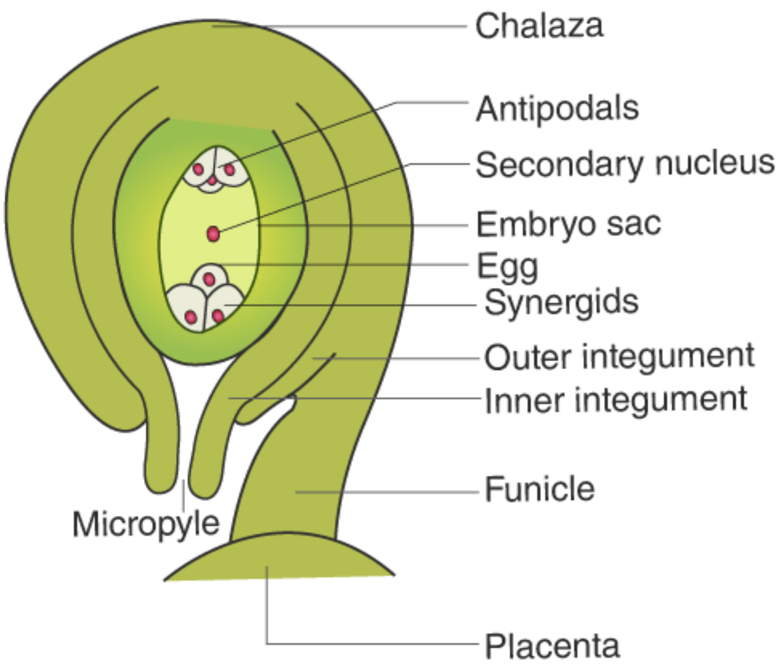
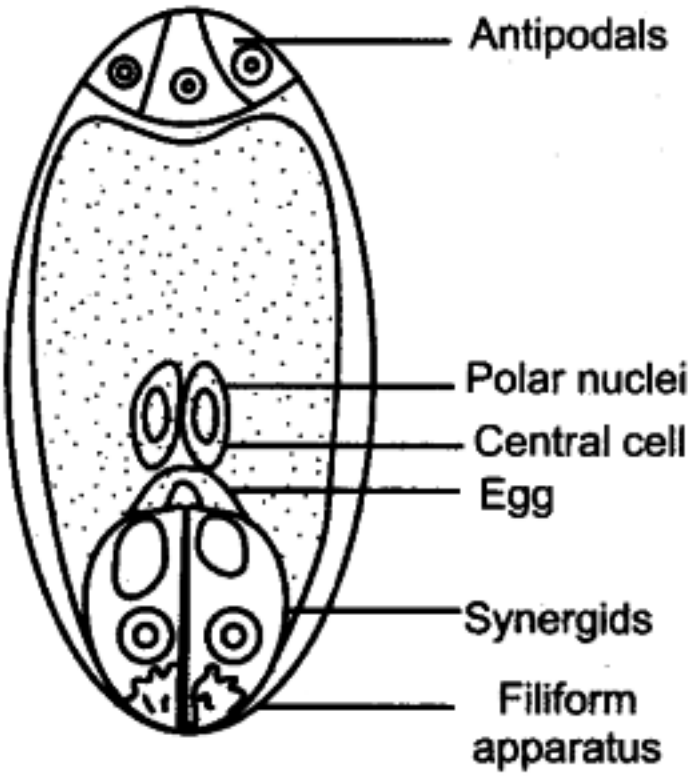
<u>**Post test analysis: Mock NEET paper 1: Plant Physiology and Human Biology**</u>

Plant Physiology Questions (Total: 9 Questions)

Q.95
Megasporangium is equivalent to:

1. Embryo sac
2. Fruit
3. Nucellus
4. Ovule





Mature Embryo sac of an angiosperm

Megaspores:

- **Simple Term**: Large reproductive cells
- **Explanation**: Megaspores are the cells in plants that eventually develop into the female part of the plant, where the egg is formed.

Gametophyte:

- **Simple Term**: Reproductive stage
- **Explanation**: The gametophyte is the stage in a plant's life cycle that produces the sex cells (sperm and egg).

Sporophyte:

- **Simple Term**: Growth stage
- **Explanation**: The sporophyte is the stage in a plant's life cycle that grows and produces spores, which can eventually lead to the formation of new plants.

Integuments:

- **Simple Term**: Protective layers

- **Explanation**: Integuments are the layers that surround and protect the developing seed inside the ovule of a plant.

Integuments | <-- Protective layers surrounding the ovule
|
|
Micropyle <-- Small opening where pollen tube enters
|
|
Nucellus <-- Tissue that nourishes the developing embryo sac
|
|
Embryo Sac <-- Female gametophyte that contains the egg cell
|
|
Funiculus <-- Stalk that attaches the ovule to the ovary wall

1. What is Megasporangium?

Definition:
Megasporangium is a structure found in seed plants where megaspores are formed. It is a key part of the female reproductive organ and eventually gives rise to female gametophytes.

Location:

- Megasporangium is typically found within the ovule of flowering plants. It is enclosed by integuments and is commonly referred to as the nucellus.

Purpose:

- The main function of the megasporangium is to produce and protect the megaspore mother cell (MMC), which undergoes meiosis to form megaspores.
- One of these megaspores develops into the female gametophyte or the embryo sac.

Design and Function:

- **Structure:** Megasporangium is typically surrounded by protective layers called integuments, which later develop into the seed coat.
- **Function:** It houses the megaspore mother cell that undergoes meiosis to produce megaspores. Out of four megaspores formed, usually, one megaspore becomes functional and develops into the female gametophyte, or embryo sac. The design ensures that the female gametophyte is well-protected and nurtured during its development.

2. What Can Be Considered as Equivalent to Megasporangium?

Equivalent Structure:

- The closest equivalent to the megasporangium in the life cycle of seed plants is the ovule because the ovule contains the megasporangium (nucellus) and eventually develops into the seed after fertilization.

