CUET PG 2025 PLANT BIOTECHNOLOGY Question Paper with Solutions

Time Allowed :1 Hour 30 Mins	Maximum Marks :300	Total Questions :75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The examination duration is 90 minutes. Manage your time effectively to attempt all questions within this period.
2. The total marks for this examination are 300. Aim to maximize your score by strategically answering each question.
3. There are 75 mandatory questions to be attempted in the Agro forestry paper. Ensure that all questions are answered.
4. Questions may appear in a shuffled order. Do not assume a fixed sequence and focus on each question as you proceed.
5. The marking of answers will be displayed as you answer. Use this feature to monitor your performance and adjust your strategy as needed.
6. You may mark questions for review and edit your answers later. Make sure to allocate time for reviewing marked questions before final submission.
7. Be aware of the detailed section and sub-section guidelines provided in the exam. Understanding these will aid in effectively navigating the exam.

---

1. Plants having half the somatic chromosome number than found in normal individual are called -

(A) Monoploid
(B) Haploid
(C) Aneuploids
(D) Monosomics

Correct Answer: (B) Haploid

Solution:

Step 1: Understanding the Concept:
The question asks to identify the term for a plant that possesses half the number of chromosomes found in its normal somatic (body) cells.
Somatic cells in most plants are diploid, meaning they have two sets of chromosomes, denoted

as $2n$.
Gametes (sex cells) have half this number, which is one set of chromosomes, denoted as n.

Step 2: Detailed Explanation:
Let's analyze the given options:

- **Haploid (n):** An organism or cell having a single set of unpaired chromosomes. This corresponds to half the somatic chromosome number ($2n$) of a diploid organism. This is the correct definition.

- **Monoploid (x):** An organism that has the basic chromosome number of a polyploid series. In a diploid organism, the haploid number (n) is the same as the monoploid number (x). However, in a polyploid organism, like hexaploid wheat ($2n = 6x = 42$), the haploid number is $n = 3x = 21$, while the monoploid number is $x = 7$. Haploid is the more general and accurate term for half the somatic number.

- **Aneuploids:** Organisms with an abnormal number of chromosomes, where one or more chromosomes are either added or deleted from the normal diploid set (e.g., $2n + 1$ or $2n - 1$). This does not represent half the chromosome number.

- **Monosomics:** A type of aneuploidy where one chromosome is missing from the diploid set, represented as $2n - 1$. This is not half the somatic number.

Step 3: Final Answer:
Based on the definitions, a plant with half the somatic chromosome number is called a haploid.

Quick Tip

Remember the key distinction: **Haploid (n)** refers to the gametic chromosome number (half of the somatic number, $2n$). **Monoploid (x)** refers to the basic number of chromosomes in a polyploid set. For diploid organisms, $n = x$, but for polyploids, they are different.

---

2. The production of haploids by anther and pollen culture was first demonstrated by -

(A) Maheswari and Guha
(B) Ravi and Chan
(C) Kasha and Kao
(D) Clausen and Cameron

Correct Answer: (A) Maheswari and Guha

Solution:

Step 1: Understanding the Concept:
This question is about a significant historical discovery in the field of plant tissue culture. It asks to identify the scientists who first successfully produced haploid plants using anther and pollen culture techniques.

Step 2: Detailed Explanation:
The groundbreaking work on producing haploids through in vitro culture of anthers was performed by two Indian scientists, Sipra Guha and Satish C. Maheshwari.
In 1964, they reported the direct development of embryos from microspores of *Datura innoxia* (thorn apple) through the culture of its excised anthers.
This discovery was a milestone in plant biotechnology as it opened up a rapid method for producing homozygous diploid lines through chromosome doubling of haploids, significantly speeding up breeding programs.
The other options list scientists known for other contributions but not this specific discovery.

Step 3: Final Answer:
The first demonstration of haploid production from anther culture was by Maheswari and Guha.

Quick Tip

For competitive exams in biology and biotechnology, it's crucial to remember the names of key scientists associated with major discoveries, such as Mendel (genetics), Watson and Crick (DNA structure), and in this case, Maheswari and Guha (anther culture).

---

3. Plants cannot absorb molecular nitrogen from the atmosphere because

(A) It has double bonds making it highly stable.
(B) It has triple bonds making it highly stable.
(C) Its abundance in atmosphere inhibits absorption.
(D) It has double bonds making it highly unstable.

Correct Answer: (B) It has triple bonds making it highly stable.

Solution:

Step 1: Understanding the Concept:
The question asks for the chemical reason why plants are unable to use the abundant nitrogen gas (N_2) directly from the atmosphere. Nitrogen is an essential nutrient for plant growth.

Step 2: Detailed Explanation:
Atmospheric nitrogen exists as a diatomic molecule, N_2.
The two nitrogen atoms in the N_2 molecule are linked by a very strong **triple covalent bond** ($N \equiv N$).
This triple bond has very high bond dissociation energy (~ 945 kJ/mol), which makes the N_2 molecule chemically inert and extremely stable.
Plants, and indeed almost all eukaryotes, lack the necessary enzymes to break this strong triple bond.
The process of converting atmospheric N_2 into a usable form like ammonia (NH_3) is called nitrogen fixation. This process is primarily carried out by certain prokaryotic microorganisms (like *Rhizobium*) that possess the enzyme complex called **nitrogenase**, which can break the triple bond.

Step 3: Final Answer:
The presence of a highly stable triple bond in molecular nitrogen makes it unavailable for direct absorption by plants.

Quick Tip

Remember the structure of molecular nitrogen ($N \equiv N$) and the enzyme responsible for its fixation (nitrogenase). The stability of this triple bond is the central reason for the existence of the biological nitrogen cycle.

---

4. Inducing the formation of various vegetative organs from cells or tissues in plant tissue culture is called -

(A) Somatic embryogenesis
(B) Dedifferentiation
(C) Organogenesis
(D) Somatic hybridization

Correct Answer: (C) Organogenesis

Solution:

Step 1: Understanding the Concept:
The question asks for the specific term used in plant tissue culture to describe the process of forming vegetative organs like roots, shoots, and leaves from a mass of cells or a piece of tissue (explant).

Step 2: Detailed Explanation:
Let's define the given terms in the context of plant tissue culture:

- **Somatic embryogenesis:** The process where embryos are formed from somatic (body) cells, rather than from the fusion of gametes. These embryos can then develop into whole plants. It forms an embryo structure, not directly organs.

- **Dedifferentiation:** The process by which mature, specialized cells lose their specialized features and revert to a more embryonic, meristematic state. This often leads to the formation of an unorganized mass of cells called a callus. It is a step *before* organ formation, not the formation itself.

- **Organogenesis:** Literally means "the genesis of organs." In plant tissue culture, it refers to the development and formation of organs (like shoots, roots, flowers) from a callus or directly from an explant. This perfectly matches the question's description.

- **Somatic hybridization:** A technique involving the fusion of protoplasts (cells without cell walls) from different plant species to create a hybrid cell, which can then be regenerated into a hybrid plant.

Step 3: Final Answer:
The induction and formation of vegetative organs from cells or tissues in culture is correctly termed organogenesis.

Quick Tip

Differentiate between the two main pathways of plant regeneration in vitro: **Organogenesis** (forms organs like shoots/roots, often sequentially) and **Somatic Embryogenesis** (forms bipolar structures resembling zygotic embryos).

---

5. Production of secondary metabolites require the use of -

(A) Cell suspension
(B) Solid agar medium
(C) Meristem
(D) Axillary bud

Correct Answer: (A) Cell suspension

Solution:

Step 1: Understanding the Concept:
The question asks for the most suitable in vitro culture technique for the production of secondary metabolites. Secondary metabolites are organic compounds produced by plants that are not directly involved in the normal growth, development, or reproduction (e.g., alkaloids,

flavonoids, terpenoids), but often have important ecological functions or medicinal properties.

Step 2: Detailed Explanation:
For commercial or large-scale production of specific chemical compounds from plants, a method is needed that can be easily scaled up and controlled.

- **Cell suspension culture:** This technique involves growing individual cells or small aggregates of cells in a liquid medium inside a flask or a large bioreactor. This method is ideal for producing secondary metabolites because it allows for uniform growth conditions, easy control of nutrient levels and pH, and straightforward extraction of the desired compounds from the medium or cells.

- **Solid agar medium:** This is used to grow callus or to induce organogenesis. It is not suitable for large-scale, uniform production and extraction of chemical compounds.

- **Meristem culture:** This technique is used to cultivate the apical meristem to produce virus-free plants. Its primary goal is clonal propagation, not metabolite production.

- **Axillary bud culture:** This is another method of micropropagation (cloning) to produce a large number of plants, not for harvesting chemicals.

Step 3: Final Answer:
Cell suspension cultures in bioreactors are the standard method for the industrial production of secondary metabolites from plant cells.

Quick Tip

Associate **liquid cultures (cell suspension)** with the production of biochemicals and large-scale applications in bioreactors. Associate **solid cultures (agar)** with plant regeneration, cloning (micropropagation), and callus maintenance.

---

6. Media that contain some chemical with unknown chemical composition is called ____ media.

(A) Synthetic
(B) Enrichment
(C) Complex
(D) Selective

Correct Answer: (C) Complex

Solution:

Step 1: Understanding the Concept:
This question asks to classify a microbiological culture medium based on the knowledge of its chemical components. The key detail is that some ingredients have an "unknown chemical composition."

Step 2: Detailed Explanation:
Culture media can be classified based on their composition:

- **Synthetic or Defined Media:** In these media, the exact chemical composition is known. Every component is a pure chemical with a known formula and concentration.

- **Complex or Undefined Media:** These media contain at least one ingredient whose chemical composition is not precisely known. Such ingredients are often derived from natural sources, like yeast extract, beef extract, peptone, or tryptone. These extracts provide a rich mix of nutrients, but the exact amounts of each chemical are variable and unknown. The question's description fits this category.

- **Enrichment Media:** These are usually liquid media containing specific nutrients that favor the growth of a particular desired microbe, which may be present in low numbers in a mixed sample.

- **Selective Media:** These media contain components that inhibit the growth of unwanted microbes while allowing the desired microbes to grow.

Step 3: Final Answer:
A medium containing chemicals of unknown composition, such as yeast extract or peptone, is called a complex medium.

Quick Tip

Remember the core difference: **Synthetic = Defined/Known**. **Complex = Undefined/Unknown** (contains natural extracts). Enrichment and Selective media are classified by their function, not just their composition.

---

7. For obtaining pure cultures of bacteria ____ plate method is not used.

(A) Streak
(B) Spread
(C) Pour

(D) Dip

Correct Answer: (D) Dip

Solution:

Step 1: Understanding the Concept:
The question asks to identify which of the listed methods is not a standard laboratory technique for isolating bacteria to obtain a pure culture on a plate. A pure culture contains only one species or strain of bacteria.

Step 2: Detailed Explanation:
The primary goal of plating techniques for pure culture isolation is to separate individual bacterial cells on the surface of a solid medium so that each cell can grow into an isolated colony.

- **Streak Plate Method:** This is the most common technique for isolating pure cultures. A sterile loop is used to streak a sample across the agar surface in a specific pattern, progressively diluting the inoculum to obtain isolated colonies.

- **Spread Plate Method:** A small volume of a diluted liquid sample is pipetted onto the surface of an agar plate and then spread evenly with a sterile L-shaped spreader. This technique is used for both isolating and quantifying bacteria.

- **Pour Plate Method:** A known volume of the sample is mixed with molten agar and then poured into a sterile Petri dish. Colonies develop both on the surface and within the agar. This is also used for isolation and quantification.

- **Dip Method:** This typically refers to a "dip slide," which is a plastic slide coated with agar. It is dipped into a liquid sample (e.g., urine) to estimate the microbial load (bacterial count). While it involves a culture, its primary purpose is quantification and screening, not the meticulous isolation of pure cultures in the same way as the other three methods. It is not considered a standard "plate method" for obtaining pure cultures.

Step 3: Final Answer:
The streak, spread, and pour plate methods are all standard techniques for obtaining pure cultures. The dip method is not used for this purpose.

Quick Tip

The three fundamental techniques for isolating pure cultures on a Petri plate are Streak, Spread, and Pour. Memorize these three as the primary methods. Any other option listed is likely the answer to a question asking which method is "not used."

8. Select the correct statements regarding somaclonal variations
A. These variations can also result in unwanted traits.
B. Somaclones have been developed and proved advantageous in several crops.
C. These variations can be used to engineer novel traits.
D. Short term invitro callus and cell suspension, cultures results in somaclonal variation.
Choose the correct answer from the options given below :

(A) A, C and D Only
(B) A, B and C Only
(C) A and B Only
(D) A and D Only

Correct Answer: (B) A, B and C Only

Solution:

Step 1: Understanding the Concept:
Somaclonal variation refers to the genetic variations that arise in plants regenerated from in vitro cell or tissue cultures. This question asks to identify the correct statements about this phenomenon.

Step 2: Detailed Explanation:
Let's analyze each statement:

- **A. These variations can also result in unwanted traits.** This statement is **correct**. The genetic changes that occur during tissue culture are random and can lead to desirable, neutral, or undesirable traits. For example, a variation might cause reduced yield or poor growth.

- **B. Somaclones have been developed and proved advantageous in several crops.** This statement is **correct**. Scientists have successfully used somaclonal variation to select for advantageous traits like disease resistance (e.g., in sugarcane, potato) and improved yield or quality.

- **C. These variations can be used to engineer novel traits.** This statement is **correct**. Somaclonal variation is a source of new genetic diversity. By screening large populations of regenerated plants (somaclones), breeders can identify and select for novel traits that were not present in the original parent plant.

- **D. Short term invitro callus and cell suspension, cultures results in somaclonal variation.** This statement is **incorrect**. Somaclonal variation is typically induced by the stress of the culture environment over a **long period**. Short-term cultures are generally

more genetically stable. The longer the cells are kept in culture, the higher the frequency of mutations and variations.

Step 3: Final Answer:
Statements A, B, and C are correct, while statement D is incorrect. Therefore, the correct option includes A, B, and C only.

Quick Tip

Remember that somaclonal variation is a double-edged sword: it can be a valuable source of novel traits for crop improvement but can also lead to unwanted changes. The key cause is stress during **long-term** culture, not short-term.

---

9. In plant tissue culture formation of organ primordia-like shoot or root in callus cells is called -

(A) Dedifferentiation
(B) Redifferentiation
(C) Somatic embryogenesis
(D) Regeneration

Correct Answer: (B) Redifferentiation

Solution:

Step 1: Understanding the Concept:
The question asks for the specific term that describes the process where undifferentiated callus cells begin to form specialized structures like shoot or root primordia.

Step 2: Detailed Explanation:
Let's define the terms in the context of plant tissue culture:

- **Dedifferentiation:** The process where mature, specialized cells from an explant lose their specialized characteristics and revert to an unorganized, proliferative state, forming a callus.

- **Redifferentiation:** The process where the dedifferentiated cells of a callus differentiate again to form new, specialized cells, tissues, and organized structures like organ primordia (shoots, roots). This perfectly matches the question's description.

- **Somatic embryogenesis:** A process where somatic cells form structures resembling zygotic embryos, which are bipolar (having both a shoot and a root pole). This is different

from forming only a shoot or a root primordium.

- **Regeneration:** A general term for the development of a whole plant from a cell or tissue culture. Redifferentiation is the specific cellular process that leads to organ formation during regeneration.

Step 3: Final Answer:
The formation of organ primordia from callus cells is the process of redifferentiation.

Quick Tip

Memorize the sequence in organogenesis via callus culture: **Explant (Differentiated) → Dedifferentiation → Callus (Undifferentiated) → Redifferentiation → Organs (Differentiated)**.

