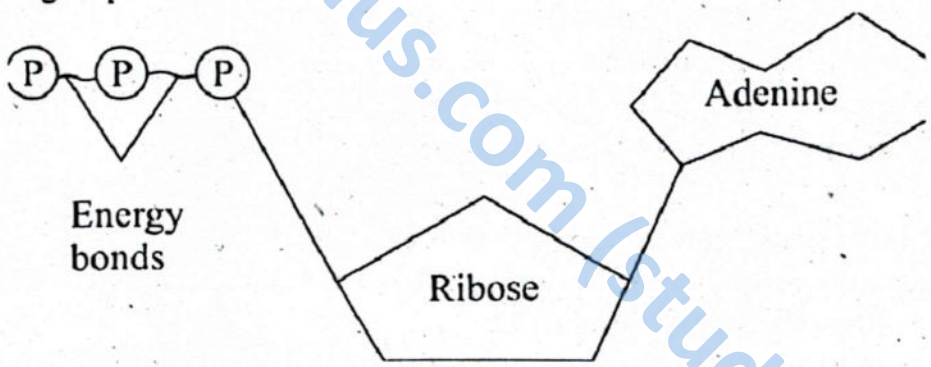
Ans. ADP stands for adenosine diphosphate.

7. What does AMP stand for?

Ans. AMP stands for adenosine monophosphate.

8. Draw molecular structure of ATP.

Ans. Phosphate groups



9. Which band is present between two phosphates in the molecule of ATP?

Ans. Covalent bonds are present between two phosphates in the molecule of ATP.

10. What does happen when the covalent bonds between two phosphates in the molecule of ATP is broken?

Ans. When the covalent bonds between two phosphates in the molecule of ATP is broken, inorganic phosphate (Pi) separates and energy is released.

11. When do cells make ATP?

Ans. *When* cells store energy, they make ATP.

12. When do cells break ATP?

Ans. Where cells need energy, then they break ATP

13. How much energy is released, when one phosphate is broken?

Ans. When one phosphate is broken, 7.3 kcal (7300 calories) per mole energy is released.

14. How many sub units are there in one molecule of ATP? Name them.

Ans. There are three subunits in one molecule of ATP i.e; adenine (a nitrogen containing base); ribose (a five carbon sugar) and three phosphate groups.

15. What does happen when P-P high energy bond break?

Ans. When P-P high energy bond breaks, ATP (adenoine triphosphate) becomes ADP (adenine diphosphate) and Pi is released. In some cases, ADP (adenine diphosphate) is further broken down to AMP (adenosine monophosphate) and Pi.

16. How do the cells get energy?

Ans. Cells get energy from the oxidation of food.

17. How do cells store energy?

Ans. Cells store energy by combining ADP with Pi to form ATP.

18. In which processes ATP is made and broken down?

Ans. ATP is made during energy releasing processes and it is broken down during energy consuming processes.

19. How does ATP transfer energy between metabolic reactions?

Ans. ATP is made during energy-releasing processes and it is broken down during energy consuming processes. In this way ATP transfers energy between metabolic reactions.

20. What is the importance of ATP?

Ans. ATP acts a ready as Source of energy that cells can access whenever they need it for processes such as growth, repair, movement and reproduction.

8.2 Photosynthesis

21. What do autotrophic organisms use to prepare their organic food?

Ans. Autotrophic organisms (plants algae, some bacteria) use inorganic raw materials to prepare their organic food.

22. In which form do autotrophic organisms prepare their organic food?

Ans. Autotrophic organisms prepare their organic food in the form of carbohydrates. Carbohydrates are used for getting energy.

23. What is the advantage of carbohydrates to the autotrophic organisms?

Ans. Carbohydrates are used for providing energy to the autotrophic organisms. It is also converted to other molecules like proteins, lipids, etc.

24. Define photosynthesis.

Ans. Photosynthesis:

It is the synthesis of glucose from carbon dioxide and water in the presence of sunlight and chlorophyll with oxygen as a by-product.

