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 Atmospheric Science 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.

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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:
This question requires a precise understanding of cytogenetic terminology related to chromosome numbers in organisms. The key is to differentiate between terms that describe complete sets of chromosomes versus those that describe the gain or loss of individual chromosomes. A **somatic cell** is a typical body cell of a plant (e.g., a leaf cell or root cell) and is generally

diploid (2n), containing two complete sets of chromosomes. Gametes (like pollen or egg cells) are produced through meiosis and contain half the number of chromosomes, which is the haploid (n) number.

Step 2: Detailed Explanation:
Let's analyze the given options in detail:
1. **Monoploid (x):** This term refers to an organism or cell that has the basic chromosome number of a polyploid series. It represents a single, fundamental set of chromosomes. In a simple diploid organism (2n), the haploid number (n) is the same as the monoploid number (x). However, in a polyploid organism, these numbers differ. For example, bread wheat is a hexaploid, meaning it has six sets of chromosomes (2n = 6x = 42). Its somatic cells have 42 chromosomes. Its gametes are **haploid** with n = 21 chromosomes. But the **monoploid** or basic number is x = 7. Therefore, haploid is the more general and correct term for half the somatic number.
2. **Haploid (n):** This term specifically denotes a cell or organism having half the chromosome number of a normal somatic cell (i.e., the gametic chromosome number). This definition perfectly matches the condition described in the question.
3. **Aneuploids:** This is a broad category for organisms whose chromosome number is not an exact multiple of the haploid set. It involves the gain or loss of one or more individual chromosomes. For example, a diploid organism that is 2n+1 (trisomy) or 2n-1 (monosomy) is an aneuploid. This is an abnormal number, but it is not half the somatic number.
4. **Monosomics:** This is a specific type of aneuploidy where one chromosome is missing from an otherwise diploid set (2n-1). Again, this is not half the somatic chromosome number.

Step 3: Final Answer:
Based on the precise definitions, a plant having half the somatic chromosome number (the gametic number) is correctly called a haploid.

Quick Tip

Remember the key difference: **Haploid (n)** refers to the gametic chromosome number (half of the somatic number). **Monoploid (x)** refers to the number of unique chromosomes in a single basic set. For diploid species, n = x. For polyploid species, n is a multiple of x.

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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 probes the historical origins of a cornerstone technique in plant biotechnology known as **androgenesis**. This is the process of generating haploid plants from male gametophytic cells, specifically microspores (pollen), through in vitro culture of anthers or isolated pollen. The development of haploid plants is a massive shortcut in plant breeding because their chromosome number can be doubled (e.g., using colchicine) to produce a completely homozygous diploid plant in a single step. This dramatically speeds up the process of creating new, stable crop varieties.

Step 2: Detailed Explanation:
The groundbreaking work that first successfully demonstrated this technique was performed by two Indian botanists, **Sipra Guha-Mukherjee and Satish C. Maheshwari**. In a series of publications starting in **1964**, they reported their success in culturing the anthers of the plant *Datura innoxia*. They observed that instead of developing into mature pollen grains, the microspores inside the cultured anthers were induced to divide and develop into embryo-like structures (embryoids), which then grew into complete haploid plantlets. This was the first unequivocal proof that the developmental pathway of a male gamete could be reprogrammed to a sporophytic pathway, leading to the formation of a whole plant. This discovery revolutionized plant breeding and genetics. The other scientists listed are known for other significant contributions but are not credited with this specific initial discovery.

Step 3: Final Answer:
The pioneering demonstration of haploid production via anther culture was accomplished by Maheswari and Guha.

Quick Tip

For competitive exams, it's crucial to remember key scientists and their specific contributions. Create flashcards or a list associating names with their discoveries, like "Guha & Maheshwari" with "Anther Culture (*Datura*)".

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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:
Nitrogen is a critical component of many organic molecules essential for life, including amino acids (the building blocks of proteins) and nucleic acids (DNA and RNA). The Earth's atmosphere is approximately 78% nitrogen gas (N_2). Despite this abundance, most organisms, including all plants and animals, cannot directly use atmospheric nitrogen. This phenomenon is known as the "nitrogen paradox". The question asks for the fundamental chemical reason for this inertness.