---

10. Who is regarded as father of 'Plant Tissue Culture' (P. T. C.)?

(A) Gottlieb Haberlandt
(B) Theodor Schwann
(C) Friedrich J. Haberlandt
(D) Robert Koch

Correct Answer: (A) Gottlieb Haberlandt

Solution:

Step 1: Understanding the Concept:
This is a factual question asking to identify the scientist credited as the "Father of Plant Tissue Culture."

Step 2: Detailed Explanation:

- **Gottlieb Haberlandt:** In 1902, this Austrian botanist was the first person to attempt the in vitro culture of isolated plant cells (from Lamium and Eichhornia) in a nutrient solution. Although he was unable to make the cells divide, he correctly predicted that one could theoretically regenerate a whole plant from a single somatic cell, a concept he called "totipotentiality" (now known as totipotency). His vision and pioneering experiments laid the foundation for the entire field of plant tissue culture.

- **Theodor Schwann:** A German biologist who is a co-founder of the Cell Theory in 1839.

- **Friedrich J. Haberlandt:** Likely a distractor option. Gottlieb Haberlandt is the correct individual.

- **Robert Koch:** A German microbiologist known for his postulates that established the link between specific microbes and specific diseases. He is a father of modern bacteriology.

Step 3: Final Answer:
Gottlieb Haberlandt is universally regarded as the father of Plant Tissue Culture for his foundational concepts and experiments.

Quick Tip

For history-of-science questions, create a list of key figures and their major contributions. Haberlandt → Plant Tissue Culture, Schwann → Cell Theory, Koch → Koch's Postulates.

---

11. The first androgenic haploid plant product by anther culture was from -

(A) Soybean
(B) Datura
(C) Potato
(D) Barley

Correct Answer: (B) Datura

Solution:

Step 1: Understanding the Concept:
Androgenesis is the development of a haploid plant from the male gametophyte (microspore or pollen). The question asks for the plant species in which this was first successfully demonstrated using anther culture.

Step 2: Detailed Explanation:
The landmark discovery of producing haploid plants through anther culture was made by two Indian scientists, Sipra Guha and Satish C. Maheshwari, in 1964. They conducted their experiments on the plant ***Datura innoxia*** (thorn apple). They successfully cultured excised anthers and observed the development of embryos directly from the microspores within the anthers. This achievement opened the door for haploid breeding in many other crop species.

Step 3: Final Answer:
The first androgenic haploid plants were produced from *Datura*.

Quick Tip

Associate the pioneering work of **Guha and Maheshwari (1964)** with the first successful anther culture and haploid production in the plant ***Datura***.

---

12. The process of combining cytoplasmic genomes of one parent with nuclear genome of other parent is called -

(A) Somatic hybridization
(B) Micropropagation
(C) Cybridization
(D) Regeneration

Correct Answer: (C) Cybridization

Solution:

Step 1: Understanding the Concept:
The question describes a specific genetic modification technique where the resulting cell contains the nucleus from one parent and the cytoplasm (containing mitochondria and chloroplasts) from another parent.

Step 2: Detailed Explanation:

- **Somatic hybridization:** This is the fusion of whole protoplasts (plant cells without walls) from two different species. The resulting hybrid cell (heterokaryon) contains the nuclei and cytoplasms of *both* parents.

- **Micropropagation:** This is a method for rapidly cloning plants in vitro to produce a large number of genetically identical offspring. It does not involve combining genomes from different parents.

- **Cybridization:** This term stands for "cytoplasmic hybridization." It is a modification of somatic hybridization where protoplasts are fused, but the nucleus of one parent is eliminated, either before or after fusion. The resulting cell, or "cybrid," contains the nucleus of one parent and the cytoplasm of the other, or a mixture of cytoplasms from both. This precisely matches the description.

- **Regeneration:** The general process of growing a whole plant from cultured cells or tissues.

Step 3: Final Answer:
The process of creating a cell with the nucleus of one parent and the cytoplasm of another is

called cybridization.

Quick Tip

Break down the terms: **Somatic Hybrid** = somatic cells fused completely. **Cybrid** = **Cy**toplasmic Hy**brid**, indicating a hybrid cytoplasm with one parent's nucleus.

---

13. ____ Molecules of ATP are required to fix one molecule of nitrogen (N_2) to $2NH_3$.

(A) 4
(B) 8
(C) 16
(D) 20

Correct Answer: (C) 16

Solution:

Step 1: Understanding the Concept:
Biological nitrogen fixation is the process where atmospheric nitrogen (N_2) is converted into ammonia (NH_3). This reaction is catalyzed by the nitrogenase enzyme complex and is extremely energy-intensive, requiring a significant amount of ATP.

Step 2: Key Formula or Approach:
The overall balanced chemical equation for biological nitrogen fixation is:

$$N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_i$$

Step 3: Detailed Explanation:
As shown in the equation, the reduction of one molecule of dinitrogen (N_2) to form two molecules of ammonia (NH_3) requires the hydrolysis of **16 molecules of ATP** to ADP and inorganic phosphate (P_i). This energy is used by the nitrogenase enzyme complex to overcome the high activation energy required to break the strong triple bond of the N_2 molecule. The process also requires 8 electrons and 8 protons. A byproduct, hydrogen gas (H_2), is also formed.

Step 4: Final Answer:
To fix one molecule of N_2, 16 molecules of ATP are consumed.

Quick Tip

Memorize the stoichiometry of nitrogen fixation: 1 N_2 requires 8 electrons and **16 ATP**. This high energy cost is a common topic in exams.

14. Symbiotic nitrogen fixing bacteria are found in -
A. Azolla
B. Gnetum
C. Anthoceros
D. Cycas
E. Riccia
Choose the correct answer from the options given below :

(A) A, C and D Only
(B) B, C and E Only
(C) C, D and E Only
(D) B, C and D Only

Correct Answer: (A) A, C and D Only

Solution:

Step 1: Understanding the Concept:
The question asks to identify which of the listed plants form a symbiotic relationship with nitrogen-fixing microorganisms (specifically bacteria or cyanobacteria).

Step 2: Detailed Explanation:
Let's examine each plant:

- **A. Azolla:** This is an aquatic fern that has a well-known symbiotic relationship with the nitrogen-fixing cyanobacterium *Anabaena azollae*, which lives in cavities of its leaves. This makes Azolla a potent biofertilizer in rice paddies. **(Correct)**

- **B. Gnetum:** This is a gymnosperm that does not form symbiotic relationships for nitrogen fixation. **(Incorrect)**

- **C. Anthoceros:** This is a hornwort (a bryophyte) that has cavities in its thallus which are colonized by the nitrogen-fixing cyanobacterium *Nostoc*. **(Correct)**

- **D. Cycas:** This is a gymnosperm (a cycad) that possesses specialized roots called 'coralloid roots'. These roots are negatively geotropic and house symbiotic nitrogen-fixing cyanobacteria, such as *Nostoc* or *Anabaena*. **(Correct)**

- **E. Riccia:** This is a liverwort (a bryophyte) that does not have symbiotic nitrogen-fixing associations. **(Incorrect)**

Step 3: Final Answer:
The plants with symbiotic nitrogen-fixing bacteria are Azolla, Anthoceros, and Cycas. Therefore, the correct option is A, C, and D only.

Quick Tip

Remember these key examples of N-fixing symbiosis: Legumes with *Rhizobium*, *Azolla* with *Anabaena*, and *Cycas* (coralloid roots) and *Anthoceros* with cyanobacteria like *Nostoc*.

---

15. Important enzymes involved in nitrogen fixation are -

(A) Nitrogenase and peptidase
(B) Nitrogenase and hexokinase
(C) Hexokinase and dehydrogenase
(D) Nitrogenase and hydrogenase

Correct Answer: (D) Nitrogenase and hydrogenase

Solution:

Step 1: Understanding the Concept:
The question asks to identify the key enzymes that are directly involved in the process of biological nitrogen fixation.

Step 2: Detailed Explanation:
The process of converting atmospheric nitrogen (N_2) to ammonia (NH_3) involves a complex interplay of enzymes.

- **Nitrogenase:** This is the primary and essential enzyme complex that catalyzes the reduction of N_2 to NH_3. It is highly sensitive to oxygen. No nitrogen fixation can occur without it.

- **Hydrogenase:** A significant side reaction of the nitrogenase enzyme is the production of hydrogen gas (H_2), which wastes energy (ATP) and reducing power (electrons). Many nitrogen-fixing organisms possess an "uptake hydrogenase" enzyme. This enzyme recaptures the H_2 and oxidizes it, thereby recovering some of the energy that was lost. Therefore, hydrogenase is a very important enzyme for improving the overall efficiency of nitrogen fixation.

- **Peptidase, Hexokinase, Dehydrogenase:** These are important enzymes in general cellular metabolism (protein breakdown, glycolysis, respiration) but are not the specific

key enzymes of the nitrogen fixation pathway itself.

Step 3: Final Answer:
Both Nitrogenase (for the main reaction) and Hydrogenase (for improving efficiency) are the important enzymes involved in nitrogen fixation.

Quick Tip

Think of Nitrogenase as the "worker" that fixes nitrogen and Hydrogenase as the "recycler" that recovers wasted energy, making the whole process more efficient. Both are crucial for the organism.

---

16. 'Pomato' a hybrid of potato and tomato was produced through-

(A) Shoot tip culture
(B) Anther culture
(C) Somatic hybridization
(D) Seed culture

Correct Answer: (C) Somatic hybridization

Solution:

Step 1: Understanding the Concept:
The question asks about the technique used to create 'Pomato', a plant that combines traits of potato and tomato. These two plants belong to the same genus (*Solanum*) but are different species (*Solanum tuberosum* and *Solanum lycopersicum*) and cannot be cross-bred using conventional sexual hybridization.

Step 2: Detailed Explanation:
'Pomato' was created using a biotechnological technique called **somatic hybridization**.
This process involves the following steps:

1. Protoplasts (plant cells with their cell walls removed) are isolated from the somatic cells of both potato and tomato plants.

2. These protoplasts are induced to fuse together using fusogens like polyethylene glycol (PEG) or a mild electric shock.

3. The resulting hybrid protoplast contains the genetic material from both plants.

4. This hybrid protoplast is then cultured in vitro on a suitable medium to regenerate its cell wall and develop into a callus, which is then induced to form a whole new hybrid plant.

This technique allows for the creation of hybrids between sexually incompatible species.

Step 3: Final Answer:
The 'Pomato' was produced through the fusion of somatic cells, a process known as somatic hybridization.

Quick Tip

Somatic hybridization is the go-to technique for overcoming sexual incompatibility between plant species. Remember 'Pomato' as the classic example of this application.

---

17. Arrange the following steps in the process of nitrogen cycle in correct sequence:
A. Nitrogen fixation
B. Nitrification
C. Denitrification
D. Assimilation
E. Ammonification
Choose the correct answer from the options given below :

(A) A, B, C, D, E
(B) C, D, E, A, B
(C) A, B, D, E, C
(D) C, A, B, D, E

Correct Answer: (C) A, B, D, E, C

Solution:

Step 1: Understanding the Concept:
The nitrogen cycle is the biogeochemical cycle by which nitrogen is converted into multiple chemical forms as it circulates among the atmosphere, terrestrial, and marine ecosystems. The question requires arranging the key processes in a logical sequence.

Step 2: Detailed Explanation:
Let's trace the path of nitrogen through the ecosystem:

1. **A. Nitrogen fixation:** The cycle begins with bringing atmospheric nitrogen (N_2), which is unusable by most organisms, into the ecosystem. Nitrogen-fixing bacteria convert N_2 into ammonia (NH_3) or ammonium (NH_4^+).

2. **B. Nitrification:** Nitrifying bacteria in the soil convert ammonium (NH_4^+) first into nitrites (NO_2^-) and then into nitrates (NO_3^-).

3. **D. Assimilation:** Plants absorb the usable forms of nitrogen (ammonium or nitrates) from the soil through their roots and incorporate them into biological molecules like proteins and nucleic acids. Animals then get nitrogen by eating plants.

4. **E. Ammonification:** When plants and animals die, decomposers (bacteria and fungi) break down their organic nitrogen compounds and release ammonium (NH_4^+) back into the soil.

5. **C. Denitrification:** Denitrifying bacteria convert nitrates (NO_3^-) back into atmospheric nitrogen gas (N_2), which returns to the atmosphere, thus completing the cycle.

This logical flow corresponds to the sequence A $\rightarrow$ B $\rightarrow$ D $\rightarrow$ E $\rightarrow$ C.

Step 3: Final Answer:
The correct sequence of steps in the nitrogen cycle is Nitrogen fixation, Nitrification, Assimilation, Ammonification, and Denitrification.

Quick Tip

Visualize the nitrogen cycle as follows: **Fixation** (into the system), **Nitrification** (conversion in soil), **Assimilation** (uptake by life), **Ammonification** (decomposition/recycling), and **Denitrification** (exit from the system).

---

18. Virus free plants can be grown by : -

(A) Embryo culture
(B) Apical meristem culture
(C) Callus culture
(D) Organ culture

Correct Answer: (B) Apical meristem culture

Solution:

Step 1: Understanding the Concept:
The question asks for a plant tissue culture technique specifically used to produce plants that are free from viral infections.

Step 2: Detailed Explanation:
Even if a plant is systemically infected with a virus, the **apical meristem** (the growing tip of the shoot) is often free of the virus. There are two main reasons for this:

1. The rate of cell division in the meristem is very rapid, often outpacing the rate of viral replication and movement.

2. The apical meristem lacks a fully developed vascular system (xylem and phloem), which is the primary route for the long-distance transport of viruses throughout the plant.

Therefore, by excising this small region (the apical meristem, sometimes with a few leaf primordia, a technique called meristem tip culture) and growing it in vitro, it is possible to regenerate a whole plant that is genetically identical to the parent but completely free of the virus.

Step 3: Final Answer:
Apical meristem culture is the standard and most effective method for obtaining virus-free plants from an infected parent stock.

Quick Tip

Remember this key fact: The apical meristem is a "sanctuary" from viruses in an infected plant due to its rapid cell division and lack of vascular tissue. This makes it ideal for producing clean stock.

---

19. Match LIST-I with LIST-II

LIST-I		LIST-II	
A.	Somatic hybridization	I.	Cell suspension culture
B.	Parthenocarpy	II.	Fusion protoplasts from somatic cells
C.	Micropropagation	III.	Seedless fruits without fertilization
D.	Single cell production	IV.	Multiplication of plants without sexual reproduction

Choose the correct answer from the options given below:

(A) A-II, B-IV, C-I, D-III
(B) A-II, B-III, C-IV, D-I
(C) A-III, B-II, C-I, D-IV
(D) A-IV, B-III, C-II, D-I

Correct Answer: (B) A-II, B-III, C-IV, D-I

Solution:

Step 1: Understanding the Concept:
This question requires matching biological terms (LIST-I) with their correct definitions or associated concepts (LIST-II).

Step 2: Detailed Explanation:
Let's match each term in LIST-I with its description in LIST-II.

- **A. Somatic hybridization:** This is a technique where protoplasts (cells without cell walls) from somatic cells of two different plants are fused. This directly matches with **II. Fusion protoplasts from somatic cells**.

- **B. Parthenocarpy:** This is the natural or artificially induced production of fruit without fertilization of ovules, which makes the fruit seedless. This matches with **III. Seedless fruits without fertilization**.

- **C. Micropropagation:** This is a set of techniques used to rapidly multiply stock plant material to produce a large number of progeny plants, using modern plant tissue culture methods. It is a form of asexual or vegetative propagation. This matches with **IV. Multiplication of plants without sexual reproduction**.

- **D. Single cell production:** The large-scale production of individual plant cells is typically done in a liquid medium, which is known as a **I. Cell suspension culture**.

Step 3: Final Answer:
The correct matching is: A-II, B-III, C-IV, D-I.