25. In how many phases does photosynthesis occur?

Ans. Photosynthesis occurs in two phases i.e;

- Light reactions
- Dark reactions

26. On which organelles do light reactions take place?

Ans. Light reactions take place on the thylakoid membranes of chloroplasts.

27. Where do dark reactions take place?

Ans. Dark reactions take place in the stroma of the chloroplasts.

28. What is nicotinamide adenine dinucleotide (NAD)?

Ans. Nicotinamide adenine dinucleotide (NAD) is a coenzyme.

29. What is difference between NAD and NADP?

Ans. Nicotinamide adenine dinucleotide (NAD) is a coenzyme while NADP is one form of NAD also carrying phosphate.

30. What is used to reduce NADP into NADPH?

Ans. The electrons of chlorophyll after the production of ATP and the hydrogen ions of water are used to reduce a NADP into NADPH.

31. Which gas is released when hydrogen atoms give electrons to chlorophyll and become hydrogen ions during light reactions?

Ans. Oxygen is released when hydrogen atoms give electrons to chlorophyll and become hydrogen ions during light reactions.

32. During dark reactions, which gas is reduced to make glucose?

Ans. During dark reactions, carbon dioxide is reduced to make glucose.

33. Who discovered the details of dark reactions?

Ans. Melvin Calvin discovered the details of dark reactions.

34. Give examples of main pigments and accessory pigments?

Ans. **Main Pigments→** Chlorophyll-a
Accessory Pigments → Chlorophyll-b and Carotenoids.

35. Light of what wave length is absorbed by Chlorophyll a?

Ans. Light of blue and red wavelengths is absorbed by chlorophyll a.

36. What wavelengths of light are absorbed by accessary pigments?

Ans. The wavelengths of light which are not absorbed by chlorophyll a are absorbed by accessory pigments.

37. How much light falling on the leaf surface is absorbed?

Ans. Only about 01% of the light falling on the leaf surface is absorbed, the rest is reflected of transmitted.

38. What are pigments?

Ans. Pigments are the substances that absorb visible light. Different pigments absorb light of different wavelengths (colours).

39. What are accessory pigments? Give an example.

Ans. All the pigments except chlorophyll a are Known as accessory pigments e.g; chlorophyll -b and carotenoids.

40. What products are produced during photosynthesis?

Ans. Glucose, Oxygen and water are the by- products of photosynthesis.

41. What is cellular respiration?

Ans. Organisms get energy by breaking the CH bonds of food. For this purpose, they carry out the oxidation of food inside cells. This oxidation of food is called cellular respiration.

42. What is the most common food used by Cells to get energy?

Ans. The most common food used by cells to get energy is glucose.

43. What are different types of cellular respiration?

Ans. There are two different types of cellular respiration:

- Aerobic respiration
- Anaerobic respiration

44. Differentiate between aerobic respiration and anaerobic respiration.

Ans. Aerobic Respiration:

Cellular respiration occurring in the presence of oxygen is called aerobic respiration.

Anaerobic Respiration:

Cellular respiration that occurs in the absence of oxygen is called anaerobic respiration.

45. What does happen in the first phase of aerobic respiration?

Ans. In the first phase of aerobic respiration, a molecule of glucose (6-C) is broken down into two molecules of pyruvic acid (3-C).

46. What does happen in the second phase of aerobic respiration?

Ans. In the second phase of aerobic respiration, the molecules of pyruvic acid are completely oxidized (all C-H bonds are broken) and all energy is released.

47. What are types of anaerobic respiration?

Ans. There are two types of anaerobic respiration.

- Alcoholic fermentation
- Lactic acid fermentation

48. How much oxidation of glucose takes place in aerobic and anaerobic respiration?

Ans. In aerobic respiration, the complete oxidation of glucose with maximum release of energy takes place.

While in anaerobic respiration, glucose is incompletely Oxidized with less amount of energy released.

49. Which type of cellular respiration is also known as fermentation?

Ans. Anaerobic respiration is also known as fermentation.

50. What is by product of alcoholic fermentation in bacteria and yeast?

Ans. The by product of alcoholic fermentation in bacteria and yeast is ethyl alcohol and Carbon dioxide.