Step 2: Detailed Explanation:
The molecular form of nitrogen, N_2, consists of two nitrogen atoms connected by a **triple covalent bond (N≡N)**. This triple bond is one of the strongest chemical bonds known in nature. It has an extremely high bond dissociation energy of about **945 kJ/mol**. This means an immense amount of energy is required to break these three bonds apart to make the individual nitrogen atoms available to react with other elements like hydrogen or oxygen.
Plants lack the biochemical machinery to supply this activation energy and cleave the N≡N bond. This ability is restricted to a specialized group of microorganisms (like *Rhizobium* bacteria and cyanobacteria) that possess a unique enzyme complex called **nitrogenase**, which can catalyze this difficult reaction.
- Options (A) and (D) are factually incorrect; the bond is a triple bond, not a double bond.
- Option (C) is incorrect because the abundance of N_2 is not the barrier; its chemical stability is the limiting factor. If it were reactive, its abundance would make it readily available.

Step 3: Final Answer:
The immense stability conferred by the triple covalent bond in the N_2 molecule makes it chemically inert and inaccessible for direct absorption and use by plants.

Quick Tip

Remember the structure of molecular nitrogen: N≡N. The triple bond is the key to its stability and the reason why nitrogen fixation (breaking this bond) is such an energy-intensive process, both biologically and industrially (Haber-Bosch process).

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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:
Plant tissue culture encompasses several techniques for growing and regenerating plants in vitro. One of the main goals is to regenerate a whole plant from a small piece of tissue (explant). This regeneration can happen through two main pathways. The question asks for the specific term that describes the pathway where distinct organs, like shoots and roots, are formed sequentially from an undifferentiated cell mass.

Step 2: Detailed Explanation:
Let's define the terms provided in the context of plant regeneration:
1. **Somatic embryogenesis:** This is a developmental pathway where somatic cells (non-reproductive cells) are induced to form structures that are morphologically and developmentally similar to zygotic embryos. These "somatic embryos" are **bipolar**, meaning they possess both a shoot apical meristem and a root apical meristem within a single structure, just like a seed embryo. They can then germinate to form a complete plantlet.
2. **Dedifferentiation:** This is a preliminary step in many tissue culture procedures. It is the process by which mature, specialized plant cells revert to an undifferentiated, proliferative state, losing their specialized characteristics and forming a mass of cells called a **callus**. It is a regression from a specialized state.
3. **Organogenesis:** This term literally means "the origin of organs". In plant tissue culture, it refers to the process where the undifferentiated cells of a callus are induced to differentiate and develop into organized structures, specifically plant organs. This process is typically **unipolar**. By manipulating the ratio of plant hormones (specifically auxins and cytokinins) in the culture medium, one can induce the formation of either shoots (**caulogenesis**) or roots (**rhizogenesis**) from the callus. A whole plant is formed by first inducing shoots and then transferring them to a different medium to induce roots. This directly matches the question's description.
4. **Somatic hybridization:** This is a genetic modification technique involving the fusion of protoplasts (plant cells with their cell walls removed) to create a hybrid cell. It is a method for creating new genetic combinations, not a pathway for regeneration itself.

Step 3: Final Answer:
The process of inducing the formation of vegetative organs like shoots or roots from cultured tissues is called organogenesis.

Quick Tip

Distinguish between organogenesis and somatic embryogenesis. **Organogenesis** is unipolar (forms a shoot or a root), and is controlled by the auxin:cytokinin ratio. **Somatic embryogenesis** is bipolar (forms an entire embryo-like structure with both shoot and root poles).

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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:
Plants produce a vast array of chemical compounds. These are classified into primary and secondary metabolites. **Primary metabolites** (like carbohydrates, proteins, lipids) are essential for the plant's survival, growth, and development. **Secondary metabolites** (e.g., alkaloids like morphine, terpenoids like taxol, phenolics like resveratrol) are not essential for basic survival but play important roles in defense, attraction, and competition. Many of these have significant medicinal, industrial, or commercial value. The question asks which in vitro technique is best suited for producing these compounds on a large scale.