Quick Tip

For matching questions, start with the term you are most confident about. This can help you eliminate incorrect options quickly and narrow down the possibilities.

---

20. Arrange the following steps for plant tissue culture (P.T.C.) in correct sequence:
A. Selection of desired material and suitable nutrient media for P. T. C.
B. Inoculation of explants
C. Surface sterilization of explant
D. Transfer of growing cultures
E. Transfer of plantlets to soil in pots
Choose the correct answer from the options given below :

(A) A, B, C, D, E
(B) A, C, B, D, E

(C) A, C, E, B, D
(D) B, C, A, E, D

Correct Answer: (B) A, C, B, D, E

Solution:

Step 1: Understanding the Concept:
The question asks for the correct chronological order of the general steps involved in performing a plant tissue culture experiment, from initiation to the final establishment of plants.

Step 2: Detailed Explanation:
Let's analyze the steps to establish a logical workflow:

1. **A. Selection of desired material and suitable nutrient media for P. T. C.:** This is the planning stage and the first step. You must decide which plant and which part of the plant (explant) to use and prepare the appropriate sterile nutrient medium.

2. **C. Surface sterilization of explant:** Before introducing the explant into the sterile culture environment, all surface microorganisms must be killed to prevent contamination. This is a critical step.

3. **B. Inoculation of explants:** After sterilization, the explant is placed onto or into the sterile nutrient medium inside a culture vessel. This process is called inoculation.

4. **D. Transfer of growing cultures:** As the cultures grow, they deplete the nutrients in the medium. They need to be periodically transferred (subcultured) to fresh medium to maintain growth. This step occurs during the in vitro growth phase.

5. **E. Transfer of plantlets to soil in pots:** Once the in vitro culture has developed into a complete plantlet with roots and shoots, it must be carefully moved from the sterile, high-humidity lab environment to the non-sterile soil environment. This process is called hardening or acclimatization and is the final stage.

Therefore, the correct sequence is A $\rightarrow$ C $\rightarrow$ B $\rightarrow$ D $\rightarrow$ E.

Step 3: Final Answer:
The correct sequence of steps for plant tissue culture is A, C, B, D, E.

Quick Tip

Remember the logic of asepsis in biology labs: **Prepare** (A), **Sterilize** (C), then **Inoculate** (B). Never inoculate before sterilizing the explant. The final step is always moving the plantlet out of the lab and into the soil (E).

---

21. In nitrogen cycle, Ammonification is the process of generating ammonia from-

(A) Amino acids
(B) Nitrates
(C) Nitrites
(D) Nitrogen

Correct Answer: (A) Amino acids

Solution:

Step 1: Understanding the Concept:
The question asks to identify the source material that is converted into ammonia during the process of ammonification in the nitrogen cycle.

Step 2: Detailed Explanation:
Ammonification is the process of decomposition. When plants and animals die, or when animals excrete waste, the organic matter contains complex nitrogen-containing compounds such as proteins, nucleic acids, and urea.
Microbial decomposers (bacteria and fungi) break down these complex organic molecules. Proteins are broken down into their constituent building blocks, which are **amino acids**.
These decomposers then metabolize the amino acids, removing the amino group (-NH_2) and converting it into ammonia (NH_3) or ammonium ions (NH_4^+), releasing it back into the soil.
The other options are incorrect:

- Nitrates and Nitrites are converted to ammonia via a different process (dissimilatory nitrate reduction), not ammonification.

- Nitrogen gas (N_2) is converted to ammonia via nitrogen fixation.

Step 3: Final Answer:
Ammonification is the generation of ammonia from the breakdown of organic nitrogen, primarily from amino acids derived from proteins.

Quick Tip

Link the terms: **Ammoni**fication produces **ammoni**a from the **amino** groups in organic matter like **amino** acids.

---

22. Match LIST-I with LIST-II

LIST-I		LIST-II	
A.	Gene inhibition	I.	Addition of functional gene to their genome to replace missing
B.	Gene editing	II.	Disarm the product of faulty gene
C.	Gene targeting	III.	CRISPR/Cas9
D.	Gene Augmentation therapy	IV.	Replacement of non functional gene with normal gene

Choose the correct answer from the options given below:

(A) A-III, B-IV, C-II, D-I
(B) A-II, B-III, C-IV, D-I
(C) A-I, B-II, C-III, D-IV
(D) A-IV, B-III, C-I, D-II

Correct Answer: (B) A-II, B-III, C-IV, D-I

Solution:

Step 1: Understanding the Concept:
This question requires matching different gene therapy strategies (LIST-I) with their corresponding descriptions or mechanisms (LIST-II).

Step 2: Detailed Explanation:

- **A. Gene inhibition:** This strategy is used for diseases caused by a faulty gene that produces a harmful product (gain-of-function mutation). The goal is to stop or 'inhibit' the gene from working. This can be done by blocking transcription or translation. This matches with **II. Disarm the product of faulty gene**.

- **B. Gene editing:** This refers to the technology that allows scientists to make precise changes to the DNA sequence of an organism. The most well-known and versatile tool for this is **III. CRISPR/Cas9**.

- **C. Gene targeting:** This is a specific technique that uses homologous recombination to modify an endogenous gene. It can be used to create specific mutations, correct a faulty gene, or replace a gene. This matches well with **IV. Replacement of non functional gene with normal gene**.

- **D. Gene Augmentation therapy:** This is the most common form of gene therapy, used for diseases caused by the loss of a gene's function (e.g., cystic fibrosis). The strategy is to introduce a healthy, functional copy of the gene into the cells to compensate for the faulty one. This matches perfectly with **I. Addition of functional gene to their genome to replace missing product**.

Step 3: Final Answer:
The correct matching is: A-II, B-III, C-IV, D-I.

Quick Tip

Remember the core ideas: **Augmentation** = Adding a good copy. **Inhibition** = Stopping a bad copy. **Editing** = Making precise changes (think CRISPR). **Targeting/Replacement** = Swapping out a gene.

---

23. Conversion of ammonia to nitrates is called -

(A) Ammonification
(B) Assimilation
(C) Nitrification
(D) Denitrification

Correct Answer: (C) Nitrification

Solution:

Step 1: Understanding the Concept:
This question asks for the name of a specific process within the nitrogen cycle: the oxidation of ammonia to nitrates.

Step 2: Detailed Explanation:
Let's define the terms related to the nitrogen cycle:

- **Ammonification:** The conversion of organic nitrogen from dead organisms into ammonia (NH_3) or ammonium (NH_4^+) by decomposers.

- **Assimilation:** The process by which plants and other organisms absorb nitrates or ammonia from the soil and incorporate the nitrogen into their own proteins and nucleic acids.

- **Nitrification:** This is a two-step process where ammonia/ammonium is oxidized first to nitrites (NO_2^-) by bacteria like *Nitrosomonas*, and then the nitrites are further oxidized to nitrates (NO_3^-) by bacteria like *Nitrobacter*. The overall conversion from ammonia to

nitrates is called nitrification. This matches the question perfectly.

- **Denitrification:** The process where nitrates (NO_3^-) are converted back into atmospheric nitrogen gas (N_2) by denitrifying bacteria, returning nitrogen to the atmosphere.

Step 3: Final Answer:
The conversion of ammonia to nitrates is correctly termed nitrification.

Quick Tip

Remember that "nitrification" is the process of *making nitrates*, which is a usable form of nitrogen for most plants. It's a key step in making nitrogen available in the soil.

---

24. Choose the correct statements regarding plant tissue culture -
A. Organogenesis is inducing the formation of various vegetative organs from cells or tissues.
B. Formation of mass of undifferentiation cells from callus redifferentiation.
C. Cytoplasmic hybrids are prepared by taking the nucleus from one parent and cytoplasm from both the parents.
D. Relative concentration of growth hormones play important role in organogenesis.
Choose the correct answer from the options given below :

(A) A, B, and C Only
(B) B, C and D Only
(C) A and B Only
(D) A, C and D Only

Correct Answer: (D) A, C and D Only

Solution:

Step 1: Understanding the Concept:
The question requires evaluating the correctness of four statements related to different aspects of plant tissue culture.

Step 2: Detailed Explanation:

- **A. Organogenesis is inducing the formation of various vegetative organs from cells or tissues.** This is the correct definition of organogenesis in the context of plant tissue culture. **(Correct)**

- **B. Formation of mass of undifferentiation cells from callus redifferentiation.** This statement is incorrect. The formation of an undifferentiated cell mass (callus) from a differentiated explant is called **dedifferentiation**. The formation of organs from the callus is called **redifferentiation**. The statement has these terms reversed. **(Incorrect)**

- **C. Cytoplasmic hybrids are prepared by taking the nucleus from one parent and cytoplasm from both the parents.** This describes the creation of a cybrid (cytoplasmic hybrid). This is typically achieved by fusing a normal protoplast (nucleus + cytoplasm) of one parent with an enucleated protoplast (cytoplasm only) of the other, resulting in a cell with the nucleus from one parent and a mixed cytoplasm from both parents. **(Correct)**

- **D. Relative concentration of growth hormones play important role in organogenesis.** This is a fundamental principle of plant tissue culture. The ratio of auxins to cytokinins in the culture medium determines whether the callus will differentiate into roots, shoots, or remain undifferentiated. **(Correct)**

Step 3: Final Answer:
Statements A, C, and D are correct. Therefore, the correct option is A, C and D Only.

Quick Tip

Remember the auxin-to-cytokinin ratio rule: High Auxin/Cytokinin ratio generally induces root formation, while a Low Auxin/Cytokinin ratio induces shoot formation.

---

25. Full form of CRISPR, a term used in genome editing is -

(A) Clustered regularly inter spaced short palindromic repeats
(B) Cumulative routinely inter spaced short palindromic repeats
(C) Cumulative regularly inter spaced short palindromic repeats
(D) Clustered routinely inter spaced slight palindromic repeats

Correct Answer: (A) Clustered regularly inter spaced short palindromic repeats

Solution:

Step 1: Understanding the Concept:
This is a factual recall question asking for the correct expansion of the acronym CRISPR, which is a powerful gene-editing technology.

Step 2: Detailed Explanation:
The acronym CRISPR stands for **Clustered Regularly Interspaced Short Palindromic**

Repeats.
This name describes a specific region in the DNA of bacteria and archaea.

- **Clustered:** The repeat sequences are found grouped together.
- **Regularly Interspaced:** These repeats are separated by unique sequences called "spacers."
- **Short:** The repeat sequences are brief.
- **Palindromic:** The repeat sequences read the same forwards and backwards on opposite DNA strands.

The other options use similar-sounding but incorrect words like "Cumulative," "routinely," and "slight" to serve as distractors.

Step 3: Final Answer:
The correct full form is Clustered regularly inter spaced short palindromic repeats.

Quick Tip

To remember the full form, break it down and understand what each word means in the context of DNA sequences. This makes it easier to spot the incorrect words in distractor options.

---

26. Choose the correct statements regarding homozygous diploid plants -
A. They are produced by doubling the chromosome number of haploids.
B. Doubling of chromosome enables the recessive traits to express too.
C. Chromosome doubling is done by Ozone treatment.
D. Chromosome doubling is done by colchicine treatment.
Choose the correct answer from the options given below:

(A) A, B and D Only
(B) A, C and D Only
(C) A, B and C Only
(D) A, and D Only

Correct Answer: (A) A, B and D Only

Solution:

Step 1: Understanding the Concept:
The question is about the production and characteristics of "doubled haploids," which are homozygous diploid plants used in plant breeding.

Step 2: Detailed Explanation:

- **A. They are produced by doubling the chromosome number of haploids.** This is the definition of a doubled haploid. Haploid plants (n) are first produced via anther or ovule culture, and then their chromosome set is doubled to create a completely homozygous diploid (2n) plant. **(Correct)**

- **B. Doubling of chromosome enables the recessive traits to express too.** In a haploid organism, every gene (including recessive alleles) is expressed because there is no other allele to mask it. When the chromosomes are doubled (e.g., a haploid with allele 'r' becomes a diploid 'rr'), the recessive trait remains expressed and is now fixed in a homozygous state. **(Correct)**

- **C. Chromosome doubling is done by Ozone treatment.** Ozone is a strong oxidizing agent used for sterilization, not for inducing polyploidy. This statement is **(Incorrect)**.

- **D. Chromosome doubling is done by colchicine treatment.** Colchicine is a chemical extracted from the autumn crocus. It is a mitotic inhibitor that disrupts the formation of the spindle fibers during cell division. This prevents the separation of chromosomes, leading to a doubling of the chromosome number in the cell. This is the standard method used for producing doubled haploids. **(Correct)**

Step 3: Final Answer:
Statements A, B, and D are correct.

Quick Tip

Associate **Colchicine** with **Chromosome doubling**. It's a classic tool in plant breeding to induce polyploidy and create homozygous lines from haploids.

---

27. Transgenic plants developed by introducing *Bt* gene in crops like brinjal, maize, cotton etc. provide resistance to:

(A) insect pests
(B) viral infection
(C) heat
(D) fungal diseases

Correct Answer: (A) insect pests

Solution:

Step 1: Understanding the Concept:
The question asks about the specific trait conferred by the *Bt* gene when introduced into crops.

Step 2: Detailed Explanation:
The *Bt* gene is derived from the soil bacterium ***Bacillus thuringiensis***.
This bacterium produces a protein crystal, known as Cry protein, during sporulation.
This Cry protein is an endotoxin that is specifically toxic to certain groups of insects (e.g., lepidopterans - bollworms, dipterans - flies/mosquitoes, coleopterans - beetles).
When an insect pest ingests the plant tissues containing the Bt toxin, the alkaline pH of its midgut solubilizes the crystals. The toxin is then activated by proteases in the insect gut, binds to receptors on the gut wall, and creates pores. This leads to cell lysis, gut paralysis, and ultimately the death of the insect.
Therefore, introducing the gene that codes for this protein into plants makes them genetically modified to be resistant to specific **insect pests**.

Step 3: Final Answer:
The *Bt* gene provides resistance against insect pests.

Quick Tip

Remember the source: **B**acillus **t**huringiensis. The name itself is a clue. It's a biological pesticide, and the gene provides resistance to **b**ugs (insects).

---

28. Which of the following converts nitrites to nitrates?

(A) Clostridium
(B) Nitrobacter
(C) Nitrosomonas
(D) Nitrococcus

Correct Answer: (B) Nitrobacter

Solution:

Step 1: Understanding the Concept:
This question asks to identify the specific bacterium responsible for the second step of nitrification in the nitrogen cycle.

Step 2: Detailed Explanation:
Nitrification is a two-step process:

1. **Ammonia Oxidation:** Ammonia (NH_3) or ammonium (NH_4^+) is oxidized to nitrite (NO_2^-). This step is carried out by ammonia-oxidizing bacteria. Examples include ***Nitrosomonas*** and ***Nitrococcus***.

2. **Nitrite Oxidation:** Nitrite (NO_2^-) is oxidized to nitrate (NO_3^-). This step is carried out by nitrite-oxidizing bacteria. The most common example is ***Nitrobacter***.

Clostridium is a genus of bacteria known for various metabolic processes, including nitrogen fixation and fermentation, but not nitrification.
Therefore, *Nitrobacter* is the correct bacterium that converts nitrites to nitrates.

Step 3: Final Answer:
Nitrobacter is the bacterium that converts nitrites to nitrates.

Quick Tip

Use a mnemonic to separate the two steps of nitrification: Bacteria with "nitroso-" in their name (like *Nitroso*monas) come first, converting ammonia to nitrite. Bacteria with "nitro-" (like *Nitro*bacter) come second, converting nitrite to nitrate.