3. Purpose, Design, and Functions of Embryo Sac, Fruit, Nucellus, and Ovule

- **Embryo Sac:**
    - **Purpose:** It is the female gametophyte that houses the egg cell and other cells essential for fertilization and development.
    - **Design:** Typically, a mature embryo sac is an 8-nucleate structure with antipodal cells, polar nuclei, synergids, and an egg cell.
    - **Function:** Facilitates fertilization by harbouring the egg cell and nurturing the zygote post-fertilization.
- **Fruit:**
    - **Purpose:** The fruit serves to protect the seeds and aid in their dispersal.
    - **Design:** Fruits develop from the ovary after fertilization. They can be fleshy or dry and are adapted for various dispersal mechanisms (e.g., wind, water, animals).
    - **Function:** Fruits protect the seeds and help in their distribution, ensuring the propagation of the plant species.
- **Nucellus:**
    - **Purpose:** It is the tissue inside the ovule, equivalent to the megasporangium, that surrounds and nourishes the developing female gametophyte (embryo sac).
    - **Design:** It is a mass of parenchymatous cells inside the ovule.
    - **Function:** The nucellus provides nutrients and structural support to the developing embryo sac.
- **Ovule:**
    - **Purpose:** The ovule is the structure that develops into a seed after fertilization.
    - **Design:** It consists of the integuments (which become the seed coat), the nucellus (megasporangium), and the embryo sac.

- **Function:** The ovule houses the megasporangium, undergoes fertilization, and develops into the seed that contains the embryonic plant.

Q.98
Interfascicular cambium develops from the cells of:

1. Medullary rays
2. Xylem parenchyma
3. Endodermis
4. Pericycle

Sequence of Cells or Tissues from Outside to Inside in a Stem:

1. **Epidermis**: Outermost protective layer.
2. **Cortex**: Layer of cells between the epidermis and the vascular bundles.
3. **Endodermis**: Innermost layer of the cortex, which regulates the flow of materials into the vascular bundles.
4. **Pericycle**: A layer of cells just inside the endodermis that can give rise to lateral roots.
5. **Vascular Bundles**: Comprising xylem (inside) and phloem (outside), responsible for the transport of water, nutrients, and food.
6. **Pith**: Central part of the stem, often used for storage.

Sequence of Cells or Tissues from Outside to Inside in a Root:

1. **Epidermis**: The outermost layer, often with root hairs for absorption of water and nutrients.
2. **Cortex**: A thick layer of parenchyma cells that store food and transport water and nutrients from the root hairs to the vascular tissue.
3. **Endodermis**: A single layer of cells that forms a boundary between the cortex and the vascular tissue, regulating the flow of materials into the vascular cylinder.

4. **Pericycle**: Located just inside the endodermis, this layer of cells can become meristematic and is responsible for the formation of lateral roots.
5. **Vascular Cylinder (Stele)**: This central part contains the xylem and phloem. In roots, the xylem is usually arranged in a star shape, with the phloem located between the arms of the xylem.

Notable Difference:

- **Pith is usually absent in most dicot roots**. In monocot roots, there might be a small pith in the center, but it's generally not as prominent as in stems.

1. What is Cambium?

Cambium is a layer of actively dividing cells between the xylem (the water-conducting tissue) and the phloem (the food-conducting tissue) in plants. It is responsible for the secondary growth of stems and roots, leading to an increase in thickness.

2. Purpose, Design, and Function of Cambium

- **Purpose:** The cambium's primary purpose is to generate new cells for the plant, contributing to the plant's growth in thickness (secondary growth).
- **Design:** Cambium is designed as a thin layer of meristematic cells that lie between the xylem and phloem tissues. This structure allows it to efficiently produce new cells, adding layers to both the xylem and phloem.
- **Function:**
    - The cambium produces secondary xylem on the inside and secondary phloem on the outside.
    - It also plays a key role in the healing of wounds and the formation of callus tissue in plants.

3. What are the Different Types of Cambium?

The primary types of cambium are:

- **Vascular Cambium**
- **Cork Cambium (Phellogen)**

4. Where Does Different Types of Cambium Develop From?

Type of Cambium	Origin	Function
Vascular Cambium	Develops from the procambium in the vascular bundles or from the dedifferentiation of mature parenchyma cells in the interfascicular region	Produces secondary xylem (wood) and secondary phloem (bark), contributing to the thickening of stems and roots.
Cork Cambium (Phellogen)	Arises from the outer layers of the cortex in stems and roots	Produces cork (phellem) on the outside and secondary cortex (phelloderm) on the inside, contributing to the formation of protective bark.

6. Meaning, Origin, Location of Existence, Purpose, Design, and Function of Medullary Rays, Xylem Parenchyma, Endodermis, Pericycle

Term	**Meaning**	**Origin**	**Location**	**Purpose**	**Design and Function**
Medullary Rays	Radial sheets or ribbons extending vertically through the stem	Derived from the vascular cambium	In the stem and roots, running horizontally	Transport of water, nutrients, and food across the plant's stem	Designed as horizontal sheets, they facilitate lateral transport and store nutrients within the plant.
Xylem Parenchyma	Parenchyma cells found within xylem tissue	Derived from the vascular cambium	Within the xylem tissue	Storage of water and nutrients, lateral transport of water	Designed as thin-walled living cells, they store nutrients and help in the lateral conduction of water and minerals.
Endodermis	Innermost layer of the cortex in	Derived from ground meristem	Surrounds the vascular bundle in	Regulates water and mineral	Endodermis cells are arranged in a single layer,

Term	Meaning	Origin	Location	Purpose	Design and Function
	roots and stems		roots and some stems	uptake by the root	forming a selective barrier for the transport of water and minerals into the vascular tissue.
Pericycle	A layer of cells just inside the endodermis	Derived from the procambium	Surrounds the vascular bundles in roots	Gives rise to lateral roots and contributes to secondary growth	Composed of parenchyma or sclerenchyma cells, the pericycle helps in the formation of lateral roots and can become meristematic during secondary growth.

Q.100
Lenticels are involved in:

1. Transpiration
2. Gaseous exchange
3. Food transport
4. Photosynthesis

Lenticels are specialized structures that facilitate gas exchange in woody plants, which is crucial for respiration in tissues that are not exposed to the air due to the presence of bark.