Step 2: Detailed Explanation:
1. **Cell suspension culture:** This technique involves growing dedifferentiated plant cells as individual cells or small aggregates in a liquid nutrient medium. The medium is constantly agitated in flasks or large-scale **bioreactors** to ensure proper aeration, nutrient distribution, and to prevent cell sedimentation. This method is the preferred choice for industrial production of secondary metabolites for several reasons:
- **Scalability:** It can be scaled up to thousands of liters in controlled bioreactors, similar to microbial fermentation.
- **Control:** Environmental factors like pH, temperature, oxygen levels, and nutrient composition can be precisely controlled to maximize product yield.
- **Extraction:** Harvesting the product is often simpler, as the metabolites can be secreted into the liquid medium, allowing for continuous or batch-wise extraction without destroying the cell biomass.
2. **Solid agar medium:** This is used to grow callus or regenerate whole plants. It is not practical for large-scale chemical production due to the difficulty of scaling up solid cultures and extracting compounds from the solid matrix and tissues.
3. **Meristem culture:** This technique isolates the apical meristem to produce virus-free plants. Its purpose is sanitation and clonal propagation, not metabolite production.
4. **Axillary bud culture:** This is a standard method of micropropagation for creating large numbers of identical plants (clones). The focus is on multiplying organized plantlets, not on producing undifferentiated cells for chemical synthesis.

Step 3: Final Answer:
For large-scale, controlled production of secondary metabolites, cell suspension cultures are the required and most efficient method.

Quick Tip

Think of cell suspension cultures as analogous to microbial fermentation in a bioreactor. When the goal is to produce a chemical compound in large quantities in vitro, a liquid (suspension) culture is almost always the most efficient method due to scalability and process control.

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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:
In microbiology and tissue culture, the nutrient solution used to grow organisms is called a culture medium. Media can be classified based on various criteria, one of the most important being the chemical exactness of their components. This question asks for the term describing a medium where not all components are chemically pure or present in precisely known quantities.

Step 2: Detailed Explanation:
Let's analyze the different classifications of media:
1. **Synthetic or Defined Medium:** This is a medium in which the exact chemical composition is known, down to the last milligram. Every component is a pure chemical, and its concentration is precisely specified. An example is the Murashige and Skoog (MS) medium used in plant tissue culture, where the exact amounts of all macro- and micro-nutrients, vitamins, and sugar are known.
2. **Enrichment Medium:** This is a type of medium, usually liquid, that is formulated to favor the growth of a specific type of microorganism over others in a mixed sample. It is a selection method based on enhancing the growth of the desired organism.
3. **Complex or Undefined Medium:** This is a medium that contains at least one ingredient that is not chemically defined, meaning its exact composition is unknown and can vary from batch to batch. Such ingredients are typically derived from natural sources. Common examples in microbiology include **yeast extract, beef extract,** and **peptones** (partially digested proteins). In plant tissue culture, examples include adding **coconut milk, banana homogenate,** or **casein hydrolysate**. These provide a rich mix of growth factors, vitamins, and amino acids, but their exact concentrations are not known. This perfectly matches the question's description.
4. **Selective Medium:** This type of medium is designed to actively suppress the growth of unwanted microorganisms while allowing the desired organism to grow. It usually contains

inhibitory agents like antibiotics, dyes, or high concentrations of salt.

Step 3: Final Answer:
A medium containing ingredients of unknown chemical composition, such as natural extracts, is called a complex or undefined medium.

Quick Tip

Remember the key distinction: **Defined/Synthetic = everything is known**. **Complex/Undefined = contains natural extracts with unknown composition**. For example, MS medium is defined, but MS medium with added coconut milk becomes complex.

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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:
A **pure culture** is a laboratory culture containing a single species of microorganism. Obtaining a pure culture is one of the most fundamental skills in microbiology, as it allows for the study of a specific organism's characteristics. This is usually achieved by an **isolation technique** that physically separates individual cells on a solid medium. Each isolated cell then divides and grows into a visible mound of identical cells called a **colony**. The question asks which of the listed techniques is not a standard method for achieving this isolation.