---

29. San Noeum first successfully cultured gynogenic haploid plants from unfertilized ovaries of -

(A) Maize
(B) Barley
(C) Wheat
(D) Rice

Correct Answer: (B) Barley

Solution:

Step 1: Understanding the Concept:
This is a factual, historical question about a milestone in plant tissue culture. It asks to identify the plant species in which gynogenesis (production of haploids from the female gametophyte) was first successfully demonstrated.

Step 2: Detailed Explanation:
While the production of haploids from male gametes (androgenesis, via anther culture) was first achieved by Guha and Maheshwari in *Datura* in 1964, the production of haploids from the female gametophyte (gynogenesis) came later.
In 1976, San Noeum published a groundbreaking paper reporting the successful production of haploid plants from the in vitro culture of unfertilized ovaries of **Barley** (*Hordeum vulgare*).

This opened up an alternative pathway for haploid production, particularly for species where androgenesis was difficult.

Step 3: Final Answer:
The first successful culture of gynogenic haploids was achieved in Barley.

Quick Tip

For exams, it's useful to remember key "firsts" in biotechnology:

- Anther culture (Androgenesis): Guha & Maheshwari in *Datura*.
- Ovary culture (Gynogenesis): San Noeum in *Barley*.

---

30. Nitrogen fixation occurs with the help of symbiotic bacteria in -
A. Pea
B. Lettuce
C. Beans
D. Tomato
E. Black gram
Choose the correct answer from the options given below :

(A) A, B and C Only
(B) B, C and D Only
(C) B, C and E Only
(D) A, C and E Only

Correct Answer: (D) A, C and E Only

Solution:

Step 1: Understanding the Concept:
The question asks to identify which of the listed plants engage in a symbiotic relationship with nitrogen-fixing bacteria. This symbiotic relationship is characteristic of plants belonging to the legume family (Fabaceae).

Step 2: Detailed Explanation:
Let's analyze each plant:

- **A. Pea (*Pisum sativum*):** This is a classic example of a legume. It forms root nodules that house nitrogen-fixing bacteria of the genus *Rhizobium*. **(Correct)**

- **B. Lettuce (*Lactuca sativa*):** This is a leafy green vegetable from the Asteraceae family. It is not a legume and does not form nitrogen-fixing symbiotic relationships. **(In-**

correct)

- **C. Beans (e.g., *Phaseolus vulgaris*):** Beans are a major group within the legume family and are well-known for their ability to fix nitrogen via symbiosis with *Rhizobium*. **(Correct)**

- **D. Tomato (*Solanum lycopersicum*):** The tomato belongs to the Solanaceae (nightshade) family. It is not a legume. **(Incorrect)**

- **E. Black gram (*Vigna mungo*):** This is another important pulse crop belonging to the legume family, and it actively fixes nitrogen. **(Correct)**

Step 3: Final Answer:
The plants that perform symbiotic nitrogen fixation are Pea, Beans, and Black gram. Therefore, the correct option is A, C and E Only.

Quick Tip

To answer such questions, learn to identify common legumes. Most plants referred to as peas, beans, lentils, and grams belong to the legume family and can fix nitrogen symbiotically.

---

31. In biological nitrogen fixation conversion of dinitrogen molecule into ammonia is carried out by enzyme.

(A) Hydrogenase
(B) Dehydrogenase
(C) Nitrogenase
(D) Nitrate reductase

Correct Answer: (C) Nitrogenase

Solution:

Step 1: Understanding the Concept:
Biological nitrogen fixation is the process by which atmospheric nitrogen gas (N_2), which is largely inert, is converted into ammonia (NH_3), a form of nitrogen that can be readily used by plants. This vital process is carried out by certain microorganisms. The question asks for the specific enzyme that catalyzes this conversion.

Step 2: Detailed Explanation:

- **Hydrogenase:** An enzyme that catalyzes the reversible oxidation of molecular hydrogen (H_2). It is often associated with nitrogen fixation to recycle H_2 produced as a byproduct, but it doesn't act on N_2.

- **Dehydrogenase:** A broad class of enzymes that oxidize a substrate by transferring one or more hydrides (H^-) to an acceptor, usually $NAD^+/NADP^+$ or a flavin coenzyme. They are involved in respiration, not directly in nitrogen fixation.

- **Nitrogenase:** This is the key enzyme complex responsible for biological nitrogen fixation. It breaks the strong triple bond of the dinitrogen molecule and reduces it to ammonia. This enzyme is found only in prokaryotes (bacteria and archaea).

- **Nitrate reductase:** An enzyme that catalyzes the reduction of nitrate (NO_3^-) to nitrite (NO_2^-), a step in nitrogen assimilation by plants and bacteria, but not nitrogen fixation.

Step 3: Final Answer:
The enzyme that converts dinitrogen into ammonia is Nitrogenase.

Quick Tip

Directly associate the process **Nitrogen fixation** with the enzyme **Nitrogenase**. The names are directly linked, making it an easy-to-remember pair.

---

32. Choose the correct statements regarding cytology of haploids -
A. A haploid in Arabidopsis will have 5 chromosomes.
B. Haploids are found as bivalents at metaphase-I of meiosis.
C. Haploids are found as univalent at metaphase-I of meiosis.
D. The haploids in maize will have 10 chromosomes.
E. The haploids in maize will have 20 chromosomes.
Choose the correct answer from the options given below :

(A) A, B and C Only
(B) A, C and E Only
(C) A, C and D Only
(D) A, B and E Only

Correct Answer: (C) A, C and D Only

Solution:

Step 1: Understanding the Concept:
The question tests knowledge about the chromosome number and meiotic behavior of haploid

organisms, using Arabidopsis and maize as examples. A haploid organism has a single set of chromosomes (n).

Step 2: Detailed Explanation:

- **A. A haploid in Arabidopsis will have 5 chromosomes.** The model plant *Arabidopsis thaliana* is a diploid with $2n = 10$ chromosomes. Therefore, its haploid (n) gamete or a haploid plant would have $10/2 = 5$ chromosomes. **(Correct)**

- **B. Haploids are found as bivalents at metaphase-I of meiosis.** A bivalent is a pair of synapsed homologous chromosomes. Since haploids have only one set of chromosomes, they lack homologous partners. Thus, bivalents cannot be formed. **(Incorrect)**

- **C. Haploids are found as univalent at metaphase-I of meiosis.** In a haploid cell undergoing meiosis, each chromosome has no homolog to pair with, so it remains as a single, unpaired chromosome, which is called a univalent. **(Correct)**

- **D. The haploids in maize will have 10 chromosomes.** Diploid maize (*Zea mays*) has $2n = 20$ chromosomes. Consequently, a haploid cell or plant will have $n = 10$ chromosomes. **(Correct)**

- **E. The haploids in maize will have 20 chromosomes.** 20 is the diploid ($2n$) chromosome number for maize, not the haploid number. **(Incorrect)**

Step 3: Final Answer:
The correct statements are A, C, and D.

Quick Tip

Meiosis in haploids is abnormal because there are no homologous chromosomes to form pairs (bivalents). Chromosomes remain as univalents, leading to irregular segregation and sterility.

---

33. Haploids can be artificially produced by -
A. Colchicine doubling
B. X-ray treatment
C. Pollen culture
D. Distant hybridization
E. Infrared radiation
Choose the correct answer from the options given below :

(A) A, B, and C Only
(B) B, C, and E Only
(C) A, D, and E Only
(D) B, C, and D Only

Correct Answer: (D) B, C, and D Only

Solution:

Step 1: Understanding the Concept:
The question asks to identify the valid techniques used for the artificial production of haploid plants.

Step 2: Detailed Explanation:

- **A. Colchicine doubling:** Colchicine is used to *double* the chromosome number, for example, to convert a haploid into a homozygous diploid. It does not produce haploids. **(Incorrect)**

- **B. X-ray treatment:** Irradiating pollen with X-rays can destroy the genetic material in the male gamete. If this pollen is used for pollination, it can stimulate the egg cell to develop parthenogenetically into a haploid embryo. This is a valid, though less common, method. **(Correct)**

- **C. Pollen culture:** Also known as anther/microspore culture, this is a standard and widely used technique where immature pollen grains (microspores) are cultured in vitro to develop into haploid plants (androgenesis). **(Correct)**

- **D. Distant hybridization:** Crossing two distantly related species (e.g., wheat with maize, or barley with *Hordeum bulbosum*) can lead to the selective elimination of the chromosomes of one parent during early embryo development, resulting in a haploid plant of the other parent. **(Correct)**

- **E. Infrared radiation:** This is a form of electromagnetic radiation associated with heat and is not used for inducing haploidy. **(Incorrect)**

Step 3: Final Answer:
The correct techniques listed are X-ray treatment, Pollen culture, and Distant hybridization.

Quick Tip

The two most important methods for haploid production are anther/pollen culture (androgenesis) and ovary/ovule culture (gynogenesis). Distant hybridization leading to chromosome elimination is another key method, especially in cereals.

---

34. Autonomously replicating circular extrachromosomal DNA is called -

(A) Recombinant DNA
(B) Cybrid
(C) Plasmid
(D) Yeast artificial chromosome

Correct Answer: (C) Plasmid

Solution:

Step 1: Understanding the Concept:
The question provides a definition and asks for the corresponding biological term. The key features are: autonomously replicating, circular, and extrachromosomal DNA.

Step 2: Detailed Explanation:

- **Recombinant DNA:** A molecule of DNA created by joining together DNA segments from different sources. It is not a naturally occurring entity with a specific name.

- **Cybrid:** A cytoplasmic hybrid cell produced by fusing a whole cell with an enucleated cell. It is a cell, not a DNA molecule.

- **Plasmid:** A small, circular, double-stranded DNA molecule that is distinct from a cell's chromosomal DNA. Plasmids are found in bacteria and some eukaryotes, and they replicate independently of the main chromosome. This perfectly matches the definition.

- **Yeast artificial chromosome (YAC):** An engineered DNA molecule used to clone DNA sequences in yeast cells. YACs are linear, not circular.

Step 3: Final Answer:
The term for an autonomously replicating, circular, extrachromosomal DNA molecule is a plasmid.

Quick Tip

Memorize the definition of a plasmid. It is a fundamental tool in molecular cloning and genetic engineering, acting as a "vector" to carry foreign genes into bacteria.

---

35. Nitrogen fixing cyanobacteria *Anabaena* is found in the root pockets of -

(A) Azolla
(B) Pistia
(C) Marsilea
(D) Salvinia

Correct Answer: (A) Azolla

Solution:

Step 1: Understanding the Concept:
The question asks to identify the plant that hosts the nitrogen-fixing cyanobacterium *Anabaena* in a symbiotic relationship.

Step 2: Detailed Explanation:
The symbiosis between the aquatic fern ***Azolla*** and the cyanobacterium ***Anabaena azollae*** is a classic example of a mutualistic relationship.
The *Anabaena* lives within specialized cavities in the dorsal lobes of *Azolla*'s leaves, not in its roots. (The question uses the term "root pockets," which is biologically inaccurate, but points towards the known symbiotic pair). The cyanobacterium fixes atmospheric nitrogen, providing this essential nutrient to the fern. In return, the fern provides a protected environment and carbohydrates to the *Anabaena*.
The other plants listed (*Pistia*, *Marsilea*, *Salvinia*) are also aquatic ferns or floating plants but are not known for this specific symbiosis with *Anabaena*.

Step 3: Final Answer:
Despite the inaccuracy of "root pockets" (it should be leaf cavities), *Azolla* is the correct answer as it is the well-known symbiotic partner of *Anabaena*.

Quick Tip

The *Azolla-Anabaena* combination is a very important biofertilizer, especially in rice cultivation. This unique and powerful symbiotic relationship is a frequently tested topic.

---

36. The cutting of DNA at specific locations became possible with the discovery of -

(A) Reverse transcriptase
(B) Restriction endonuclease
(C) Bacteriophage
(D) P. C. R.

Correct Answer: (B) Restriction endonuclease

Solution:

Step 1: Understanding the Concept:
The question asks about the discovery that enabled scientists to cleave DNA molecules at precise, predictable sites, a foundational technique for genetic engineering.

Step 2: Detailed Explanation:

- **Reverse transcriptase:** An enzyme that synthesizes DNA from an RNA template. It is used to create complementary DNA (cDNA) but does not cut DNA.

- **Restriction endonuclease:** Also known as a restriction enzyme, this is a protein that recognizes a specific short nucleotide sequence (the restriction site) and cuts the DNA molecule at or near that site. Their discovery allowed for the precise cutting and pasting of DNA, launching the era of recombinant DNA technology. They act as "molecular scissors."

- **Bacteriophage:** A virus that infects bacteria. While some phages are sources of useful enzymes or are used as cloning vectors, the phage itself is not the tool for cutting DNA.

- **P. C. R. (Polymerase Chain Reaction):** A technique used to amplify a specific segment of DNA, creating millions of copies. It involves DNA synthesis, not cutting.

Step 3: Final Answer:
The discovery of restriction endonucleases made the specific cutting of DNA possible.

Quick Tip

Remember the key tools of genetic engineering and their functions:

- **Cutting DNA:** Restriction Endonucleases
- **Pasting DNA:** DNA Ligase
- **Copying DNA:** DNA Polymerase (used in PCR)
- **Making DNA from RNA:** Reverse Transcriptase

37. Arrange the basic steps to develop G. M. O. (Genetically modified organisms) in sequence:
A. Transfer of DNA with desired genes to its progeny
B. Identification of DNA with desired genes
C. Introduction of the DNA into the host.
D. Maintenance of introduced DNA in the host.
Choose the correct answer from the options given below :

(A) A, B, C, D
(B) B, C, A, D
(C) B, A, D, C
(D) B, C, D, A

Correct Answer: (D) B, C, D, A

Solution:

Step 1: Understanding the Concept:
The question asks for the logical sequence of steps involved in the creation and establishment of a genetically modified organism.

Step 2: Detailed Explanation:
Let's arrange the steps in a logical order:

1. **B. Identification of DNA with desired genes:** The very first step is to identify and isolate the gene of interest that confers the desired trait.

2. **C. Introduction of the DNA into the host:** Once the gene is identified and isolated (often cloned into a vector), it must be introduced into the cells of the host organism. This is the transformation step.

3. **D. Maintenance of introduced DNA in the host:** After transformation, it's crucial to select the cells that have successfully incorporated the new DNA and ensure that this DNA is stable, either by integrating into the host's genome or by replicating as an episome. The host must be grown and regenerated while maintaining the new gene.

4. **A. Transfer of DNA with desired genes to its progeny:** The final goal of creating a GMO, especially in agriculture, is to have a stable line where the new trait is heritable. This means the introduced DNA must be passed on to the next generation through normal reproduction.

The correct sequence is B $\rightarrow$ C $\rightarrow$ D $\rightarrow$ A.

Step 3: Final Answer:
The correct sequence of steps is represented by the option B, C, D, A.

Quick Tip

Think of the process logically: **Find** the gene → **Insert** the gene → **Stabilize** the gene in the parent → **Inherit** the gene in the offspring.

---

38. A microbial biocontrol agent which control butterfly caterpillars in plants is -

(A) Bacillus thuringiensis
(B) Streptococcus sps.
(C) Saccharomyces cerevisiae
(D) Trichoderma polysperum

Correct Answer: (A) Bacillus thuringiensis

Solution:

Step 1: Understanding the Concept:
The question asks to identify a microbe that acts as a biological control agent specifically against the larvae (caterpillars) of butterflies and moths.

Step 2: Detailed Explanation:

- **Bacillus thuringiensis (Bt):** This is a soil-dwelling bacterium that is widely used as a biological pesticide. It produces crystalline proteins (Cry proteins) that are toxic to specific insect orders, most notably Lepidoptera (butterflies and moths). When a caterpillar ingests the Bt toxin, it becomes paralyzed, stops feeding, and dies.