1. What are Lenticels?

Lenticels are small, spongy openings in the bark of woody plants, particularly on stems and roots. They allow for the exchange of gases (like oxygen and carbon dioxide) between the internal tissues of the plant and the atmosphere, facilitating respiration in parts of the plant that are covered by bark.

2. Tabulated Representation of Lenticels

Aspect	**Details**
Origin	Lenticels develop from the periderm, specifically from the cork cambium (phellogen). They form in areas where the epidermis is ruptured as secondary growth progresses.
Purpose	The primary purpose of lenticels is to facilitate gaseous exchange in parts of the plant that are covered by bark, where stomata are no longer functional.
Design (Structure)	Lenticels are typically raised, oval or round structures composed of loosely packed parenchyma cells with large intercellular spaces. These spaces allow for efficient gas exchange.
Function	Lenticels ensure that oxygen reaches the internal tissues of the stem and roots, and carbon dioxide is expelled, supporting respiration and metabolic processes in woody parts of the plant.

Q.101
Age of a tree can be estimated by:

1. Its height and girth
2. Biomass
3. Number of annual rings
4. Diameter of its heartwood

Descriptions of terms:

1. **Height**:
    - **Definition**: The measurement of how tall something is from the base to the top.
    - **In trees**: The distance from the ground to the highest point of the tree.

2. **Girth**:
   - **Definition**: The measurement around the widest part of an object.
   - **In trees**: The circumference or distance around the trunk of the tree at a specific height from the ground, usually measured at chest height (often called "breast height").
3. **Heartwood**:
   - **Definition**: The dense, inner part of a tree trunk that is usually darker and harder.
   - **In trees**: The central wood of a tree, which no longer conducts water and is filled with deposits that strengthen it.
4. **Sapwood**:
   - **Definition**: The softer, outer layer of the wood in the trunk, just beneath the bark.
   - **In trees**: The living part of the tree that conducts water and nutrients from the roots to the leaves.
5. **Annual Rings**:
   - **Definition**: Rings visible in a cross-section of a tree trunk, representing one year's growth.
   - **In trees**: Each ring marks a year of growth, with wider rings indicating more growth during favorable years.

PTA Questions:

1. **What is Heartwood?**
   - **Definition**: Heartwood is the central, non-living part of a tree trunk. It is usually darker, harder, and more resistant to decay than the outer layers.
2. **Where Does It Come From?**
   - **Origin**: Heartwood forms from older sapwood as the tree grows. Over time, the inner layers of sapwood no longer conduct water and become heartwood.
3. **Why Should It Be Produced/What Is Its Purpose?**
   - **Purpose**: Heartwood provides structural support to the tree. It is dense and strong, helping the tree to stay upright and resist external forces like wind and gravity.

4. **How Is It Designed?**
    - **Design**: Heartwood is designed with dense, tightly-packed cells that are often filled with resins, oils, and other compounds that make it resistant to decay.
5. **What Is Its Function?**
    - **Function**: The primary function of heartwood is to support the tree structurally. It no longer plays a role in the transport of water and nutrients, which is the job of the sapwood.
6. **What Disadvantages Does It Put the Plant In?**
    - **Disadvantages**: While heartwood provides strength, it no longer contributes to the tree's growth or nutrient transport. Also, once it becomes heartwood, it is more prone to fungal infections if it becomes exposed.
7. **What Are Annual Rings?**
    - **Definition**: Annual rings are the concentric circles visible in a cross-section of a tree trunk, formed by the growth of new wood each year.
8. **How Do We Count the Rings to Determine the Age of Trees?**
    - **Method**: To determine the age of a tree, you count the number of annual rings visible in a cross-section of the trunk. Each ring represents one year of growth, with the outermost ring indicating the most recent year.

When determining the age of a tree by counting its rings, **you count all the rings** that are visible in a cross-section of the tree trunk, which includes both **sapwood and heartwood rings**.

Here's why:

- **Annual rings** are formed each year as the tree grows. Each ring represents one year of growth and consists of two parts:
    - **Earlywood (Springwood)**: Lighter, less dense wood formed in the spring when growth conditions are optimal.
    - **Latewood (Summerwood)**: Darker, denser wood formed later in the growing season.
- The **heartwood** is made up of older rings that no longer conduct water, but they were once part of the sapwood. Over time, these sapwood rings become heartwood as the tree ages and new sapwood is formed on the outside.

Conclusion:

- When counting the rings to determine the age of the tree, you include both the sapwood and heartwood rings since each ring represents one complete year of growth. The combined total of these rings gives you the tree's age.

This method provides an accurate record of the tree's age, as it accounts for all the years of growth that have occurred since the tree began developing.

9. Does the thickness of rings in the heartwood region and sapwood region vary?

No, the thickness of the annual rings in the heartwood region is generally not smaller than that in the sapwood region. Here's why:

Growth Process:

- **Annual rings** are formed as a tree grows each year. During a single growing season, a tree produces a ring that consists of two parts: the earlywood (springwood), which is formed during the rapid growth of spring, and the latewood (summerwood), which forms later in the season and is denser.
- **Heartwood** and **sapwood** are differentiated based on the function of the wood rather than the thickness of the rings. As a tree ages, the innermost layers of sapwood transition into heartwood, but this transition does not change the thickness of the rings that were already formed.

Key Points:

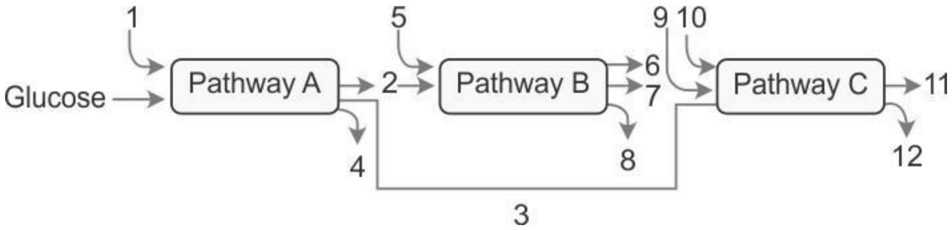
- The **thickness of each annual ring** is determined by the growing conditions during that year, such as the availability of water, nutrients, and sunlight. Favorable conditions lead to thicker rings, while unfavorable conditions result in thinner rings.
- **Heartwood** is simply the older, non-functional wood that no longer transports water and nutrients. It is usually darker and more resistant to decay, but the rings themselves remain the same width as when they were originally formed.
- **Sapwood** is the younger, functional wood that is actively involved in transporting water and nutrients.