Step 2: Detailed Explanation:
Let's examine the standard isolation methods and the outlier:
1. **Streak Plate Method:** This is the most widely used isolation technique. A sterile inoculating loop is used to pick up a sample of the mixed culture and is then streaked across the surface of a solid agar plate in a specific pattern (e.g., quadrant streak). The process physically thins out the bacteria on the loop, so that by the final streaks, individual cells are deposited far apart from each other. These separated cells then grow into well-isolated colonies.
2. **Spread Plate Method:** This method involves first creating a serial dilution of a liquid culture. A small, known volume of a dilute sample is then pipetted onto the center of an agar plate. A sterile, L-shaped glass or plastic spreader is used to evenly distribute the liquid across the entire surface of the plate. If the dilution is appropriate, the cells will be distributed far

enough apart to form individual colonies.
3. **Pour Plate Method:** In this technique, a small volume from a serial dilution is pipetted into a sterile, empty Petri dish. Then, molten (but cooled) agar medium is poured into the dish and mixed gently with the inoculum. After the agar solidifies, cells are trapped both on the surface and within the agar matrix. They grow into colonies that can be counted and isolated.
4. **Dip Plate Method:** This is a screening tool, not an isolation method. It typically consists of a plastic slide or paddle coated on both sides with agar medium. The slide is dipped into a liquid sample (like urine or industrial fluids), withdrawn, and incubated. The purpose is to get a semi-quantitative estimate of the microbial load (e.g., colony-forming units per milliliter) by comparing the density of colonies on the slide to a chart. The colonies are usually too dense and confluent to allow for the reliable isolation of a pure culture.

Step 3: Final Answer:
The streak, spread, and pour plate methods are all designed to produce isolated colonies for obtaining pure cultures. The dip plate method is used for estimation of microbial count, not for isolation.

Quick Tip

The three classic methods for bacterial isolation and enumeration are **Streak**, **Spread**, and **Pour**. Any other method mentioned is likely for a different purpose, such as the Dip plate for screening or estimation.

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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 is the term for the genetic and phenotypic variation observed among plants regenerated from in vitro cell or tissue cultures (somaclones). This variation arises

spontaneously during the culture process. It was initially considered a problem for micropropagation, which aims to produce genetically identical clones. However, scientists soon realized it could be a valuable source of new genetic diversity for crop improvement. The question requires an evaluation of several statements about this phenomenon.

Step 2: Detailed Explanation:
Let's evaluate each statement critically:
A. These variations can also result in unwanted traits. - Correct. The genetic changes that cause somaclonal variation (e.g., changes in chromosome number, point mutations, epigenetic modifications) occur randomly. Therefore, the resulting traits can be unpredictable and may include undesirable characteristics such as reduced fertility, poor yield, abnormal growth, or increased susceptibility to diseases.
B. Somaclones have been developed and proved advantageous in several crops. - Correct. Plant breeders have successfully screened large populations of somaclones to find individuals with valuable new traits. Notable successes include developing sugarcane varieties with resistance to eyespot disease and Fiji disease, potato varieties with improved tuber shape and disease resistance, and tomatoes with altered ripening characteristics.
C. These variations can be used to engineer novel traits. - Correct. While not "engineering" in the sense of genetic modification (GMOs), somaclonal variation provides a powerful tool to generate novel genetic combinations that can be selected for. It can uncover traits that are not present in the original parent plant, effectively allowing breeders to create novel phenotypes for crop improvement. It is a form of mutation breeding induced by the tissue culture process itself.
D. Short term invitro callus and cell suspension, cultures results in somaclonal variation. - Incorrect. The incidence and frequency of somaclonal variation are strongly correlated with the **duration of the culture period**. The longer cells are maintained in an undifferentiated state (especially as callus), and the more times they are subcultured, the higher the likelihood of accumulating genetic and epigenetic changes. Therefore, variation is a characteristic of **long-term** cultures. For clonal propagation (micropropagation), where genetic fidelity is paramount, short-term culture from organized meristems is used to minimize this variation.

Step 3: Final Answer:
Statements A, B, and C accurately describe aspects of somaclonal variation, while statement D is incorrect. Therefore, the correct option is (B).

Quick Tip

Remember that somaclonal variation is a "double-edged sword". It is a problem for clonal propagation (micropropagation) where uniformity is key, but it is an opportunity for plant breeding where new genetic variation is desired. The risk increases with the duration of the culture.

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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:
This question focuses on the specific cellular processes and developmental stages involved in regenerating a plant from an undifferentiated callus. The journey from a specialized plant part (like a leaf piece) to a new organ involves distinct shifts in the state of cellular differentiation.
- **Differentiated cells** are specialized cells that make up the tissues and organs of a mature plant (e.g., parenchyma, xylem).
- **Undifferentiated cells** are meristematic cells that are capable of division and have not yet specialized (e.g., callus cells).