51. What is by product of lactic acid fermentation in the skeletal muscles of humans and other animals?

Ans. The by product of lactic acid fermentation in the skeletal muscles of humans and other animals is lactic acid.

52. Write names of main stages of Aerobic respiration.

Ans. The main stages of aerobic respiration are:

(i) Glycolysis **(ii)** Krebs Cycle **(iii)** Electron transport chain

53. Write the use of fermentation in yeast.

Ans. Fermentation in yeast is used in brewing and baking industries.

54. What are FAD and NAD?

Ans. FAD: Flavin adenine dinucleotide (FAD) is a coenzyme. It gets 2 hydrogen and reduce to $FADH_2$.

NAD: Nicotinamide adenine dinucleotide (NAD) is a coenzyme that takes electrons, hydrogen ions and thus reduced to NADH.

55. How many ATP are produced during Aerobic and Anaerobic respiration.

Ans. 36 ATP are produced during Aerobic respiration while 2 ATP are produced during Anaerobic respiration.

56. What is the use of fermentation in bacteria?

Ans. The fermentation in bacteria is used for making cheese and yogurt.

57. Write the use of fermentation in yeast?

Ans. Fermentation in yeast is used in brewing and baking industries.

58. Define glycolysis.

Ans. Glycolysis:

Glycolysis is the first stage of cellular respiration in which glucose is split into two molecules of pyruvic acid.

59. In which organelle does glycolysis take place?

Ans. Glycolysis takes place in cytoplasm.

60. Why does glycolysis occur in anaerobic respiration?

Ans. Oxygen is not required for glycolysis. That is why, glycolysis occurs in anaerobic respiration.

61. Who did discover Krebs cycle?

Ans. A British scientist Sir Hans Krebs discovered Krebs cycle.

62. Before Krebs cycle into what each pyruvic acid is converted?

Ans. Before Krebs cycle, each pyruvic acid is converted into acetyl coenzyme - A, carbon dioxide and NADH.

63. What are by products of Krebs cycle?

Ans. The by products of Krebs Cycle are Carbon dioxide along with the formation of ATP, NADH and $FADH_2$ brewing and baking industries.

64. Where does electron transport chain occur?

Ans. Electron transport chain occurs on the membranes of mitochondria.

65. What does happen during electron transport chain?

Ans. During electron transport chain, NADH and $FADH_2$ change back to NAD and FAD by releasing electrons and hydrogen ions.

66. What does happen at the end of electron transport chain?

Ans. At the end of electron transport chain, electrons and hydrogen ions combine with oxygen and form water.

67. What is site of occurrence of aerobic respiration?

Ans. The sites of occurrence of aerobic respiration are cytoplasm and mitochondria.

68. What is site of occurrence of anaerobic respiration?

Ans. The site of occurrence of anaerobic respiration is cytoplasm.

69. What is site of occurrence of photosynthesis?

Ans. The sites of occurrence of photosynthesis are chloroplasts in green parts only.

70. What is site of occurrence of respiration?

Ans. The sites of occurrence of respiration are cytoplasm and mitochondria in all cells.

71. What is the time of occurrence of photosynthesis?

Ans. Photosynthesis occurs in day time only in the presence of sunlight.

72. What is the time of occurrence of respiration?

Ans. Respiration occurs all the time.

73. What is meant by anaerobes?

Ans. Even today when free oxygen is available, some organisms including some bacteria and fungi get energy from anaerobic respiration and are called anaerobes.

74. Can yeast and bacteria ferment sugars of berries to alcohol?

Ans. Yes, yeast and bacteria ferment sugars of berries to alcohol.

75. What can ferment sugars of berries to alcohol?

Ans. Yeast and bacteria can ferment sugars of berries to alcohol.

Conceptual Short Questions

1. Define ATP. Write its function in cell.

Ans. ATP stands for adenosine triphosphate. This nucleotide is the major energy currency of all cells. Its main function is to store energy.

2. When ATP was come into existence?

Ans. ATP is the main energy currency in all living organisms. So it also came into existence as life become evolve on this Earth.