Conclusion:

The thickness of the annual rings remains consistent regardless of whether the rings are part of the heartwood or sapwood. The thickness reflects the growth conditions during the year the ring was formed, not its current position as heartwood or sapwood. Therefore, **the thickness of rings in the heartwood region is typically similar to that in the sapwood region**.

Q.108

The three boxes in this diagram represent the three major biosynthetic pathways in aerobic respiration. Arrows represent net reactants or products:



- (Diagram related to glycolysis, Krebs cycle, and the electron transport chain)

1. NADH
2. ATP
3. H2O
4. FAD+ or FADH2

PTA Notes:

The diagram provided represents the three major stages of aerobic respiration:

- **Pathway A**: Glycolysis
- **Pathway B**: Krebs Cycle (Citric Acid Cycle)
- **Pathway C**: Electron Transport Chain (ETC)

Analysis of the Diagram:

- **Arrow 1 (Glucose to Pathway A)**: Represents the entry of glucose into glycolysis.
- **Arrow 2**: The products of glycolysis (such as pyruvate) move to the Krebs cycle.
- **Arrow 3**: Likely represents NADPH, which enters ETC to further transfer energy for the production of ATP.
- **Arrow 4**: Could represent NADH or FADH2 as these are products that feed into the electron transport chain from the Krebs cycle.
- **Arrow 5**: Likely represent Acetyl CoA which enters the Krebs cycle. Pyruvate, which is the product of glycolysis is converted to acetyl-CoA as it enters the Kreb's cycle.
- **Arrow 6**: Represents NADH or FADH2, which carry electrons to the electron transport chain.

- **Arrow 7**: Likely represent carbon dioxide (CO_2) released during the Krebs cycle.
- **Arrow 8**: Could represent ATP, as ATP is generated in the Krebs cycle.
- **Arrow 9**: Electrons transferred to the electron transport chain.
- **Arrow 10**: Represents oxygen entering the electron transport chain.
- **Arrow 11**: Water (H_2O) is produced at the end of the electron transport chain.
- **Arrow 12**: Represents ATP, as ATP is produced by the electron transport chain.

Pathways in Aerobic Respiration:

1. **Glycolysis (Pathway A)**:
   - Produces 2 molecules of NADH.
   - Also produces 2 ATP (net gain) and 2 molecules of pyruvate.
2. **Krebs Cycle (Pathway B)**:
   - Produces NADH and $FADH_2$ as high-energy electron carriers.
   - Produces a small amount of ATP directly.
   - Releases CO_2 as a byproduct.
3. **Electron Transport Chain (Pathway C)**:
   - Uses NADH and $FADH_2$ to produce ATP.
   - Oxygen is the final electron acceptor and forms water (H_2O) with hydrogen.

Energy dynamics of glucose metabolism:

Let's break down the production of ATP, NADH, and $FADH_2$ during Glycolysis and the Krebs Cycle:

1. Glycolysis:

Glycolysis is the process of breaking down one molecule of glucose into two molecules of pyruvate.

- **ATP Production:**
  - **Gross ATP Produced**: 4 ATP
  - **Net ATP Produced**: 2 ATP (since 2 ATP are used in the initial steps)
- **NADH Production:**

    - **Total NADH Produced**: 2 NADH (from the oxidation of glyceraldehyde-3-phosphate to 1,3-bisphosphoglycerate)
- **FADH2 Production:**
    - **Total FADH2 Produced**: 0 (FADH2 is not produced during glycolysis)

Summary for Glycolysis:

- **Net ATP**: 2 ATP
- **NADH**: 2 NADH
- **FADH2**: 0 FADH2

2. Krebs Cycle (Citric Acid Cycle):

The Krebs Cycle occurs twice for each molecule of glucose (once for each pyruvate).

- **ATP Production:**
    - **Total ATP Produced**: 2 ATP (1 ATP per cycle turn; GTP is formed and is often considered equivalent to ATP)
- **NADH Production:**
    - **Total NADH Produced**: 6 NADH (3 NADH per cycle turn)
- **FADH2 Production:**
    - **Total FADH2 Produced**: 2 FADH2 (1 FADH2 per cycle turn)

Summary for Krebs Cycle (Per Glucose Molecule):

- **ATP**: 2 ATP
- **NADH**: 6 NADH
- **FADH2**: 2 FADH2

Overall Summary (Per Glucose Molecule):

Combining the results of Glycolysis and the Krebs Cycle, the total production of ATP, NADH, and FADH2 per glucose molecule is:

- **ATP**: 4 ATP (2 from Glycolysis, 2 from Krebs Cycle)
- **NADH**: 8 NADH (2 from Glycolysis, 6 from Krebs Cycle)
- **FADH2**: 2 FADH2 (all from Krebs Cycle)

These NADH and FADH2 molecules are then used in the Electron Transport Chain (ETC) to produce additional ATP.