Step 2: Detailed Explanation:
Let's trace the typical sequence in organogenesis and define the terms:
1. **Dedifferentiation:** When an explant (a piece of a differentiated tissue like a leaf or stem) is placed on a suitable culture medium (usually rich in auxin), its mature, specialized cells lose their specific characteristics and revert to an actively dividing, unspecialized state. This process of losing differentiation results in the formation of a **callus**. So, this is the step of callus formation, not organ formation from callus.
2. **Redifferentiation:** Once a callus has formed, these undifferentiated cells can be induced to differentiate again into new, specialized cells that organize into tissues and organs. The formation of organ primordia (the earliest, embryonic stage of an organ) like a shoot or a root from these previously dedifferentiated callus cells is precisely termed **redifferentiation**. It is the process of regaining a specialized, organized state.
3. **Somatic embryogenesis:** This is an alternative regeneration pathway where callus cells form embryo-like structures, not distinct organs like shoots or roots directly.
4. **Regeneration:** This is a very broad term that refers to the entire process of developing a whole plant from an explant. It includes both the dedifferentiation phase (callus formation) and the subsequent redifferentiation phase (organ formation). While correct in a general sense, **redifferentiation** is the specific scientific term for the exact process described in the question (organ primordia formation from callus).

Step 3: Final Answer:
The specific process where undifferentiated callus cells differentiate to form organized structures like organ primordia is called redifferentiation.

Quick Tip

Follow the cellular journey: **Explant (Differentiated) → Dedifferentiation → Callus (Undifferentiated) → Redifferentiation → Organs (Differentiated)**.

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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 concerning the history of plant science. It asks to identify the scientist whose pioneering vision and early experiments laid the foundation for the entire field of plant tissue culture. This title is usually given to the person who first conceptualized and attempted the core idea of the field.

Step 2: Detailed Explanation:
Gottlieb Haberlandt, an Austrian botanist, is universally acclaimed as the "Father of Plant Tissue Culture". In **1902**, he published a seminal paper detailing his attempts to culture isolated plant somatic cells in vitro. He used simple nutrient solutions containing salts and sugar to try and grow single cells isolated from various plants.
Although his experiments were ultimately unsuccessful in achieving sustained cell division and regeneration (primarily because plant hormones like auxins, which are essential for cell division, had not yet been discovered), his contribution was monumental for two reasons:
1. He was the first person to even attempt to culture isolated plant cells, thus establishing the new field of inquiry.
2. More importantly, he clearly articulated the concept of **totipotency** – the inherent potential of a single, non-reproductive plant cell to grow and develop into a complete, whole plant under the right conditions. This concept remains the central theoretical basis of plant tissue culture to this day.
The other individuals listed are famous for other major scientific achievements:
- **Theodor Schwann:** A key figure in the development of the Cell Theory in the 1830s, stating that all living things are composed of cells.
- **Robert Koch:** A founder of modern bacteriology, known for his postulates for identifying pathogens and his work on tuberculosis and cholera.

Step 3: Final Answer:
Gottlieb Haberlandt is regarded as the father of Plant Tissue Culture due to his pioneering

experiments and, most importantly, his formulation of the concept of totipotency in 1902.

Quick Tip

Associate **Gottlieb Haberlandt** with the year **1902** and the concept of **totipotency**. These three pieces of information are often linked in questions about the history of plant tissue culture.

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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 plant from the male gametophyte, i.e., the microspore or pollen grain. This results in a **haploid** plant, which has only one set of chromosomes. This question is a historical one, asking to identify the specific plant species in which this revolutionary technique was first successfully demonstrated.

Step 2: Detailed Explanation:
The landmark breakthrough in androgenesis was achieved in the mid-1960s by Indian scientists **Sipra Guha-Mukherjee and Satish C. Maheshwari**. They were experimenting with anther culture, a technique where immature anthers (the part of the stamen containing pollen) are excised and placed on a sterile nutrient medium. Their model organism for this research was ***Datura innoxia***, a plant commonly known as thorn-apple.
They observed that the microspores within the cultured anthers, instead of maturing into functional pollen, were diverted onto a new developmental path. They began to divide mitotically, mimicking the early stages of zygotic embryogenesis, and formed structures called embryoids. These embryoids could then be germinated into complete plantlets. Because these plantlets originated from microspores (which are haploid), the resulting plants were also haploid. This was the first clear and reproducible demonstration of androgenesis, a technique that has since become a vital tool in plant breeding programs for many crops, including barley and potato.