3. Why oxidation-reduction reactions is called Redox reaction?

Ans. The lose of electrons is called oxidation while the gain of electrons is called reduction. Redox reactions involve exchange of electrons between atoms that is why oxidation reduction reactions are called redox reactions.

4. Differentiate between light reaction and dark reaction.

Ans. The series of reaction in photosynthesis which need light for their completion is called light reaction.

On the other hand the series of reaction in photosynthesis which occur in absence of light is called dark reaction.

5. Differentiate between respiration and cellular respiration.

Ans. Respiration:

Respiration is an act of breathing. It is the process of taking in oxygen and giving out carbon dioxide by organism.

Cellular Respiration:

Cellular respiration is the process by which C-H bonds are broken down by oxidation. reduction reaction and energy produced in the form of carbon dioxide and water.

Exercise Questions

A. Select the correct answers for the following questions.

1. When we get energy from ATP, which bonds are broken?

a) P-P bonds b) C-H bonds c) C-N bonds d) C-O bonds

2. Light reactions of photosynthesis occur in;

a) Plasma membrane of cell b) Cytoplasm of cell

c) Stroma of chloroplasts d) Thylakoids of chloroplasts

3. Which type of chlorophyll is most common in plants?

a) Chlorophyll a b) Chlorophyll b c) Chlorophyll c d) Chlorophyll d

4. Which wavelengths of light are absorbed to maximum by chlorophylls?

a) Green and blue b) Green and red c) Red and blue d) Only green

5. When yeast ferments glucose, the products are;

a) Alcohol and CO_2 b) Alcohol and water

c) Lactic acid d) CO_2 and H_2O

6. Where do the dark reactions of photosynthesis occur?

a) Stroma of chloroplast b) Thylakoids of chloroplast

c) Outer membrane d) Cytoplasm

7. Which molecule donates electrons in the light-dependent reactions of photosynthesis?

a) NADPH b) Water c) Oxygen d) Carbon dioxide

8. Which process in aerobic respiration produces the most ATP?

a) Glycolysis b) Krebs cycle

c) Electron transport chain d) Fermentation

9. How many ATP molecules are the net profit from one glucose molecule during anaerobic respiration?

a) 2 b) 4 c) 12 d) 36

10. What is a common byproduct of anaerobic respiration in animal cells?

a) Oxygen b) Water c) Lactic acid d) Carbon dioxide

ANSWERS:

1. (a)	**2.** (d)	**3.** (a)	**4.** (c)	**5.** (a)
6. (a)	**7.** (b)	**8.** (c)	**9.** (a)	**10.** (c)

B. Write short answers.

1. Write the importance of oxidation-reduction reactions.

Ans. Oxidation-reduction (redox) reactions are fundamental to the metabolism'of organismsHn these reactions, electrons are transferred between molecules. In oxidation, molecule loses electrons and in reduction, it gains electrons. This electron flow is essential for generating energy in the form of ATP during processes like cellular respiration and photosynthesis.

2. What do ATP and ADP mean? What are the roles of these molecules for the cellular metabolism?

Ans. "ATP" means Adenosine triphosphate while "ADP" means Adenosine diphosphate.

Role of ATP and ADP for cellular metabolism:

ATP and ADP are molecules that work together to provide energy for cellular metabolism.

The main energy molecule in cells is ATP that stores energy. When cells need energy, they break ATP. ATP becomes ADP and releases energy.

ADP is low energy molecule. When cells have extra energy, they store this energy by combining ADP with Pi to form ATP.

So, we can summarize that ATP is made during energy releasing process and is broken down during energy consuming processes. In this way ATP transfers energy between metabolic reactions.

3. Write down the word equation for photosynthesis.

Ans. The word equation for photosynthesis is:

$$\text{Carbon dioxide} + \text{Water} + \text{Light energy} \longrightarrow \text{Glucose} + \text{Oxygen} + \text{Water}$$

4. Why is chlorophyll important for photosynthesis?

Ans. Chlorophyll is the green pigment located in the chloroplasts that are the site for the photosynthesis. Sunlight has light of different wavelengths. The blue and red lights carry out more photosynthesis. Chlorophyll-a absorbs light of blue and red wavelength and converts it to make high energy molecules (ATP and NADPH) that is used to make the food of the plants.