Glycolysis tabulated:

Assumption: 1 NADH is equivalent to 3 ATP:

Sl No.	**What Enters**	**What Exits**	**Enzyme**	**Reversibility of Reaction**	**Energy Used**	**Energy Produced**	**Net Energy (in terms of ATP equivalent)**
1	Glucose	Glucose-6-phosphate	Hexokinase	Irreversible	1 ATP	0	-1 ATP
2	Glucose-6-phosphate	Fructose-6-phosphate	Phosphoglucose isomerase	Reversible	0	0	0 ATP
3	Fructose-6-phosphate	Fructose-1,6-bisphosphate	Phosphofructokinase-1 (PFK-1)	Irreversible	1 ATP	0	-1 ATP
4	Fructose-1,6-bisphosphate	Glyceraldehyde-3-phosphate (G3P) and Dihydroxyacetone phosphate (DHAP)	Aldolase	Reversible	0	0	0 ATP
5	Dihydroxyacetone phosphate (DHAP)	Glyceraldehyde-3-phosphate (G3P)	Triose phosphate isomerase	Reversible	0	0	0 ATP
6	Glyceraldehyde-3-phosphate (G3P)	1,3-Bisphosphoglycerate	Glyceraldehyde-3-phosphate dehydrogenase	Reversible	0	2 NADH (from 2 G3P)	+6 ATP (from 2 NADH, assuming NADH = 3 ATP each in

							mitochondria)
7	1,3-Bisphosphoglycerate	3-Phosphoglycerate	Phosphoglycerate kinase	Reversible	0	2 ATP (from 2 G3P)	+2 ATP
8	3-Phosphoglycerate	2-Phosphoglycerate	Phosphoglycerate mutase	Reversible	0	0	0 ATP
9	2-Phosphoglycerate	Phosphoenol pyruvate (PEP)	Enolase	Reversible	0	0	0 ATP
10	Phosphoenol pyruvate (PEP)	Pyruvate	Pyruvate kinase	Irreversible	0	2 ATP (from 2 PEP)	+2 ATP

Summary of Net Energy Yield:

- **Total ATP Used**: 2 ATP (in Steps 1 and 3)
- **Total ATP Produced**: 4 ATP (in Steps 7 and 10)
- **Net ATP**: 2 ATP (4 ATP produced - 2 ATP used)
- **Total NADH Produced**: 2 NADH (in Step 6), which can yield approximately 6 ATP (assuming 1 NADH = 3 ATP).
- **Total Net Energy (in terms of ATP equivalent)**: 2 ATP (direct) + 6 ATP (from NADH) = **8 ATP equivalent** per glucose molecule through glycolysis.

Conversion of Pyruvate to Acetyl-CoA

Here is the reaction of pyruvate being converted to Acetyl-CoA in the same format as requested:

Sl No.	**What Enters**	**What Exits**	**Enzyme**	**Reversibility of Reaction**	**Energy Used**	**Energy Produced**	**Net Energy (in terms of ATP**

							equivalent)
1	Pyruvate	Acetyl-CoA + CO2	Pyruvate dehydrogenase complex	Irreversible	0 ATP	1 NADH	+3 ATP (assuming 1 NADH = 3 ATP)

Summary:

- **What Enters:** Pyruvate (produced at the end of glycolysis)
- **What Exits:** Acetyl-CoA (enters the Krebs Cycle) and CO2 (as a byproduct)
- **Enzyme:** Pyruvate dehydrogenase complex (a multi-enzyme complex that catalyzes this conversion)
- **Reversibility:** This reaction is irreversible under normal cellular conditions.
- **Energy Used:** No direct ATP is used in this reaction.
- **Energy Produced:** 1 NADH is produced per pyruvate molecule.
- **Net Energy:** +3 ATP equivalent (from the 1 NADH produced, assuming 1 NADH = 3 ATP)

Context:

- This conversion takes place in the mitochondria, where pyruvate is decarboxylated, and the resulting acetyl group is attached to coenzyme A to form Acetyl-CoA. This is a crucial step linking glycolysis to the Krebs Cycle.

Here’s a detailed table representing the reactions of the Krebs Cycle (Citric Acid Cycle), formatted as requested:

Sl No.	What Enters	What Exits	Enzyme	Reversibility of Reaction	Energy Used	Energy Produced	Net Energy (in terms of ATP equivalent)
1	Acetyl-CoA + Oxaloacetate	Citrate	Citrate synthase	Irreversible	0 ATP	0	0 ATP

2	Citrate	Isocitrate	Aconitase	Reversible	0 ATP	0	0 ATP
3	Isocitrate	α-Ketoglutarate + CO2	Isocitrate dehydrogenase	Irreversible	0 ATP	1 NADH	+3 ATP (assuming 1 NADH = 3 ATP)
4	α-Ketoglutarate + CoA	Succinyl-CoA + CO2	α-Ketoglutarate dehydrogenase	Irreversible	0 ATP	1 NADH	+3 ATP (assuming 1 NADH = 3 ATP)
5	Succinyl-CoA	Succinate	Succinyl-CoA synthetase	Reversible	0 ATP	1 GTP (equivalent to 1 ATP)	+1 ATP
6	Succinate	Fumarate	Succinate dehydrogenase	Reversible	0 ATP	1 FADH2	+2 ATP (assuming 1 FADH2 = 2 ATP)
7	Fumarate	Malate	Fumarase	Reversible	0 ATP	0	0 ATP
8	Malate	Oxaloacetate	Malate dehydrogenase	Reversible	0 ATP	1 NADH	+3 ATP (assuming 1 NADH = 3 ATP)

Summary of Krebs Cycle (Per Cycle Turn):

- **Total ATP (GTP) Produced:** 1 ATP (as GTP)
- **Total NADH Produced:** 3 NADH (equivalent to 9 ATP)
- **Total FADH2 Produced:** 1 FADH2 (equivalent to 2 ATP)
- **Net Energy (ATP Equivalent):** 12 ATP per turn of the Krebs Cycle.

Summary of Net Energy Yield (Per Glucose Molecule):

- Since one molecule of glucose generates 2 Acetyl-CoA molecules, the Krebs Cycle turns twice for each glucose molecule.
- Net Energy (ATP Equivalent) Per Glucose: 2 turns × 12 ATP = 24 ATP.

Explanation:

- **Step 1:** Acetyl-CoA combines with oxaloacetate to form citrate, catalyzed by citrate synthase.
- **Step 2:** Citrate is converted to isocitrate by aconitase.
- **Step 3:** Isocitrate is oxidized to α-ketoglutarate, producing NADH and releasing CO_2.
- **Step 4:** α-Ketoglutarate is further oxidized to succinyl-CoA, producing NADH and releasing CO_2.
- **Step 5:** Succinyl-CoA is converted to succinate, producing GTP (equivalent to ATP).
- **Step 6:** Succinate is oxidized to fumarate, producing $FADH_2$.
- **Step 7:** Fumarate is hydrated to malate by fumarase.
- **Step 8:** Malate is oxidized to oxaloacetate, producing NADH.