Step 3: Final Answer:
The first successful production of androgenic haploid plants via anther culture was achieved with the plant genus *Datura*.

Quick Tip

Remember the key combination: **Androgenesis**, **Haploids**, **Guha & Maheshwari**, and ***Datura***. These are frequently asked together in biology examinations.

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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:
A plant cell contains genetic information in three locations: the nucleus (the nuclear genome), the mitochondria, and the chloroplasts (the cytoplasmic genomes). Typically, cytoplasmic genomes are inherited maternally. The question describes an advanced technique that allows for the creation of a novel cell by combining the nucleus from one parent with the cytoplasm (containing mitochondria and chloroplasts) from a different parent.

Step 2: Detailed Explanation:
Let's analyze the terms to find the precise match:
1. **Somatic hybridization:** This is the general process of fusing two somatic protoplasts (plant cells with their cell walls enzymatically removed). The resulting hybrid cell, called a heterokaryon, initially contains both nuclei and a mixture of both cytoplasms. If the nuclei fuse, a true amphidiploid hybrid is formed. This process combines **both** the nuclear and cytoplasmic contents of the two parents.
2. **Micropropagation:** This is a set of techniques for rapid vegetative cloning of plants in vitro. It does not involve the fusion or combination of genomes from different parents.
3. **Cybridization:** This term, a blend of "**cy**toplasmic hy**brid**", refers specifically to the process of producing a cell with the nuclear genome of one species and the cytoplasm of another. This is usually achieved by first isolating protoplasts from both parents. The protoplasts from the 'cytoplasm donor' parent are then treated with X-rays or gamma irradiation to destroy their nuclear DNA, leaving the cytoplasmic organelles intact. These enucleated protoplasts (cytoplasts) are then fused with normal protoplasts from the 'nucleus donor' parent. The resulting "cybrid" cell contains the desired combination. This technique is very useful for transferring cytoplasmically-encoded traits, like cytoplasmic male sterility (CMS), into elite crop varieties.
4. **Regeneration:** This is the subsequent step of growing a whole plant from the engineered cybrid cell, but it is not the process of creating the cell itself.

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

Quick Tip

Break down the words: **Somatic Hybrid** = a hybrid from somatic cells (nucleus A + nucleus B). **Cybrid** = a CYtoplasmic hyBRID (nucleus A + cytoplasm B). This distinction is key for answering such questions.

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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 (BNF) is the conversion of inert atmospheric dinitrogen gas (N_2) into ammonia (NH_3), a form usable by plants. This vital process is carried out by diazotrophic microorganisms using the enzyme complex nitrogenase. The reaction is biochemically very difficult because it requires breaking the extremely strong N≡N triple bond. This process is therefore highly endergonic, meaning it requires a substantial input of energy in the form of ATP, and reducing power in the form of electrons.

Step 2: Key Formula or Approach:
The overall, accepted stoichiometry for the reaction catalyzed by the nitrogenase enzyme is:

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

Step 2: Detailed Explanation:
Let's dissect the balanced equation to understand the energy requirement:
- The nitrogenase complex consists of two components: Dinitrogenase reductase (Fe protein) and Dinitrogenase (MoFe protein).
- The process begins with the transfer of electrons, one at a time, from a reductant (like ferredoxin) to the Fe protein.
- For each electron transferred from the Fe protein to the MoFe protein, **two molecules of ATP** are hydrolyzed to ADP + P_i. This ATP hydrolysis drives a conformational change in the Fe protein that is necessary for the electron transfer.

- The overall reduction of one N_2 molecule to two NH_3 molecules requires a total of **eight electrons**.
- Therefore, the total ATP requirement is 8 electrons $\times$ 2 ATP per electron = **16 ATP**.
- It is also important to note that the reaction has an obligate side reaction where two electrons and two protons are used to produce one molecule of hydrogen gas (H_2). This is why 8 electrons are needed, even though the reduction of N_2 to $2NH_3$ would stoichiometrically only require 6 electrons.