- **Streptococcus sps.:** A genus of bacteria known for various roles, including some species that are part of the normal human flora and others that are significant human pathogens (e.g., causing strep throat). They are not used as insect biocontrol agents.

- **Saccharomyces cerevisiae:** This is brewer's or baker's yeast, a fungus used extensively in the food and beverage industry. It has no insecticidal properties.

- **Trichoderma polysperum:** A species of fungus belonging to the genus *Trichoderma*. Many *Trichoderma* species are used as biocontrol agents against fungal plant pathogens, but not against insects.

Step 3: Final Answer:
Bacillus thuringiensis is the microbial biocontrol agent used to control butterfly caterpillars.

Quick Tip

The abbreviation **Bt** (from *Bacillus thuringiensis*) is synonymous with microbial control of caterpillars. Bt corn and Bt cotton are famous examples of GMOs that produce this bacterial toxin to protect themselves from pests.

---

39. What is the function of leghemoglobin present in root nodulus of leguminous plants?

(A) Inhibition of nitrogenase activity
(B) Removal of oxygen
(C) Nodule differentiation.
(D) Expression of nif gene

Correct Answer: (B) Removal of oxygen

Solution:

Step 1: Understanding the Concept:
The question asks for the specific role of leghemoglobin, a protein found in the root nodules of nitrogen-fixing leguminous plants.

Step 2: Detailed Explanation:
Symbiotic nitrogen fixation presents a paradox: the nitrogen-fixing bacteria (*Rhizobium*) are aerobic and require oxygen for cellular respiration to produce the large amounts of ATP needed for nitrogen fixation. However, the key enzyme for this process, **nitrogenase**, is extremely sensitive to oxygen and is irreversibly inactivated by it.

Leghemoglobin solves this problem. It is an oxygen-binding protein, similar to hemoglobin in animal blood, that gives the active nodules their characteristic pink/red color. Its function is to act as an "oxygen buffer" or "oxygen scavenger". It binds strongly to free oxygen in the nodule, maintaining a very low concentration of free O_2. This protects the nitrogenase enzyme from damage while still delivering a steady supply of oxygen to the bacterial electron transport chain for respiration.

Therefore, its function is the effective removal or sequestration of free oxygen from the immediate environment of the nitrogenase enzyme.

Step 3: Final Answer:
The function of leghemoglobin is the removal of free oxygen to protect the nitrogenase enzyme.

Quick Tip

Think of leghemoglobin as the nodule's "security guard" for the nitrogenase enzyme. Its job is to keep the enemy (free oxygen) away from the enzyme so it can do its work, while still letting the bacteria breathe.

---

40. CRISPR-Cas 9 is a gene ____ technique.

(A) sequencing
(B) labelling
(C) editing
(D) locating

Correct Answer: (C) editing

Solution:

Step 1: Understanding the Concept:
The question asks to classify the CRISPR-Cas9 system based on its primary function in molecular biology.

Step 2: Detailed Explanation:
CRISPR-Cas9 is a revolutionary technology derived from a natural defense system in bacteria. It allows scientists to make precise changes to the DNA of living organisms.

- The CRISPR part of the system acts as a guide RNA that can find and bind to a specific sequence of DNA.

- The Cas9 part is a nuclease enzyme, often described as "molecular scissors," that cuts the DNA at the targeted location.

By cutting the DNA, the system allows scientists to remove, add, or alter specific DNA sequences. This process of making targeted changes to the genome is known as gene **editing**.

- **Sequencing** refers to determining the exact order of nucleotides in a DNA molecule.

- **Labelling** involves attaching a marker (like a fluorescent dye) to a molecule for detection.

- **Locating** is part of the process, but the ultimate function is to alter the gene, not just find it.

Step 3: Final Answer:
CRISPR-Cas9 is a powerful gene editing technique.

Quick Tip

Associate **CRISPR** with the concept of "molecular scissors" or a "find-and-replace" function for DNA. This directly points to its role in gene **editing**.

---

41. Choose the correct statements regarding *Agrobacterium tumefaciens* -
A. It is a gram positive round shaped bacterium
B. It is a gram negative rod shaped bacterium
C. It is a photosynthetic spiral bacterium
D. It is also known as 'Natural genetic Engineer'
E. It is capable of naturally transferring DNA into plant genome
Choose the correct answer from the options given below :

(A) A, B and C Only
(B) B, D and E Only
(C) B, C and D Only
(D) A, D and E Only

Correct Answer: (B) B, D and E Only

Solution:

Step 1: Understanding the Concept:
The question asks to identify the correct characteristics of the bacterium *Agrobacterium tumefaciens*, which is widely used in plant biotechnology.

Step 2: Detailed Explanation:

- **A. It is a gram positive round shaped bacterium.** This is incorrect. *A. tumefaciens* is Gram-negative and rod-shaped.

- **B. It is a gram negative rod shaped bacterium.** This is correct. It is a Gram-negative, motile, rod-shaped soil bacterium.

- **C. It is a photosynthetic spiral bacterium.** This is incorrect. It is not photosynthetic and not spiral-shaped.

- **D. It is also known as 'Natural genetic Engineer'.** This is correct. It earned this title because of its unique, natural ability to transfer a specific segment of its DNA (the

T-DNA from its Ti plasmid) into the host plant's genome.

- **E. It is capable of naturally transferring DNA into plant genome.** This is correct. This is the mechanism by which it causes crown gall disease and is the reason it is used as a vector for creating transgenic plants.

Step 3: Final Answer:
The correct statements are B, D, and E.

Quick Tip

Remember *Agrobacterium tumefaciens* for its main role: it's the "Natural Genetic Engineer" because it naturally injects a piece of its plasmid DNA into plant chromosomes. This makes it a perfect tool for creating GMOs.

---

42. Source organism of cry genes is -

(A) *Bacillus thuringiensis*
(B) *Agrobacterium tumefacien*
(C) *Rhizobium*
(D) *Staphylococcus*

Correct Answer: (A) *Bacillus thuringiensis*

Solution:

Step 1: Understanding the Concept:
The question asks for the origin of the 'cry genes', which are important in creating insect-resistant transgenic crops.

Step 2: Detailed Explanation:
The **cry genes** encode for Cry proteins, which are crystalline protein toxins produced by the soil bacterium ***Bacillus thuringiensis***. These proteins are specifically toxic to certain insect larvae (like caterpillars, beetles, and fly larvae).
The abbreviation **Bt** used in crops like Bt-cotton and Bt-brinjal stands for *Bacillus thuringiensis*. The cry genes from this bacterium are isolated and transferred into plants to make them produce the insecticidal protein, thus protecting them from specific pests.

- *Agrobacterium tumefaciens* is used as a vector to transfer genes but is not the source of cry genes.

- *Rhizobium* is a nitrogen-fixing bacterium.

- *Staphylococcus* is a genus of bacteria often associated with human infections.

Step 3: Final Answer:
The source organism of cry genes is *Bacillus thuringiensis*.

Quick Tip

Remember the link: **cry** genes produce insecticidal **cry**stals. They come from **B**acillus **t**huringiensis, the source of the famous **Bt** toxin.

---

43. Which of the following elements play key role in nitrogen fixation?

(A) Zinc
(B) Copper
(C) Molybdenum
(D) Manganese

Correct Answer: (C) Molybdenum

Solution:

Step 1: Understanding the Concept:
The question asks to identify a mineral element that is a crucial component of the enzyme responsible for biological nitrogen fixation.

Step 2: Detailed Explanation:
Biological nitrogen fixation, the conversion of N_2 to NH_3, is catalyzed by the enzyme complex **nitrogenase**.
Nitrogenase is a metalloenzyme, meaning it requires metal ions as cofactors to function. The most common form of nitrogenase contains two key metallic components:

1. An iron (Fe) protein.

2. An iron-molybdenum (Fe-Mo) protein.

The active site of the enzyme, where nitrogen is actually bound and reduced, is a complex metal cluster called the Iron-Molybdenum cofactor (FeMoco). Therefore, **Molybdenum (Mo)** is an essential micronutrient for nitrogen-fixing organisms. Iron (Fe) is also essential.
The other elements listed (Zinc, Copper, Manganese) are also important micronutrients for

plants but are not the key components of the nitrogenase active site.

Step 3: Final Answer:
Molybdenum plays a key role in nitrogen fixation as a component of the nitrogenase enzyme.

Quick Tip

Associate nitrogen fixation with the enzyme **nitrogenase**, and remember that its active site cofactor is **FeMoco** (Iron-Molybdenum cofactor). This directly links **Molybdenum** to the process.

---

44. Which of the following methods/tools is not used for introduction of recombinant DNA into host cell?

(A) Microinjection
(B) Denaturation
(C) Gene gun
(D) Heat shock method

Correct Answer: (B) Denaturation

Solution:

Step 1: Understanding the Concept:
The question asks to identify which option is not a method for transferring foreign DNA into a host cell, a process known as transformation or transfection.

Step 2: Detailed Explanation:
Let's analyze the given options:

- **Microinjection:** This is a physical method where a very fine glass needle is used to directly inject a DNA solution into the nucleus of a single cell. It is a commonly used method.

- **Denaturation:** This is the process of separating the two strands of a DNA double helix, typically by applying heat or chemicals. It is a crucial step in techniques like PCR and Southern blotting, but it is not a method for *introducing* DNA into a cell.

- **Gene gun (Biolistics):** This is a physical method where microscopic particles of gold or tungsten are coated with DNA and then shot at high velocity into target cells, penetrating the cell wall and membrane. It is a widely used method, especially for plant cells.

- **Heat shock method:** This is a chemical method, primarily used for bacterial transformation. Cells are first made "competent" by treating them with calcium chloride ($CaCl_2$), and then they are subjected to a brief, rapid increase in temperature (a heat shock), which temporarily makes the cell membrane permeable to DNA plasmids. It is a standard laboratory method.

Step 3: Final Answer:
Denaturation is a process that affects DNA structure; it is not a tool or method for introducing DNA into a host cell.

Quick Tip

Remember that gene transfer methods are about getting DNA *across the cell membrane*. Microinjection, gene gun, and heat shock are all ways to achieve this. Denaturation is about changing the DNA's shape from double-stranded to single-stranded.

---

45. Arrange the following steps in the process of somatic hybridization in correct sequence:
A. Plating of fused protoplasts
B. Selection of hybrid cells
C. Protoplast isolation and its treatment with fusion chemical.
D. Transfer of callus to differentiation medium
E. Selection of somatic hybrid plants
Choose the correct answer from the options given below :

(A) A, B, C, D, E
(B) C, A, B, D, E
(C) B, C, D, A, E
(D) A, C, B, D, E

Correct Answer: (B) C, A, B, D, E

Solution:

Step 1: Understanding the Concept:
The question requires ordering the steps involved in somatic hybridization, a technique used to create hybrid plants by fusing somatic cells.

Step 2: Detailed Explanation:
The logical sequence for this process is as follows:

1. **C. Protoplast isolation and its treatment with fusion chemical.** The first step is to obtain the cells and remove their cell walls to create protoplasts. Then, a fusogen (like

PEG) is applied to induce fusion.

2. **A. Plating of fused protoplasts.** The mixture containing fused and unfused protoplasts is plated on a culture medium to allow cell wall regeneration and cell division.

3. **B. Selection of hybrid cells.** Not all cells will fuse correctly. A selection method must be applied to identify and isolate the true hybrid cells (heterokaryons) from the parental cells and homokaryons.

4. **D. Transfer of callus to differentiation medium.** The selected hybrid cells are grown into an undifferentiated mass called a callus. This callus is then transferred to a medium containing specific hormones to induce the formation of shoots and roots (organogenesis).

5. **E. Selection of somatic hybrid plants.** Once plantlets are regenerated, they are often further analyzed and selected to confirm they are true hybrids and possess the desired combination of traits.

This logical flow gives the sequence: C $\rightarrow$ A $\rightarrow$ B $\rightarrow$ D $\rightarrow$ E.

Step 3: Final Answer:
The correct sequence for somatic hybridization is C, A, B, D, E.

Quick Tip

Think of the process from small to big: **Isolate** cells (C) $\rightarrow$ **Plate** and grow them (A) $\rightarrow$ **Select** the right cells (B) $\rightarrow$ **Differentiate** into a plant (D) $\rightarrow$ **Select** the best plant (E).

---

46. The correct combination of somaclonal variant released as a new cultivar is -

(A) Barley - Andro
(B) Geranium - Velvet Rose
(C) Tomato - DAMA
(D) Sugarcane - Scarlet

Correct Answer: (C) Tomato - DAMA

Solution:

Step 1: Understanding the Concept:
Somaclonal variation is the genetic variation observed among plants regenerated from tissue

culture. Sometimes, these variations can be advantageous and are selected to be released as new crop varieties (cultivars). The question asks for a correct example of this.

Step 2: Detailed Explanation:

- **Barley - Andro:** The name 'Andro' suggests it was developed via androgenesis (haploid breeding from pollen culture), not somaclonal variation.
- **Geranium - Velvet Rose:** This is often cited as a somaclonal variant of the Geranium cultivar 'Rober's Lemon Rose'. This is a potentially correct option.
- **Tomato - DAMA:** 'DAMA' is an Italian tomato variety that was specifically selected from somaclonal variants for its enhanced tolerance to saline conditions. This is a well-documented and correct example.
- **Sugarcane - Scarlet:** 'Scarlet' is a known cultivar of Pelargonium (Geranium), not sugarcane. The crop and cultivar name are mismatched.

Both (B) and (C) are technically correct examples found in literature. However, in the context of common textbook examples for agricultural crops, the development of a salt-tolerant tomato like 'DAMA' is a very strong and specific case of using somaclonal variation for crop improvement. Given the options, it stands out as a clear and intended answer.

Step 3: Final Answer:
The combination Tomato - DAMA represents a cultivar developed through the selection of somaclonal variants.

Quick Tip

Remember that somaclonal variation is a source of new traits. Key examples include disease resistance in sugarcane, salt tolerance in tomato ('DAMA'), and improved tuber shape in potato.

---

47. K. J. Kasha and coworkers found that following the cross between *Hordeum vulgare* × *Hordeum bulbosum*, chromosomes of *H. bulbosum* were eliminated in early zygotic division, so few days after pollination, embryos can be cultured to get haploids. This method is called as -

(A) Delayed pollination
(B) Distant hybridization
(C) Nucellus culture

(D) Androgenesis

Correct Answer: (B) Distant hybridization

Solution:

Step 1: Understanding the Concept:
The question describes a specific technique for producing haploid plants of barley (*Hordeum vulgare*) and asks for the scientific name of this method.

Step 2: Detailed Explanation:
The described process involves several key features:

1. A cross is made between two different species: *Hordeum vulgare* (cultivated barley) and *Hordeum bulbosum* (a wild relative). A cross between different species is known as **interspecific or distant hybridization**.

2. After fertilization, the chromosomes of one parent (*H. bulbosum*) are selectively eliminated from the cells of the developing embryo.

3. The resulting embryo is haploid, containing only the chromosome set from the *H. vulgare* parent. This embryo is then rescued and cultured in vitro to grow into a haploid plant.

The entire process is a form of distant hybridization that is specifically exploited for haploid production through chromosome elimination.

- **Nucellus culture** is used for cloning from maternal tissue.

- **Androgenesis** is haploid production from male gametes (pollen).

Step 3: Final Answer:
This method of producing haploids via an interspecific cross followed by chromosome elimination is a specific application of distant hybridization.

Quick Tip

When you see a cross between two different species (like *H. vulgare* and *H. bulbosum*), the overarching term for the technique is **Distant Hybridization**. The specific outcome here is haploid production, but the method itself is hybridization.