Electron transport chain (oxidative phosphorylation)

Purpose of the Electron Transport Chain (ETC):

- **ATP Production**: The primary purpose of the ETC is to produce ATP, the energy currency of the cell. This is achieved by using the energy released from the transfer of electrons through a series of protein complexes and electron carriers to pump protons across the inner mitochondrial membrane, creating a proton gradient.
- **Formation of Water**: The ETC also facilitates the reduction of oxygen to form water. Oxygen acts as the final electron acceptor, combining with electrons and protons to produce water, which is essential for maintaining the flow of electrons through the chain.
- **Regeneration of NAD+ and FAD**: The ETC regenerates NAD+ and FAD from NADH and $FADH_2$, respectively. These oxidized forms are crucial for continuing the earlier stages of cellular respiration (glycolysis, Krebs cycle) where they act as electron acceptors.

Where Does the ETC Operate?

- **Location**: The Electron Transport Chain operates in the **inner mitochondrial membrane** of eukaryotic cells.
  - **Mitochondria** are the "powerhouses" of the cell, where the majority of ATP is generated.
  - The **inner mitochondrial membrane** is highly folded into structures called cristae, which increase the surface area available for the ETC.

Design for the ETC to Operate:

- **Protein Complexes**: The ETC consists of a series of protein complexes (Complex I, II, III, and IV) embedded in the inner mitochondrial membrane. These complexes are arranged in a specific sequence to facilitate the stepwise transfer of electrons.
  - **Complex I (NADH dehydrogenase)**: Accepts electrons from NADH and pumps protons across the membrane.
  - **Complex II (Succinate dehydrogenase)**: Accepts electrons from FADH2 but does not pump protons.
  - **Complex III (Cytochrome bc1 complex)**: Transfers electrons from ubiquinone to cytochrome c and pumps protons.
  - **Complex IV (Cytochrome c oxidase)**: Transfers electrons to oxygen, reducing it to water, and pumps protons.
- **Electron Carriers**: Small molecules like ubiquinone (Q) and cytochrome c shuttle electrons between the protein complexes.
- **Proton Gradient**: The ETC is designed to pump protons from the mitochondrial matrix into the intermembrane space, creating a proton gradient (proton motive force). This gradient is crucial for ATP synthesis.
- **ATP Synthase**: A specialized enzyme called ATP synthase uses the energy stored in the proton gradient to convert ADP and inorganic phosphate (Pi) into ATP as protons flow back into the mitochondrial matrix.
- **Compartmentalization**: The design of the mitochondrion, with its double membrane structure, is crucial for the ETC's function. The inner mitochondrial membrane's impermeability to protons ensures that the proton gradient is maintained, which is essential for ATP production.

Summary:

- **Purpose**: The ETC generates ATP, reduces oxygen to water, and regenerates NAD+ and FAD.
- **Location**: Inner mitochondrial membrane.
- **Design**: The ETC operates through a series of protein complexes and electron carriers, utilizing a proton gradient across the inner mitochondrial membrane to drive ATP synthesis via ATP synthase.

This design ensures that the cell efficiently produces ATP while maintaining the flow of electrons and protons in a controlled manner.

Coordinated functioning of complex 4 and ATP synthase

Complex IV and **ATP synthase** operate in coordination, but they have distinct roles within the Electron Transport Chain (ETC). Their coordinated function is crucial for the overall process of ATP production in cellular respiration.

How They Coordinate:

1. **Role of Complex IV**:
    - **Electron Transfer and Proton Pumping**: Complex IV, also known as **cytochrome c oxidase**, is the final complex in the ETC. It accepts electrons from cytochrome c and transfers them to oxygen, the final electron acceptor. In this process, oxygen is reduced to form water (H_2O).
    - **Proton Pumping**: Complex IV also pumps protons (H^+) from the mitochondrial matrix into the intermembrane space. This pumping of protons contributes to the proton gradient (proton motive force) across the inner mitochondrial membrane.
2. **Role of ATP Synthase**:
    - **Utilizing the Proton Gradient**: ATP synthase is a separate enzyme complex that is not directly involved in electron transfer. Instead, it uses the energy stored in the proton gradient created by the activities of Complexes I, III, and IV.
    - **ATP Production**: Protons flow back into the mitochondrial matrix through ATP synthase, driven by the proton gradient. As protons pass through ATP synthase, the enzyme catalyzes the conversion of ADP and inorganic phosphate (Pi) into ATP.

Coordination Between Complex IV and ATP Synthase:

- **Proton Gradient Dependency**: The key connection between Complex IV and ATP synthase is the proton gradient. The activity of Complex IV (and other complexes) in pumping protons into the intermembrane space is essential for maintaining this gradient.
- **Sequential Operation**: The proton gradient generated by Complex IV and the other complexes provides the necessary energy for ATP synthase to function. Without the proton pumping by Complex IV, ATP synthase would not have the energy source it needs to produce ATP.

Summary:

- **Complex IV** helps maintain the proton gradient by pumping protons into the intermembrane space and reducing oxygen to water.
- **ATP synthase** then uses the energy stored in this proton gradient to produce ATP.