Step 3: Final Answer:
Based on the established biochemical mechanism of the nitrogenase enzyme, 16 molecules of ATP are required to fix one molecule of N_2.

Quick Tip

For nitrogen fixation, remember the "Rule of 8s": 8 electrons, 8 protons, and 2 x 8 = 16 ATP. This will help you recall the stoichiometry for the reaction quickly during an exam. Don't forget the H_2 byproduct!

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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:
Symbiotic nitrogen fixation is a mutually beneficial relationship between a plant and a nitrogen-fixing microorganism. The plant provides carbohydrates (energy) and a protected environment for the microbe, while the microbe converts atmospheric N_2 into ammonia for the plant. The most famous example is the legume-*Rhizobium* symbiosis, but several other important symbioses exist across the plant kingdom. This question tests knowledge of these other key examples.

Step 2: Detailed Explanation:
Let's evaluate each plant for known symbiotic relationships:
A. Azolla: This is a small, floating aquatic fern. It maintains a well-known and agriculturally important symbiosis with the nitrogen-fixing cyanobacterium *Anabaena azollae*. The cyanobacterium lives in specialized cavities within the fern's leaves. This association is so efficient that *Azolla* is often used as a "green manure" in rice paddies to enrich the soil with nitrogen. **(Correct)**
B. Gnetum: This is a type of gymnosperm belonging to the Gnetophyta. It is not known to form specific, specialized symbiotic structures for nitrogen fixation.
C. Anthoceros: This is a genus of hornworts, a group of bryophytes. The gametophyte thallus of *Anthoceros* has internal mucilage-filled cavities, which are typically colonized by the nitrogen-fixing cyanobacterium *Nostoc*. The cyanobacterium enters through slime pores on the ventral surface of the thallus. **(Correct)**
D. Cycas: This is a genus of cycads, an ancient group of gymnosperms. *Cycas* plants develop specialized roots called **coralloid roots**. These roots grow upwards towards the soil surface (they are apogeotropic) and are highly branched, resembling coral. They contain a distinct zone that is inhabited by symbiotic nitrogen-fixing cyanobacteria, usually species of *Nostoc* or *Anabaena*. **(Correct)**
E. Riccia: This is a genus of liverworts, another group of bryophytes. It does not have any known symbiotic relationship with nitrogen-fixing microorganisms.

Therefore, the plants from the list that engage in symbiotic nitrogen fixation are Azolla, Anthoceros, and Cycas.

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

Quick Tip

Beyond the common legume-*Rhizobium* symbiosis, remember these key non-legume examples: *Azolla-Anabaena*, *Cycas* coralloid roots, *Anthoceros-Nostoc*, and *Alnus-Frankia* (an actinomycete). These are frequently asked in exams.

---

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:
This question asks to identify the key enzymes that are integral to the overall process of biological nitrogen fixation. This includes the primary enzyme that catalyzes the core reaction, as well as any crucial supporting enzymes that make the process more efficient or viable.

Step 2: Detailed Explanation:
1. **Nitrogenase:** This is the absolute cornerstone enzyme of nitrogen fixation. It is a complex of two proteins: the Fe protein (dinitrogenase reductase) and the MoFe protein (dinitrogenase). The nitrogenase complex is responsible for catalyzing the reduction of N_2 to NH_3, a reaction that is central to the definition of biological nitrogen fixation. Without nitrogenase, the process cannot occur.
2. **Hydrogenase:** The nitrogenase enzyme is not perfectly efficient. As an obligate part of its reaction mechanism, it always reduces some protons (H^+) to hydrogen gas (H_2), wasting a significant portion (at least 25%) of the energy and electrons supplied to it. Many nitrogen-fixing organisms have evolved a solution to this problem: an enzyme called **uptake hydrogenase**. This enzyme captures the H_2 produced by nitrogenase and oxidizes it back to protons and electrons ($H_2 \rightarrow 2H^+ + 2e^-$). This serves two vital functions:
- It recycles the reducing power (electrons) that would otherwise be lost.
- The oxidation of H_2 can be coupled to ATP synthesis, recovering some of the energy.
- It removes H_2, which can act as a competitive inhibitor of nitrogenase.
By improving the overall energy efficiency of nitrogen fixation, hydrogenase is considered a critically important associated enzyme.