48. Antisense RNA technique is used -

(A) To silence the gene expression
(B) To enhance the gene expression
(C) For cell mediated gene transfer
(D) For DNA fingerprinting

Correct Answer: (A) To silence the gene expression

Solution:

Step 1: Understanding the Concept:
The question asks about the primary application of the antisense RNA technique. This technique involves an RNA molecule that is complementary to a specific messenger RNA (mRNA).

Step 2: Detailed Explanation:
The central dogma of molecular biology states that a gene (DNA) is transcribed into mRNA, which is then translated into a protein.
An "antisense" RNA molecule is designed to have a sequence that is the reverse complement of the "sense" mRNA molecule.
When the antisense RNA is introduced into a cell, it binds to its target mRNA molecule, forming a double-stranded RNA duplex.
This duplex cannot be translated by the ribosome, and it is often rapidly degraded by cellular enzymes like RNase H.
By preventing the translation of the mRNA into a protein, the antisense RNA effectively stops or "silences" the expression of the target gene. A famous example of its application is the Flavr Savr tomato, where it was used to slow down the ripening process.

Step 3: Final Answer:
The antisense RNA technique is used to bind to and prevent the translation of mRNA, thereby silencing gene expression.

Quick Tip

Think of "antisense" as being "anti-message." It binds to the messenger RNA and stops the message from being read, thus silencing the gene.

---

49. Using natural predators for the control of pathogens is known as ____ control.

(A) Physical
(B) Biological
(C) Chemical
(D) Enzymatic

Correct Answer: (B) Biological

Solution:

Step 1: Understanding the Concept:
The question asks for the term that describes a pest management strategy based on using living organisms.

Step 2: Detailed Explanation:
Pest control methods can be broadly categorized:

- **Physical Control:** Using barriers, traps, heat, or manual removal to manage pests.
- **Biological Control (Biocontrol):** Using other living organisms, such as predators, parasitoids, or pathogens, to suppress a pest population. The use of a natural predator fits this definition perfectly. For example, using ladybugs to control aphids.
- **Chemical Control:** Using synthetic pesticides or chemicals to kill pests.
- **Enzymatic Control:** This is not a standard category of pest control. It would imply using specific enzymes, which is not what is described.

Step 3: Final Answer:
The use of natural predators to control pathogens or pests is the definition of biological control.

Quick Tip

Remember that "bio" means life. **Bio**logical control is controlling pests using other forms of **life**.

---

50. Optimum pH for protoplast culture is -

(A) 6.5 to 7.0
(B) 5.5 to 5.9
(C) 4.5 to 4.9
(D) 7.5 to 7.9

Correct Answer: (B) 5.5 to 5.9

Solution:

Step 1: Understanding the Concept:
This is a factual question about the specific environmental requirements for in vitro culture of protoplasts (plant cells without cell walls). The pH of the culture medium is a critical factor for cell viability and growth.

Step 2: Detailed Explanation:
Protoplasts are extremely fragile due to the absence of a protective cell wall. The pH of the culture medium affects nutrient uptake, membrane stability, and enzyme activity.
For most plant tissue culture applications, including protoplast culture, the optimal pH of the medium (like MS medium) is adjusted to be slightly acidic before autoclaving.
The generally accepted range is between **5.5 and 5.9**. A pH of 5.7 or 5.8 is very commonly used.

- pH values below 5.0 can lead to nutrient precipitation and inhibit growth.
- pH values above 6.0 can also cause problems with the availability of certain ions and promote the growth of contaminants.

Step 3: Final Answer:
The optimum pH range for protoplast culture is 5.5 to 5.9.

Quick Tip

Remember that almost all standard plant tissue culture media (MS, B5, etc.) are adjusted to a pH of ∼5.8 before sterilization. This is a crucial number to memorize for any plant biotechnology exam.

---

51. Match LIST-I with LIST-II

LIST-I (Culture Type)		**LIST-II (Use/application)**	
A.	Embryo culture	I.	Somatic hybridization
B.	Meristem culture	II.	Production of haploids
C.	Protoplast culture	III.	Shortening of breeding cycle
D.	Anther culture	IV.	Virus free plants

Choose the correct answer from the options given below:

(A) A-II, B-III, C-IV, D-I
(B) A-III, B-IV, C-II, D-I
(C) A-II, B-I, C-IV, D-III
(D) A-III, B-IV, C-I, D-II

Correct Answer: (D) A-III, B-IV, C-I, D-II

Solution:

Step 1: Understanding the Concept:
This question requires matching specific plant tissue culture techniques with their most common and important applications in plant science and breeding.

Step 2: Detailed Explanation:

- **A. Embryo culture:** This technique involves excising and growing immature embryos in vitro. It is primarily used for "embryo rescue" in wide crosses where the endosperm fails to develop, which would otherwise lead to embryo abortion. By rescuing the hybrid embryo, one can bypass years of backcrossing, thus **III. Shortening of breeding cycle**.

- **B. Meristem culture:** The apical meristem of a plant is typically free from viruses even when the rest of the plant is infected. Culturing this meristem tip is the standard method for producing **IV. Virus free plants**.

- **C. Protoplast culture:** Protoplasts (cells without walls) from different species can be fused together. This technique is called **I. Somatic hybridization**.

- **D. Anther culture:** Anthers contain microspores (pollen), which are male gametophytes. Culturing anthers or isolated microspores leads to the development of haploid plants. This technique is used for the **II. Production of haploids**.

Step 3: Final Answer:
The correct matches are A-III, B-IV, C-I, and D-II.

Quick Tip

For matching questions, start with the pairs you are most certain about. For instance, **Meristem** $\rightarrow$ **Virus free** and **Anther** $\rightarrow$ **Haploids** are classic associations. This will help you eliminate incorrect options quickly.

---

52. Prions are the -

(A) infections proteinaceous agents
(B) DNA without protein coat
(C) RNA without protein coat
(D) Protozoans

Correct Answer: (A) infections proteinaceous agents

Solution:

Step 1: Understanding the Concept:
The question asks for the definition of a prion, which is a type of acellular infectious agent.

Step 2: Detailed Explanation:

- **Prions:** These are unique infectious agents composed solely of misfolded protein. They contain no genetic material (DNA or RNA). A prion protein can induce normally folded proteins of the same type to also misfold, leading to aggregation and causing fatal neurodegenerative diseases like Creutzfeldt-Jakob disease in humans and bovine spongiform encephalopathy (mad cow disease) in cattle. Thus, they are **infectious proteinaceous agents**.

- **DNA without protein coat:** No known infectious agent fits this description.

- **RNA without protein coat:** This is the definition of a **viroid**, an infectious agent that affects plants.

- **Protozoans:** These are single-celled eukaryotic organisms like *Amoeba* or *Plasmodium*. They are cellular, not acellular agents.

Step 3: Final Answer:
Prions are infectious proteinaceous agents.

Quick Tip

The name "prion," coined by Stanley Prusiner, is derived from "**pr**oteinaceous **i**nfectious particle." The name itself is the definition.

---

53. What is CPW in protoplast culture method?

(A) Cell and protoplast washing
(B) Cytosol and protoplasm washing
(C) Cell and protoplast waste
(D) Cell and proteolytic waste

Correct Answer: (A) Cell and protoplast washing

Solution:

Step 1: Understanding the Concept:
This is a terminology question specific to the laboratory protocols used in plant protoplast

isolation. It asks for the meaning of the acronym "CPW".

Step 2: Detailed Explanation:
In the process of isolating protoplasts, plant tissue is first treated with enzymes (like cellulase and pectinase) to digest the cell walls. After digestion, the resulting mixture contains protoplasts, undigested cells, cellular debris, and the enzyme solution.
It is crucial to wash the protoplasts to remove these enzymes and debris, which can be harmful. For this purpose, a specific salt solution is used. This solution is commonly referred to as **CPW salt solution**, where CPW stands for **Cell and Protoplast Washing**.

Step 3: Final Answer:
CPW stands for Cell and protoplast washing.

Quick Tip

In technical fields like biotechnology, acronyms are common. For exams, it's helpful to create a small glossary of key acronyms like CPW, MS (Murashige and Skoog), PEG (Polyethylene glycol), etc.

---

54. Arrange the following events in Western Blotting experiment in correct order:
A. Protein resolution by PAGE
B. Primary antibody binding
C. Transfer onto nitrocellulose membrane
D. Protein denaturation in loading dye.
Choose the correct answer from the options given below :

(A) A, C, B, D
(B) D, A, C, B
(C) B, A, D, C
(D) C, B, D, A

Correct Answer: (B) D, A, C, B

Solution:

Step 1: Understanding the Concept:
The question asks for the correct chronological sequence of the major steps in a Western blot, a technique used to detect a specific protein in a complex mixture.

Step 2: Detailed Explanation:
The logical workflow of a Western blot is as follows:

1. **D. Protein denaturation in loading dye.** First, the protein sample is prepared by boiling it in a loading buffer containing a detergent like SDS (sodium dodecyl sulfate).

This denatures the proteins (unfolds them) and gives them a uniform negative charge.

2. **A. Protein resolution by PAGE.** The denatured protein mixture is loaded onto a polyacrylamide gel, and an electric current is applied. The proteins migrate through the gel and are separated based on their size. This is PolyAcrylamide Gel Electrophoresis (PAGE).

3. **C. Transfer onto nitrocellulose membrane.** After separation, the proteins are transferred (blotted) from the fragile gel onto a solid support, typically a nitrocellulose or PVDF membrane. This makes the proteins accessible for antibody binding.

4. **B. Primary antibody binding.** The membrane is then incubated with a primary antibody that is specific to the protein of interest. This antibody binds only to the target protein on the membrane. (This is followed by washing, secondary antibody binding, and detection, but primary antibody binding is the next key step listed).

Therefore, the correct sequence is D $\rightarrow$ A $\rightarrow$ C $\rightarrow$ B.

Step 3: Final Answer:
The correct order of events is D, A, C, B.

Quick Tip

For blotting techniques (Southern, Northern, Western), remember the general order: **Separate** (on a gel), **Transfer** (to a membrane), and then **Probe** (with DNA, RNA, or antibody). The initial sample preparation (like denaturation) must come first.

---

55. In cyanobacteria nitrogen fixation takes place in -

(A) Heterocyst
(B) Akinetes
(C) Nodules
(D) Hormogonia

Correct Answer: (A) Heterocyst

Solution:

Step 1: Understanding the Concept:
The question asks to identify the specialized cellular structure where nitrogen fixation occurs in certain types of cyanobacteria.

Step 2: Detailed Explanation:
Cyanobacteria perform oxygenic photosynthesis, which releases oxygen. However, the enzyme responsible for nitrogen fixation, nitrogenase, is irreversibly inactivated by oxygen. To solve this problem, many filamentous cyanobacteria (like *Nostoc* and *Anabaena*) have evolved specialized cells to carry out nitrogen fixation.

- **Heterocyst:** This is a specialized, thick-walled cell found in the filaments of some cyanobacteria. It lacks photosystem II (the oxygen-producing part of photosynthesis) and has a thick wall to limit oxygen diffusion, thereby creating the necessary anaerobic environment for the nitrogenase enzyme to function.

- **Akinetes:** These are thick-walled, dormant cells that serve as resting spores, allowing the cyanobacterium to survive harsh environmental conditions. They are not involved in nitrogen fixation.

- **Nodules:** These are structures found on the roots of leguminous plants that house symbiotic nitrogen-fixing bacteria (*Rhizobium*), not structures within cyanobacteria themselves.

- **Hormogonia:** These are short, motile filaments that break off from the main filament for dispersal and reproduction.

Step 3: Final Answer:
In cyanobacteria, nitrogen fixation takes place in specialized cells called heterocysts.

Quick Tip

Associate the problem (oxygen-sensitive nitrogenase) with the solution (a specialized, oxygen-free cell). In cyanobacteria, that special cell is the **heterocyst**.

---

56. Synthetic seeds are produced by the encapsulation of somatic embryos with-

(A) Sodium acetate
(B) Sodium chloride
(C) Sodium nitrate
(D) Sodium alginate

Correct Answer: (D) Sodium alginate

Solution:

Step 1: Understanding the Concept:
Synthetic seeds (or artificial seeds) are produced in vitro to mimic the structure and function of true seeds. They consist of a somatic embryo (which acts as the plant embryo), an artificial endosperm (containing nutrients), and a protective outer coating. The question asks for the chemical used to create this outer coating.

Step 2: Detailed Explanation:
The encapsulation of somatic embryos requires a gelling agent that is non-toxic to the embryo, allows for nutrient and gas exchange, and provides protection.
Sodium alginate is the most widely used substance for this purpose. It is a natural polysaccharide derived from brown algae.
The process involves mixing somatic embryos with a sodium alginate solution and then dropping this mixture into a solution of calcium chloride ($CaCl_2$). The calcium ions cross-link the alginate polymers, forming a solid, insoluble gel of calcium alginate around the embryo. This bead acts as the artificial seed coat.
The other options are simple salts and are not gelling agents, so they cannot be used for encapsulation.

Step 3: Final Answer:
Somatic embryos are encapsulated with sodium alginate to produce synthetic seeds.

Quick Tip

Remember the gelling reaction for synthetic seeds: **Sodium alginate + Calcium chloride → Calcium alginate gel**. This is the key chemical principle behind the artificial seed coat.

---

57. In plant tissue culture higher concentration of cytokinin generally promotes-

(A) Root regeneration
(B) Shoot regeneration
(C) Leaf primordia
(D) Flower initiation

Correct Answer: (B) Shoot regeneration

Solution:

Step 1: Understanding the Concept:
Plant organogenesis (the formation of organs) in tissue culture is primarily controlled by the balance of two key classes of plant hormones: auxins and cytokinins. The question asks about the effect of a high concentration of cytokinin.

Step 2: Detailed Explanation:
The ratio of auxin to cytokinin in the culture medium is a critical determinant of cellular differentiation:

- **High cytokinin to auxin ratio:** This condition generally stimulates cell division and promotes the differentiation of shoots from a callus or explant. This process is called caulogenesis.
- **High auxin to cytokinin ratio:** This condition typically promotes the formation and growth of roots. This process is called rhizogenesis.
- **Intermediate ratio:** A balanced level of both hormones often leads to the proliferation of an undifferentiated mass of cells called a callus.

Therefore, a higher concentration of cytokinin is used to induce shoot regeneration.

Step 3: Final Answer:
In plant tissue culture, a higher concentration of cytokinin generally promotes shoot regeneration.

Quick Tip

Memorize the "hormone ratio rule":

- High **C**ytokinin → **S**hoots (**C**ytokinin for **C**aulogenesis)
- High **A**uxin → **R**oots (**A**uxin for **R**hizogenesis)

---

58. Chemical most widely used for chromosome doubling in haploid culture is-

(A) Sorbitol
(B) Mannose
(C) Colchicine
(D) Mannitol

Correct Answer: (C) Colchicine

Solution:

Step 1: Understanding the Concept:
Haploid plants produced through techniques like anther culture are sterile because they lack homologous chromosomes for proper meiosis. To make them fertile and create homozygous

diploid lines for breeding, their chromosome number must be doubled. The question asks for the chemical used for this purpose.

Step 2: Detailed Explanation:
Colchicine is an alkaloid chemical extracted from the autumn crocus (*Colchicum autumnale*). It is a potent mitotic inhibitor.
Its mechanism of action is to bind to tubulin, the protein subunit of microtubules. This disrupts the formation of the spindle fibers during metaphase of mitosis. As a result, the sister chromatids fail to separate and move to opposite poles. The cell proceeds through the cell cycle but fails to divide, resulting in a nucleus with double the original chromosome number (e.g., a haploid 'n' cell becomes a diploid '2n' cell).
The other options—Sorbitol, Mannose, and Mannitol—are sugars or sugar alcohols commonly used as carbon sources or as osmotic stabilizers in plant tissue culture media to prevent cell lysis; they do not induce chromosome doubling.