Tabulated representation of the Electron Transport Chain (ETC):

Sl No.	Electron Donor	Electron Acceptor	Complex	Proton Pumping	ATP Produced (if applicable)	Comments/Explanation
1	NADH	Ubiquinone (Q)	Complex I (NADH dehydrogenase)	Yes	0	NADH donates electrons to Complex I, pumping protons into the intermembrane space. Electrons are passed to ubiquinone (Q).
2	FADH2	Ubiquinone (Q)	Complex II (Succinate dehydrogenase)	No	0	FADH2 donates electrons to Complex II. No protons are pumped at this step. Electrons are passed to ubiquinone (Q).
3	Ubiquinone (Q)	Cytochrome c	Complex III (Cytochrome bc1 complex)	Yes	0	Electrons from ubiquinone are transferred to cytochrome c via Complex III, pumping protons across the membrane.
4	Cytochrome c	Oxygen (O2)	Complex IV (Cytochrome c oxidase)	Yes	0	Electrons from cytochrome c are transferred to oxygen, the final electron acceptor, forming water. Protons are pumped to drive ATP synthesis.
5	Proton Gradient (H+)	ATP Synthase (ADP + Pi)	ATP Synthase	N/A	3 ATP per NADH, 2 ATP per FADH2	The proton gradient created by the previous complexes drives ATP synthesis through ATP synthase. Protons flow back into the matrix, producing ATP.

Explanation of the Columns:

- **Electron Donor**: The molecule that donates electrons to the ETC (e.g., NADH, FADH2).
- **Electron Acceptor**: The molecule that receives electrons at each step in the chain.
- **Complex**: The specific complex in the ETC where the reaction occurs.
- **Proton Pumping**: Indicates whether protons are pumped into the intermembrane space to create a proton gradient.
- **ATP Produced**: The amount of ATP synthesized as a result of the electron transfer (linked to proton gradient and ATP synthase).
- **Comments/Explanation**: Additional details and clarifications for each step.

Summary:

- **NADH and FADH2** donate electrons at different entry points, leading to the generation of a proton gradient across the mitochondrial membrane.
- **Complexes I, III, and IV** pump protons into the intermembrane space, creating the proton gradient necessary for ATP synthesis.
- **ATP Synthase** utilizes this gradient to produce ATP, with approximately **3 ATP** produced per NADH and **2 ATP** per FADH2.

Some important questions to seek answers for:

1. Movement of Protons Happens Across What Membrane in Mitochondria?

- **Answer**: The movement of protons (H^+ ions) happens across the **inner mitochondrial membrane**. This membrane separates the mitochondrial matrix from the intermembrane space.

2. Where Do the Protons Move From and Into Where?

- **Answer**:
  - Protons are pumped **from the mitochondrial matrix** into the **intermembrane space**.
  - This creates a proton gradient, with a higher concentration of protons in the intermembrane space compared to the matrix.

3. Is the Transfer of Electrons Providing Energy for the Movement of Protons?

- **Answer**:
  - Yes, the transfer of electrons through the complexes of the ETC provides the energy needed to pump protons across the inner mitochondrial membrane.

- As electrons move from one complex to another (from NADH and FADH2 to oxygen), the energy released is used to pump protons from the matrix to the intermembrane space, creating a proton gradient.

4. How Are NADH and FADH2 Ionized by the Complexes?

- **Answer**:
  - **NADH**: At Complex I (NADH dehydrogenase), NADH is oxidized, releasing two electrons and a proton (H^+). The electrons are transferred to ubiquinone (Q), and the energy released from this process is used to pump protons across the membrane.
  - **FADH2**: At Complex II (succinate dehydrogenase), FADH2 is oxidized, releasing electrons that are also transferred to ubiquinone (Q). However, Complex II does not pump protons across the membrane.

5. Details of ATP Synthase - How Is ATP Produced and How Is Water Produced?

- **ATP Production**:
  - ATP synthase is an enzyme that spans the inner mitochondrial membrane. It uses the energy from the proton gradient (created by the ETC) to synthesize ATP from ADP and inorganic phosphate (Pi).
  - Protons flow back into the mitochondrial matrix through ATP synthase, and this flow drives the production of ATP.
- **Water Production**:
  - Oxygen is the final electron acceptor in the ETC. At Complex IV (cytochrome c oxidase), oxygen combines with electrons (from the ETC) and protons (from the matrix) to form water (H_2O).
  - This reaction is crucial because it allows the ETC to continue by removing the electrons from the chain.

6. Why Should We Consider NADH as Equivalent to 3 ATP While FADH2 as 2 ATP?

- **Answer**:
  - **NADH** donates electrons to Complex I, which contributes to the pumping of protons across Complexes I, III, and IV. The full passage of electrons from NADH through these complexes generates enough proton gradient to produce approximately **3 ATP** molecules per NADH.
  - **FADH2** donates electrons to Complex II, which does not pump protons. Because FADH2 bypasses Complex I and enters the chain at a lower energy level (Complex II), it contributes to the proton gradient through Complexes III and IV only, resulting in the production of approximately **2 ATP** molecules per FADH2.

7. Where Do We Need Oxygen in This Process? Also, Why Do We Die If There Is No Oxygen?

- **Oxygen in ETC**:
    - Oxygen is required at the end of the Electron Transport Chain, at Complex IV. It acts as the final electron acceptor, combining with electrons and protons to form water.
- **Why Is Oxygen Essential?**:
    - Without oxygen, the entire electron transport chain backs up because electrons have nowhere to go. This halts the proton pumping and the production of ATP.
    - **Why We Die Without Oxygen**: Without oxygen, cells cannot produce sufficient ATP through aerobic respiration, leading to energy failure. The lack of ATP disrupts essential cellular functions, leading to cell death, organ failure, and ultimately death.

Q.110
During seed germination its stored food is mobilized by:

1. Ethylene
2. Cytokinin
3. ABA
4. Gibberellin

Q.113
Which of the metabolites is common to respiration mediated breakdown of fats, carbohydrates and proteins?

1. Glucose-6-phosphate
2. Fructose 1,6-bisphosphate
3. Pyruvic acid
4. Acetyl CoA

Q.114
Which one of the following statements is correct?