5. How is oxygen produced during photosynthesis?

Ans. During photosynthesis, sunlight absorbed by chlorophyll breaks water molecule. When hydrogen atoms give electrons to chlorophyll and becomes hydrogen ions, then oxygen is produced.

6. Which organisms carry out photosynthesis? Which cell organelle is responsible for the absorption of light for photosynthesis?

Ans. The organisms that carry out photosynthesis are plants, algae and some bacteria. Chloroplasts are the cell organelles that are responsible for the absorption of light for photosynthesis.

7. State the main purpose of cellular respiration?

Ans. The purpose of cellular respiration is to provide cells with the energy (ATP) they need to function.

8. State the equation (in words or symbols) for aerobic respiration. ".

Ans. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$

Glucose + Water Carbon dioxide + Water + Energy

9. Write a brief note on the role of oxygen in aerobic respiration.

Ans. Role of oxygen in aerobic respiration:

Oxygen is required for aerobic respiration. It is the end electron acceptor in the electron transport chain. It is necessary to maintain the flow of electrons and thus create the hydrogen ion gradient needed for ATP synthase to function.

10. Define anaerobic and aerobic respiration.

Ans. Aerobic Respiraiton: Cellulose respiration occurring in the presence of oxygen is called aerobic respiration.

Anaerobic Respiration: Cellular respiration that occurs in the absence of oxygen is called anaerobic respiration.

11. What are the end products of anaerobic respiration in animals and yeast?

Ans. End products of anaerobic respiration in animals: Lactic acid is an end product of aerobic respiration in animals.

End products of anaerobic respiration in Yeast: Ethyl alcohol and carbondioxide are the end product of anaerobic respiration in yeast.

12. How do muscles respond to oxygen deficiency during intense exercise?

Ans. During intense exercise, in the deficiency of oxygen, the skeletal muscles carry out anaerobic respiration to get energy.

13. List ways in which respiratory energy is used in the body.

Ans. Use of respiratory energy in the body:

Respiratory energy (ATP), produced during cellular respiration is used in various ways:

1. Muscle contractions and movement
2. Active transport of substances
3. Synthesis of biomolecules
4. Replication of DNA and mitosis
5. Transmission of nerve impulse
6. Maintenance of body temperature
7. Break down and elimination of toxins from the body.

C. Write answers in detail.

1. Explain ATP as a molecule that is the chief energy currency of all cells.

Ans. For answer See Q.No.3

2. Outline the processes involved in photosynthesis?

Ans. For answer See Q.No.4

3. Write a note on the intake of carbon dioxide and water by plants.

Ans. Plants make their own food in the process called photosynthesis. Photo means "light" and synthesis means "to make".

Plants need three main ingredients to make their food that are water, carbon dioxide and sunlight. Plants get light from the sun, water from the roots and carbon dioxide through stomata present in leaves.

Intake of water:

Plants take up water and minerals that they need for photosynthesis from the soil through the roots. Water and minerals enter in the inner cells of the root and eventually reach the xylem vessels, which transport water and minerals to the leaves.

Intake of carbon dioxide:

The air, carrying carbon dioxide, enters the leaf through tiny pores (stomata) and moves into the air spaces present around mesophyll cells.

Once leaves of the plant have water and carbon dioxide, they use energfy from sunlight and make their food.

4. Explain the types and importance of anaerobic respiration.

Ans. For answer See Q.No.6 & 7

5. Outline the mechanism of aerobic respiration.

Ans. For answer See Q.No.8

6. Compare the processes of respiration and photosynthesis.

Ans. For answer See Q.No.11

D. Inquiştive questions.

1. How does the structure of ATP enable it to store and release energy efficiently?

Ans. ATP (Adenosine triphosphate) store and release energy because of its unique structure. The phosphate group store energy in their chemical bonds. The electronegative charges of phosphate group repel each other and store energy. When a cell need energy, it break the bond of phosphate group so cell can use it for work.