Step 3: Final Answer:
The chemical most widely used for chromosome doubling in haploid cultures is colchicine.

Quick Tip

Directly associate the word **Colchicine** with **Chromosome doubling**. It is the classic and most famous antimitotic agent used in plant breeding to induce polyploidy.

---

59. Which combination of strategies forms the basis of in vivo haploid induction technologies in plants?
A. induction of parthenogenesis
B. culture of anthers or ovules
C. use of paternal inducer lines
D. uniparental genome elimination
Choose the correct answer from the options given below:

(A) A, B and C only
(B) B, C and D only
(C) A, C and D only
(D) B, and D only

Correct Answer: (C) A, C and D only

Solution:

Step 1: Understanding the Concept:
The question asks to identify the methods used for *in vivo* haploid induction. *In vivo* means the process occurs within a living plant, as opposed to *in vitro*, which means "in glass" (i.e., in

a lab culture).

Step 2: Detailed Explanation:
Let's analyze each strategy:

- **A. induction of parthenogenesis:** This is the development of an embryo from an unfertilized egg. This process occurs naturally or can be induced *in vivo* within the ovule of the parent plant. **(Correct - In vivo)**

- **B. culture of anthers or ovules:** This involves excising plant parts (anthers or ovules) and growing them on an artificial medium in a lab. This is the definition of an *in vitro* technique. **(Incorrect - In vitro)**

- **C. use of paternal inducer lines:** This is a modern technique, especially in maize, where pollination by a special "inducer" line triggers the development of a haploid embryo from the female gamete. The entire process up to embryo formation happens *in vivo* on the mother plant. **(Correct - In vivo)**

- **D. uniparental genome elimination:** This is the biological mechanism that underlies haploid induction through paternal inducer lines and also through distant hybridization. After fertilization, the chromosomes of one parent are selectively eliminated from the zygote. This elimination process occurs *in vivo* during the early stages of embryo development. **(Correct - In vivo)**

Therefore, the combination of strategies that form the basis of *in vivo* haploid induction are A, C, and D.

Step 3: Final Answer:
The correct combination is A, C and D only.

Quick Tip

To solve this, focus on the distinction between *in vivo* (in the plant) and *in vitro* (in the lab). Any mention of "culture" (like anther culture) immediately points to an *in vitro* method.

---

60. Match LIST-I with LIST-II

LIST-I		LIST-II	
A.	Biological nitrogen fixation	I.	Nitrobacter
B.	Conversion of ammonia to nitrite	II.	Paracoccus
C.	Conversion of nitrite to nitrate	III.	Rhizobium
D.	Denitrification	IV.	Nitrosomonas

Choose the correct answer from the options given below:

(A) A-II, B-III, C-IV, D-I
(B) A-III, B-IV, C-I, D-II
(C) A-I, B-III, C-II, D-IV
(D) A-I, B-II, C-III, D-IV

Correct Answer: (B) A-III, B-IV, C-I, D-II

Solution:

Step 1: Understanding the Concept:
This question requires matching key processes of the nitrogen cycle (LIST-I) with the specific genus of bacteria responsible for carrying out that process (LIST-II).

Step 2: Detailed Explanation:

- **A. Biological nitrogen fixation:** This is the conversion of atmospheric nitrogen (N_2) into ammonia (NH_3). **III. *Rhizobium*** is a classic example of a bacterium that performs this symbiotically in the root nodules of legumes. So, **A matches III**.

- **B. Conversion of ammonia to nitrite:** This is the first step of nitrification. It is carried out by ammonia-oxidizing bacteria, a prime example of which is **IV. *Nitrosomonas***. So, **B matches IV**.

- **C. Conversion of nitrite to nitrate:** This is the second step of nitrification. It is carried out by nitrite-oxidizing bacteria, the most common example being **I. *Nitrobacter***. So, **C matches I**.

- **D. Denitrification:** This is the process of converting nitrate (NO_3^-) back to nitrogen gas (N_2). This is performed under anaerobic conditions by denitrifying bacteria such as **II. *Paracoccus*** (and also *Pseudomonas*). So, **D matches II**.

Step 3: Final Answer:
The correct set of matches is A-III, B-IV, C-I, D-II.

Quick Tip

For nitrification, remember the order and the names: *Nitro**so**monas* works on ammonia (**so**urce), which comes first. *Nitro**bacter*** works on the product of the first step (nitrite), coming second.

61. Select the correct combination of protoplast isolation enzyme and its most popular source -

(A) Cellulase - *Helix pomatia*
(B) Hemicellulase - *Tricoderma viride*
(C) Macerozyme R - 10 - *Rhizopus arrhizus*
(D) Zymolyase - *Aspergillus niger*

Correct Answer: (B) Hemicellulase - *Tricoderma viride*

Solution:

Step 1: Understanding the Concept:
Protoplast isolation involves the enzymatic digestion of the plant cell wall. The cell wall is primarily composed of cellulose, hemicellulose, and pectin. This question asks to identify a correct pairing of a cell wall-degrading enzyme with its common biological source.

Step 2: Detailed Explanation:

- **1. Cellulase - *Helix pomatia*:** The gut of the snail *Helix pomatia* does contain cellulase, but the most popular and commercially important sources for cellulase used in biotechnology are fungi, particularly species of *Trichoderma*. So this is not the most popular source.

- **2. Hemicellulase - *Trichoderma viride*:** The fungus *Trichoderma viride* (and the closely related *T. reesei*) is a prolific producer of a wide range of cell wall-degrading enzymes, including both cellulases and hemicellulases. This is a correct and very popular combination.

- **3. Macerozyme R-10 - *Rhizopus arrhizus*:** Macerozyme is a commercial product name for a pectinase enzyme, which breaks down pectin and helps separate cells. Its source is indeed the fungus *Rhizopus*. This is also a correct statement. However, the combination in option 2 is also fundamentally correct and very common. In cases of ambiguity, both are strong candidates. Let's re-examine if there is any inaccuracy. Both 2 and 3 are factually correct pairings. Often questions may have more than one correct option, but one is considered "more correct". Given that *Trichoderma* is the workhorse for both cellulase and hemicellulase, this represents a very fundamental and popular source-enzyme pair.

- **4. Zymolyase - *Aspergillus niger*:** Zymolyase is an enzyme mix used to degrade yeast cell walls (which are made of glucan and mannan, not cellulose). It is not typically used for plant protoplasts. Furthermore, its commercial source is the bacterium *Arthrobacter luteus*, not the fungus *Aspergillus niger*. This is incorrect.

Between options 2 and 3, both of which are factually correct, option 2 represents a more general class of enzyme (hemicellulase) from its most common source.

Step 3: Final Answer:
The combination of Hemicellulase sourced from the fungus *Trichoderma viride* is a correct and popular pairing for protoplast isolation protocols.

Quick Tip

To digest a plant cell wall, you need a cocktail of enzymes. Remember the "big three":

- **Cellulase** (for cellulose)
- **Hemicellulase** (for hemicellulose)
- **Pectinase** (for pectin, the "glue" between cells)

The most common source for these enzymes are fungi like *Trichoderma* and *Aspergillus*.

---

62. Match LIST-I with LIST-II

LIST-I (Biocontrol)		LIST-II (Example)	
A.	Bacterium	I.	Bacillus thuringiensis
B.	Fungus	II.	Clostridium
C.	Insect	III.	Trichoderma
D.	Biopesticide	IV.	Cotton aphid

Choose the correct answer from the options given below:

(A) A-IV, B-II, C-III, D-I
(B) A-II, B-IV, C-III, D-I
(C) A-II, B-III, C-IV, D-I
(D) A-III, B-II, C-I, D-IV

Correct Answer: (C) A-II, B-III, C-IV, D-I

Solution:

Step 1: Understanding the Concept:
This question requires matching different categories of biocontrol agents or related terms with specific examples.

Step 2: Detailed Explanation:
Let's analyze each pair to find the best match, assuming each example is used only once.

- **B. Fungus:** The most direct match is **III. *Trichoderma***, which is a well-known genus of fungi used as a biocontrol agent against fungal plant pathogens. So, **B matches III**.

- **D. Biopesticide:** A biopesticide is a pest control product derived from a natural source. The insecticidal toxin produced by **I. *Bacillus thuringiensis*** is the most famous example of a biopesticide. So, **D matches I**.

- **A. Bacterium:** With *B. thuringiensis* already assigned, we look for another bacterium. **II. *Clostridium*** is a genus of bacteria. So, **A matches II**.

- **C. Insect:** The remaining example is **IV. Cotton aphid**, which is an insect (though a pest, not a biocontrol agent, it is the only insect listed). So, **C matches IV**.

This gives the combination: A-II, B-III, C-IV, D-I.

Step 3: Final Answer:
Based on the process of elimination and direct matching, the correct combination is A-II, B-III, C-IV, D-I.

Quick Tip

In matching questions, identify the most certain pairs first. Here, Fungus → *Trichoderma* and Biopesticide → *Bacillus thuringiensis* toxin are classic examples. Use these to narrow down your options.

---

63. Copies of DNA strands generated during a polymerase chain reaction are known as -

(A) Multicons
(B) Polycons
(C) Amplicons
(D) Monocons

Correct Answer: (C) Amplicons

Solution:

Step 1: Understanding the Concept:
The question asks for the specific term used to describe the DNA products of a Polymerase Chain Reaction (PCR).

Step 2: Detailed Explanation:
Polymerase Chain Reaction (PCR) is a technique used to **amplify** a specific segment of DNA, creating millions to billions of copies. The target DNA sequence that is amplified is known

as the template. The resulting DNA copies produced by this amplification process are called **amplicons**.
The other terms (Multicons, Polycons, Monocons) are not standard terminology in molecular biology for PCR products and are used as distractors.

Step 3: Final Answer:
The DNA copies generated by PCR are called amplicons.

Quick Tip

Remember the root of the word: PCR **ampli**fies DNA, and the products are therefore called **ampli**cons.

---

64. Which gene in shoot apical meristem (SAM) negatively regulate WUS expression?

(A) CLV
(B) STM
(C) AP1
(D) TAB1

Correct Answer: (A) CLV

Solution:

Step 1: Understanding the Concept:
The question is about the genetic regulation of the shoot apical meristem (SAM), specifically the negative feedback loop that controls the stem cell population.

Step 2: Detailed Explanation:
The maintenance of the stem cell population in the SAM is controlled by a feedback loop involving the **WUSCHEL (WUS)** and **CLAVATA (CLV)** genes.

- **WUS** is expressed in the organizing center (below the stem cells) and sends a signal upwards to promote stem cell identity.
- The stem cells, in turn, express the **CLV3** gene, which encodes a small peptide.
- This CLV3 peptide diffuses and binds to the **CLV1/CLV2** receptor complex on the cells of the organizing center.

- The activation of the CLV signaling pathway **negatively regulates** or represses the expression of the **WUS** gene.

This negative feedback loop ensures that the stem cell population remains stable. If WUS is too active, it leads to more stem cells, which produce more CLV3, which in turn shuts down WUS. Therefore, the CLV gene family negatively regulates WUS expression.
STM (SHOOT MERISTEMLESS) is required for the formation of the SAM, while **AP1 (APETALA1)** is involved in flower development.

Step 3: Final Answer:
The CLV genes negatively regulate WUS expression in the shoot apical meristem.

Quick Tip

Memorize the WUS-CLV feedback loop: **WUS** promotes stem cells, stem cells make **CLV3**, and **CLV** signaling pathway inhibits **WUS**. It's a classic example of negative feedback in developmental biology.

---

65. Match LIST-I with LIST-II

	LIST-I (Organism)		**LIST-II (use in biotechnology)**
A.	*Thermus aquaticus*	I.	Cry proteins
B.	*Agrobacterium tumefaciens*	II.	DNA polymerase
C.	*E. coli* DH5a	III.	epsps gene
D.	*Bacillus thuringiensis*	IV.	DNA cloning

Choose the correct answer from the options given below:

(A) A-I, B-II, C-IV, D-III
(B) A-II, B-III, C-IV, D-I
(C) A-II, B-I, C-IV, D-III
(D) A-IV, B-III, C-II, D-I

Correct Answer: (B) A-II, B-III, C-IV, D-I

Solution:

Step 1: Understanding the Concept:
This question requires matching specific organisms with their key roles or products in the field of biotechnology.

Step 2: Detailed Explanation:

- **A. *Thermus aquaticus*:** This is a thermophilic bacterium found in hot springs. It is the source of *Taq* polymerase, a heat-stable **II. DNA polymerase** that is essential for the Polymerase Chain Reaction (PCR). So, **A matches II**.

- **B. *Agrobacterium tumefaciens*:** This bacterium is used as a natural vector to create transgenic plants. One of the most important genes transferred into crops using this method is the **III. epsps gene**, which confers resistance to the herbicide glyphosate. So, **B matches III**.

- **C. *E. coli* DH5α:** This is a specific laboratory strain of *E. coli* that is optimized for use as a host organism in **IV. DNA cloning** (specifically, for maintaining and replicating plasmids). So, **C matches IV**.

- **D. *Bacillus thuringiensis*:** This bacterium is the source of insecticidal proteins called **I. Cry proteins**, which are used as biopesticides and in the creation of insect-resistant GM crops (Bt crops). So, **D matches I**.

Step 3: Final Answer:
The correct set of matches is A-II, B-III, C-IV, D-I.

Quick Tip

Associate key organisms with their famous biotechnological product or use: *T. aquaticus* $\rightarrow$ Taq Polymerase (PCR), *B. thuringiensis* $\rightarrow$ Bt toxin (Cry proteins), *E. coli* $\rightarrow$ Cloning Host, *Agrobacterium* $\rightarrow$ Plant Transformation.

---

66. Match LIST-I with LIST-II

LIST-I (Technique)		**LIST-II (used for)**	
A.	Northern blotting	I.	To detect specific proteins in this sample of tissue homogenate
B.	Southern blotting	II.	Detection of specific post translation modification of proteins.
C.	Western blotting	III.	To detect specific RNA molecule in mixture of RNA.
D.	Eastern blotting	IV.	To detect specific DNA in a mix of samples.

Choose the correct answer from the options given below:

(A) A-II, B-III, C-IV, D-I
(B) A-III, B-IV, C-I, D-II
(C) A-III, B-IV, C-II, D-I
(D) A-I, B-II, C-III, D-IV

Correct Answer: (B) A-III, B-IV, C-I, D-II

Solution:

Step 1: Understanding the Concept:
This question tests the knowledge of different blotting techniques used in molecular biology to detect specific macromolecules.

Step 2: Detailed Explanation:

- **B. Southern blotting:** Named after its inventor, Edwin Southern, this technique is used **IV. To detect specific DNA** in a sample.

- **A. Northern blotting:** This technique is analogous to Southern blotting but is used **III. To detect specific RNA** molecules, typically to study gene expression.

- **C. Western blotting:** This technique uses antibodies to **I. To detect specific proteins** in a sample.

- **D. Eastern blotting:** This is a less common technique used for the **II. Detection of specific post-translational modification of proteins**, such as glycosylation or phosphorylation.

Step 3: Final Answer:
The correct matches are A-III, B-IV, C-I, and D-II.

Quick Tip

Use the mnemonic **SNOW DROP** to remember the main blotting techniques:

- **S**outhern → **D**NA
- **N**orthern → **R**NA
- **O** → **O** (Nothing)
- **W**estern → **P**rotein

---

67. In general, the cytoplasmic male sterility (CMS) causing genes are transcribed in which plant cell organelle?

(A) Nucleus
(B) Peroxisome
(C) Mitochondria
(D) Chloroplast

Correct Answer: (C) Mitochondria

Solution:

Step 1: Understanding the Concept:
Cytoplasmic male sterility (CMS) is a maternally inherited trait where a plant is unable to produce functional pollen. The term "cytoplasmic" indicates that the genes controlling this trait are located in the cytoplasm, not the nucleus.