1. Hard outer layer of pollen is called intine
2. Sporogenous tissue is haploid
3. Endothecium produces the microspores

4. Tapetum nourishes the developing pollen

Q.119
Perisperm differs from endosperm in:

1. Being a haploid tissue
2. Having no reserve food
3. Being a diploid tissue
4. Its formation by fusion of secondary nucleus with several sperms

---

Human Physiology Questions (Total: 19 Questions)

Q.140
The H-zone in the skeletal muscle fiber is due to:

1. The absence of myofibrils in the central portion of the A-band
2. The central gap between myosin filaments in the A-band
3. The central gap between actin filaments extending through myosin filaments in the A-band
4. Extension of myosin filaments in the central portion of the A-band

---

Q.148
A pregnant female delivers a baby who suffers from stunted growth, mental retardation, low intelligence quotient, and abnormal skin. This is the result of:

1. Deficiency of iodine in diet
2. Low secretion of growth hormone
3. Cancer of the thyroid gland
4. Over secretion of pars distalis

Q.149
The figure shows a diagrammatic view of the human respiratory system with labels

A, B, C, and D. Select the option which gives correct identification and main function and/or characteristic:

1. A - trachea - long tube supported by complete cartilaginous rings for conducting inspired air
2. B - pleural membrane - surrounds ribs on both sides to provide cushion against rubbing
3. C - Alveoli - thin-walled vascular bag-like structures for exchange of gases
4. D - Lower end of lungs - diaphragm pulls it down during inspiration

---

Q.150
The figure shows a schematic plan of blood circulation in humans with labels A to D. Identify the label and give its function/s:

1. A – Pulmonary vein – takes impure blood from body parts, PO_2 = 60 mm Hg
2. B – Pulmonary artery – takes blood from heart to lungs, PO_2 = 90 mm Hg
3. C – Vena Cava – takes blood from body parts to right auricle, PCO_2 = 45 mm Hg
4. D – Dorsal aorta – takes blood from heart to body parts, PO_2 = 95 mm Hg

---

Q.151
The diagram given here is the standard ECG of a normal person. The P-wave represents the:

1. Contraction of both the atria
2. Initiation of the ventricular contraction
3. Beginning of the systole
4. End of systole

Q.152
Figure shows the human urinary system with structures labeled A to D. Select the option which correctly identifies them and gives their characteristics and/or functions:

1. A - Adrenal gland - located at the anterior part of kidney. Secretes Catecholamines which stimulate glycogen breakdown

2. B - Pelvis - broad funnel-shaped space inner to hilum, directly connected to loops of Henle
3. C - Medulla - inner zone of kidney and contains complete nephrons
4. D - Cortex - outer part of kidney and does not contain any part of nephrons

---

Q.153
Select the correct statement with respect to locomotion in humans:

1. A decreased level of progesterone causes osteoporosis in old people.
2. Accumulation of uric acid crystals in joints causes their inflammation.
3. The vertebral column has 10 thoracic vertebrae.
4. The joint between adjacent vertebrae is a fibrous joint.

Q.154
The characteristics and an example of a synovial joint in humans is:

1. Fluid cartilage between two bones, limited movements – Knee joints
2. Fluid filled between two joints, provides cushion – Skull bones
3. Fluid-filled synovial cavity between two bones – Joint between atlas and axis
4. Lymph-filled between two bones, limited movement – Gliding joint between carpals

---

Q.155
A diagram showing axon terminal and synapse is given. Identify correctly at least two of A-D:

1. A – Receptor
   C - Synaptic vesicles
2. B - Synaptic connection
   D - K+
3. A – Neurotransmitter
   B - Synaptic cleft
4. C – Neurotransmitter
   D - Ca++

Q.156

Parts A, B, C, and D of the human eye are shown in the diagram. Select the option which gives correct identification along with its functions/characteristics:

1. A – Retina – contains photoreceptors – rods and cones
2. B – Blind spot – has only a few rods and cones
3. C – Aqueous chamber – reflects the light which does not pass through the lens
4. D – Choroid – its anterior part forms the ciliary body

Q.157

Which of the following statements is correct in relation to the endocrine system?

1. Adenohypophysis is under direct neural regulation of the hypothalamus.
2. Organs in the body like the gastrointestinal tract, heart, kidney, and liver do not produce any hormones.
3. Non-nutrient chemicals produced by the body in trace amount that act as intercellular messengers are known as hormones.
4. Releasing and inhibitory hormones are produced by the pituitary gland.

Q.158

Select the answer which correctly matches the endocrine gland with the hormone it secretes and its function/deficiency symptom:

1. Anterior pituitary - Oxytocin - Stimulates uterus contraction during childbirth
2. Posterior pituitary - Growth Hormone (GH) - Oversecretion stimulates abnormal growth
3. Thyroid gland - Thyroxine - Lack of iodine in the diet results in goiter
4. Corpus luteum - Testosterone - Stimulates spermatogenesis

Q.159

What is the correct sequence of sperm formation?

1. Spermatid, Spermatocyte, Spermatogonia, Spermatozoa
2. Spermatogonia, Spermatocyte, Spermatozoa, Spermatid

3. Spermatogonia, Spermatozoa, Spermatocyte, Spermatid
4. Spermatogonia, Spermatocyte, Spermatid, Spermatozoa

Q.160
Menstrual flow occurs due to lack of:

1. Progesterone
2. FSH
3. Oxytocin
4. Vasopressin

Q.161
Which one of the following is not the function of placenta? It:

1. Facilitates the supply of oxygen and nutrients to the embryo.
2. Secretes estrogen.
3. Facilitates the removal of carbon dioxide and waste material from the embryo.
4. Secretes oxytocin during parturition.

Q.162
One of the legal methods of birth control is:

1. Abortion by taking an appropriate medicine
2. By abstaining from coitus from day 10 to 17 of the menstrual cycle
3. By having coitus at the time of daybreak
4. By premature ejaculation during coitus

Q.163
Which of the following cannot be detected in a developing fetus by amniocentesis?

1. Klinefelter syndrome
2. Sex of the fetus
3. Down syndrome

4. Jaundice

Q.164
Artificial insemination means:

1. Transfer of sperms of a healthy donor to a test tube containing ova
2. Transfer of sperms of husband to a test tube containing ova
3. Artificial introduction of sperms of a healthy donor into the vagina
4. Introduction of sperms of a healthy donor directly into the ovary

---

Q.173
The cell-mediated immunity inside the human body is carried out by:

1. T-lymphocytes
2. B-lymphocytes
3. Thrombocytes
4. Erythrocytes