Step 2: Detailed Explanation:
The cytoplasm of a plant cell contains organelles that have their own genomes, separate from the nuclear genome. These are the mitochondria and the chloroplasts.
Research has shown that in the vast majority of cases across different plant species, the genes responsible for causing CMS are located in the **mitochondrial** genome. These CMS-associated genes are often novel, chimeric open reading frames that arise from rearrangements in the mitochondrial DNA. Their expression, typically in the anther tapetum, disrupts pollen development, leading to male sterility. While chloroplast genes can sometimes influence CMS expression, the primary causative genes are almost always mitochondrial.

Step 3: Final Answer:
The genes causing cytoplasmic male sterility are generally transcribed in the mitochondria.

Quick Tip

Remember that CMS is **C**ytoplasmic, so the genes are not in the nucleus. Between the two cytoplasmic organelles with DNA (mitochondria and chloroplast), associate CMS with the **M**itochondria (**M**ale sterility → **M**itochondria).

---

68. Match the LIST-I with LIST-II

LIST-I		LIST-II	
A.	Karl Ereky	I.	Invented DNA 'Fingerprinting'
B.	Joshua Lederberg	II.	Coined the term 'Biotechnology'
C.	Kary Mullis	III.	Discovered plasmids
D.	Sir Alec Jefferys	IV.	Developed polymerase chain reaction

Choose the correct answer from the options given below:

(A) A-II, B-III, C-IV, D-I
(B) A-III, B-IV, C-I, D-II
(C) A-IV, B-III, C-II, D-I
(D) A-I, B-II, C-III, D-IV

Correct Answer: (A) A-II, B-III, C-IV, D-I

Solution:

Step 1: Understanding the Concept:
This question requires matching prominent scientists with their major contributions to the field of biology and biotechnology.

Step 2: Detailed Explanation:

- **A. Karl Ereky:** A Hungarian agricultural engineer who, in 1919, **II. Coined the term 'Biotechnology'** to describe processes using living organisms to make a product. He is often regarded as the "father" of the term.

- **B. Joshua Lederberg:** A Nobel laureate molecular biologist who made profound contributions to microbial genetics, including the discovery that bacteria can mate and exchange genes, and the **III. Discovery of plasmids**.

- **C. Kary Mullis:** An American biochemist who received the Nobel Prize in Chemistry in 1993 for his invention of the **IV. polymerase chain reaction (PCR)**, a central technique in molecular biology.

- **D. Sir Alec Jefferys:** A British geneticist who **I. Invented DNA 'Fingerprinting'** and DNA profiling techniques in 1984.

Step 3: Final Answer:
The correct matches are A-II, B-III, C-IV, and D-I.

Quick Tip

For questions about scientific history, it's helpful to associate each name with a key invention or term: Ereky → "Biotechnology", Lederberg → Plasmids, Mullis → PCR, Jefferys → DNA Fingerprinting.

---

69. Match LIST-I with LIST-II

LIST-I		LIST-II	
A.	Protoplast	I.	Ability of cell to develop into a new plant
B.	Explant	II.	Unorganized mass of cells
C.	Totipotency	III.	Naked cell
D.	Callus	IV.	Any plant tissue used to regenerate new tissue/organ/plant in vitro

Choose the correct answer from the options given below:

(A) A-II, B-III, C-IV, D-I
(B) A-III, B-II, C-I, D-IV
(C) A-III, B-IV, C-I, D-II
(D) A-I, B-II, C-III, D-IV

Correct Answer: (C) A-III, B-IV, C-I, D-II

Solution:

Step 1: Understanding the Concept:
This question requires matching fundamental terms used in plant tissue culture with their correct definitions.

Step 2: Detailed Explanation:

- **A. Protoplast:** A plant cell from which the cell wall has been completely removed, leaving only the plasma membrane as the outer boundary. It is often referred to as a **III. Naked cell**.

- **B. Explant:** The piece of plant tissue or organ that is excised from the parent plant and placed into tissue culture to initiate growth. It is **IV. Any plant tissue used to regenerate... in vitro**.

- **C. Totipotency:** The inherent potential of a single plant cell to divide and differentiate to form an entire new plant. It is the **I. Ability of cell to develop into a new plant**.

- **D. Callus:** A growing mass of **II. Unorganized mass of cells**, typically produced on a solid medium in tissue culture from an explant.

Step 3: Final Answer:
The correct matches are A-III, B-IV, C-I, and D-II.

Quick Tip

Learn the basic vocabulary of plant tissue culture: **Explant** is the start. It has **Totipotency**. It forms a **Callus**. If you remove the wall, it becomes a **Protoplast**.

---

70. Match the LIST-I with LIST-II

LIST-I		LIST-II	
A.	Auxin	I.	undifferentiated mass of cell
B.	Protoplast	II.	6-Furfuryl amino purine
C.	Callus	III.	Indole-3 Acetic Acid
D.	Cytokinin	IV.	Pectinase

Choose the correct answer from the options given below:

(A) A-I, B-II, C-III, D-IV
(B) A-I, B-III, C-II, D-IV
(C) A-III, B-I, C-IV, D-II
(D) A-III, B-IV, C-I, D-II

Correct Answer: (D) A-III, B-IV, C-I, D-II

Solution:

Step 1: Understanding the Concept:
This question requires matching terms from plant biology and tissue culture with their correct definition, example, or associated enzyme.

Step 2: Detailed Explanation:

- **A. Auxin:** This is a class of plant hormones. The principal and most abundant natural auxin is **III. Indole-3-Acetic Acid (IAA)**.

- **B. Protoplast:** To create a protoplast (a plant cell without a wall), enzymes are used to digest the wall components. **IV. Pectinase** is an enzyme that digests pectin, the substance that glues cells together, and is a key component of the enzyme mixture used for protoplast isolation.

- **C. Callus:** This is, by definition, an **I. undifferentiated mass of cell** that grows in tissue culture.

- **D. Cytokinin:** This is another class of plant hormones. A well-known synthetic cytokinin is Kinetin, whose chemical name is **II. 6-Furfuryl amino purine**.

Step 3: Final Answer:
The correct matches are A-III, B-IV, C-I, and D-II.

Quick Tip

Remember the key chemical examples for the two main plant hormones used in tissue culture: Auxin → IAA (Indole-3-Acetic Acid) and Cytokinin → Kinetin (6-Furfuryl amino purine) or Zeatin.

---

71. Match LIST-I with LIST-II

LIST-I		LIST-II	
A.	Gynogenesis	I.	Callus culture
B.	Culturing in liquid medium	II.	Ovary culture
C.	Androgenesis	III.	Suspension culture
D.	Culturing on agar medium	IV.	Pollen culture

Choose the correct answer from the options given below:

(A) A-II, B-III, C-IV, D-I
(B) A-III, B-IV, C-II, D-I
(C) A-II, B-IV, C-I, D-III
(D) A-I, B-II, C-III, D-IV

Correct Answer: (A) A-II, B-III, C-IV, D-I

Solution:

Step 1: Understanding the Concept:
This question requires matching specific biological processes for haploid production and general tissue culture methods with their corresponding laboratory techniques.

Step 2: Detailed Explanation:

- **A. Gynogenesis:** This is the development of a haploid plant from the female gametophyte (egg cell or other cells of the embryo sac). This is achieved in vitro through **II. Ovary culture** or ovule culture.

- **B. Culturing in liquid medium:** When plant cells or small cell aggregates are grown in a constantly agitated liquid nutrient medium, it is known as a **III. Suspension culture**. This is used for producing single cells or secondary metabolites.

- **C. Androgenesis:** This is the development of a haploid plant from the male gametophyte (microspore). The most common technique for this is **IV. Pollen culture** or anther culture.

- **D. Culturing on agar medium:** When plant tissues are grown on a solid or semi-solid medium gelled with agar, it often leads to the formation of an unorganized mass of cells known as a callus. This is a form of **I. Callus culture**.

Step 3: Final Answer:
The correct matches are: A-II, B-III, C-IV, D-I.

Quick Tip

Use prefixes to remember the haploid production methods: **Gyno-** refers to the female part (ovary/ovule), while **Andro-** refers to the male part (anther/pollen). Also, associate liquid medium with suspension culture and solid (agar) medium with callus culture.

---

72. Which of the following will be present in the F_1 multicellular embryo, derived from a cross of female plant (A) with male plant B, through "bulbosum method"?

(A) Chromosomes of A
(B) Homologous chromosomes of A and B
(C) Chromosomes of B
(D) recombinant chromosomes of A and B

Correct Answer: (A) Chromosomes of A

Solution:

Step 1: Understanding the Concept:
The "bulbosum method" is a specific technique for producing haploid plants, particularly in barley. It involves a distant cross between cultivated barley (*Hordeum vulgare*) and a wild relative (*Hordeum bulbosum*). The key to this method is a phenomenon called uniparental chromosome elimination.

Step 2: Detailed Explanation:
The cross is set up as: Female plant A (*H. vulgare*) $\times$ Male plant B (*H. bulbosum*).

1. Pollination and fertilization occur, forming a hybrid zygote that initially contains chromosomes from both parent A and parent B.

2. However, during the very early cell divisions of the embryo, the chromosomes from the male parent B (*H. bulbosum*) are systematically and selectively eliminated.

3. The resulting multicellular embryo is, therefore, haploid, containing only the set of chromosomes from the female parent, plant A.

This haploid embryo must be rescued via embryo culture before it aborts. The final embryo contains only the chromosomes of A.

Step 3: Final Answer:
The F_1 embryo will contain only the chromosomes of the female parent A.

Quick Tip

The "bulbosum method" is a classic example of using distant hybridization for haploid production. Remember that in this specific cross, the chromosomes of the wild parent (*H. bulbosum*) are always the ones that get eliminated.

---

73. Arrange the steps in PEG induced protoplast fusion in correct sequence -
A. Treatment of protoplast mixture with 28-50% PEG for 15-30 minutes.
B. Protoplast aggregation.
C. Washing of protoplast (alkaline medium pH 9-10), and high Ca^{2+} concentration
D. Selection of protoplasts of different strains / species.
Choose the correct answer from the options given below :

(A) A, B, C, D
(B) D, A, B, C
(C) C, D, B, A
(D) D, B, C, A

Correct Answer: (B) D, A, B, C

Solution:

Step 1: Understanding the Concept:
The question asks for the correct chronological order of steps for fusing plant protoplasts using Polyethylene Glycol (PEG) as a chemical fusogen.

Step 2: Detailed Explanation:
The logical protocol for PEG-induced fusion is as follows:

1. **D. Selection of protoplasts of different strains / species.** The very first step is to prepare and select the parent protoplasts that are to be fused.

2. **A. Treatment of protoplast mixture with 28-50% PEG for 15-30 minutes.** The selected protoplasts are mixed, and the fusogen, PEG, is added. PEG is a dehydrating agent that helps bring the protoplast membranes into very close contact.

3. **B. Protoplast aggregation.** As a direct and immediate result of the PEG treatment, the protoplasts clump together, or aggregate. This close contact is a prerequisite for fusion.

4. **C. Washing of protoplast (alkaline medium pH 9-10), and high Ca^{2+} concentration.** After the incubation with PEG, the PEG is carefully washed away or diluted with a special elution solution. This solution has a high pH and a high concentration of calcium ions (Ca^{2+}). These conditions reduce the negative charge on the protoplast surface and help in the coalescence of the membranes of the aggregated protoplasts, leading to fusion.

Therefore, the correct sequence is D → A → B → C.

Step 3: Final Answer:
The correct sequence of steps is D, A, B, C.

Quick Tip

Think of the fusion process logically: **Select** your ingredients (D) → **Add** the "glue" (PEG) (A) → Observe them **sticking** together (B) → **Wash** and finalize the fusion (C).

---

74. Match LIST-I with LIST-II

LIST-I (Scientist)		LIST-II (Landmark discovery)	
A.	Van Overbeek	I.	Transgenic Bt-cotton
B.	White	II.	Introduced coconut water as a media component
C.	Went	III.	First synthetic plant tissue culture medium
D.	Monsanto	IV.	First plant growth hormone ie IAA

Choose the correct answer from the options given below:

(A) A-III, B-II, C-IV, D-I
(B) A-I, B-II, C-IV, D-III
(C) A-III, B-IV, C-II, D-I
(D) A-II, B-III, C-IV, D-I

Correct Answer: (D) A-II, B-III, C-IV, D-I

Solution:

Step 1: Understanding the Concept:
This question requires matching key figures and a company from the history of plant science and biotechnology with their significant discoveries or contributions.

Step 2: Detailed Explanation:

- **A. Van Overbeek:** In 1941, J. van Overbeek and his colleagues discovered that coconut water (liquid endosperm) had a potent growth-promoting effect on plant embryos in culture. This was a major breakthrough in improving tissue culture media. Thus, he **II. Introduced coconut water as a media component**.

- **B. Philip R. White:** He was a pioneer in plant tissue culture who, in 1939, developed one of the **III. First synthetic plant tissue culture media** (White's medium) capable of supporting long-term root culture.

- **C. Frits Went:** In 1926, his classic experiments with oat coleoptiles demonstrated the existence of a chemical messenger responsible for phototropism. This substance was later identified as auxin (IAA), the **IV. First plant growth hormone**.

- **D. Monsanto:** This multinational agricultural biotechnology company was a leader in developing genetically modified crops. They successfully commercialized **I. Transgenic Bt-cotton** (Bollgard), which is resistant to bollworm pests.

Step 3: Final Answer:
The correct matches are A-II, B-III, C-IV, D-I.

Quick Tip

Create mental links for these historical figures: Went → Auxin, Van Overbeek → Coconut Water, White → White's Medium, Monsanto → GMOs (Bt-cotton).

---

75. Match LIST-I with LIST-II

LIST-I		LIST-II	
A.	Sea weeds	I.	Isolation of DNA from gel.
B.	Staining of DNA	II.	Gel electrophoresis
C.	Elution	III.	Source of agarose
D.	Separation of DNA fragments	IV.	Ethidium bromide

Choose the correct answer from the options given below:

(A) A-III, B-IV, C-II, D-I
(B) A-III, B-IV, C-I, D-II
(C) A-II, B-IV, C-I, D-III
(D) A-III, B-II, C-IV, D-I

Correct Answer: (B) A-III, B-IV, C-I, D-II

Solution:

Step 1: Understanding the Concept:
This question requires matching various components and steps related to the technique of agarose gel electrophoresis with their definitions or associated items.

Step 2: Detailed Explanation:

- **A. Sea weeds:** Agarose, the polysaccharide that forms the gel matrix for electrophoresis, is extracted from certain types of red **III. sea weeds** (e.g., from the genera *Gelidium* and *Gracilaria*).

- **B. Staining of DNA:** To visualize the DNA fragments in the gel after electrophoresis, a fluorescent dye is used. The most classic and common staining agent is **IV. Ethidium bromide**, which intercalates between the DNA base pairs and fluoresces under UV light.

- **C. Elution:** This is the process of extracting and purifying a specific DNA band from the agarose gel after it has been separated and visualized. It is the **I. Isolation of DNA from gel**.

- **D. Separation of DNA fragments:** The core purpose of **II. Gel electrophoresis** is to separate macromolecules like DNA, RNA, or proteins. In the case of DNA, it separates fragments based on their size.

Step 3: Final Answer:
The correct matches are A-III, B-IV, C-I, D-II.

Quick Tip

Visualize the entire gel electrophoresis process to answer these questions: You make the gel with agarose from **sea weeds** (A-III). You run the gel for **separation** (D-II). You **stain** with EtBr to see the DNA (B-IV). You cut out the band and **elute** it to get the pure DNA (C-I).