The other enzymes listed are involved in general cellular metabolism but are not as directly and specifically coupled to the core nitrogen fixation process:
- **Peptidase** is involved in protein breakdown.
- **Hexokinase** is the first enzyme in glycolysis.
- **Dehydrogenase** is a broad class of enzymes involved in many redox reactions that supply electrons, but hydrogenase has a specific role in managing a direct byproduct of the nitrogenase reaction.

Step 3: Final Answer:
Nitrogenase is the primary enzyme for the reaction, and hydrogenase is a critical secondary enzyme for improving the efficiency of the process. Therefore, both are considered important enzymes involved in nitrogen fixation.

Quick Tip

Remember that nitrogenase is the star player, but it's an inefficient one that produces H_2 as waste. Hydrogenase is the "recycling plant" that cleans up this waste and recovers valuable energy, making it a critical partner enzyme in many nitrogen-fixing systems.

---

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:
This question asks for the biotechnological technique used to create the 'Pomato', a plant that combines characteristics of both potato and tomato. These two plants belong to the same family (Solanaceae) but different genera, and they cannot be cross-bred using conventional sexual reproduction methods. This necessitates the use of a more advanced in vitro technique to bypass the sexual incompatibility barriers.

Step 2: Detailed Explanation:
Let's analyze the given options:
1. **Shoot tip culture:** This is a micropropagation technique primarily used for creating a large number of genetically identical (clonal) plants and for producing virus-free plants. It does not involve combining the genetic material of two different species.
2. **Anther culture:** This technique is used to produce haploid plants from pollen grains. It is a tool for accelerating breeding programs by creating homozygous lines, not for creating intergeneric hybrids.
3. **Somatic hybridization:** This is the correct technique. It involves the following steps:
- Isolating somatic (body) cells from both the potato and tomato plants.
- Using enzymes (like cellulase and pectinase) to digest the cell walls, resulting in naked cells called **protoplasts**.
- Inducing the fusion of a potato protoplast and a tomato protoplast using fusogens like polyethylene glycol (PEG) or a mild electric shock.
- The resulting fused cell contains the genetic material from both plants.
- This hybrid cell is then cultured in vitro, where it regenerates a cell wall, divides to form a callus, and is eventually regenerated into a whole hybrid plant.
This process created the 'Pomato', which could theoretically grow potatoes on its roots and tomatoes on its shoots. While the initial experiment was a scientific success, the resulting plant was not commercially viable.
4. **Seed culture:** This involves growing seeds in a sterile in vitro environment, often used for orchids or for rescuing embryos from difficult crosses, but it is not the method for creating a somatic hybrid like the Pomato.

Step 3: Final Answer:
The Pomato was produced by fusing the protoplasts of potato and tomato cells, a process known as somatic hybridization.

Quick Tip

Somatic hybridization is the go-to technique for creating hybrids between species that are sexually incompatible. Remember the key steps: protoplast isolation, protoplast fusion, and regeneration of the hybrid cell.

---

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 a complex biogeochemical cycle by which nitrogen is converted into multiple chemical forms as it circulates among the atmosphere, terrestrial, and marine ecosystems. The question asks to arrange the key processes of this cycle in a logical sequence. While it is a cycle with no true start or end, there is a logical flow of nitrogen from the atmosphere into living organisms and back.

Step 2: Detailed Explanation:
Let's define each step and place it in a logical sequence:
1. **A. Nitrogen fixation:** This is the initial step where inert atmospheric nitrogen gas (N_2) is converted into a biologically usable form, primarily ammonia (NH_3) or ammonium (NH_4^+). This is done by nitrogen-fixing bacteria. This must be the starting point for nitrogen to enter the biological system.
2. **B. Nitrification:** The ammonium (NH_4^+) produced during fixation is then oxidized by nitrifying bacteria in a two-step process: first to nitrites (NO_2^-) and then to nitrates (NO_3^-). Nitrates are the primary form of nitrogen absorbed by plants. So, this follows fixation.
3. **D. Assimilation:** Plants absorb the nitrates or ammonium from the soil through their roots and incorporate the nitrogen into organic molecules such as amino acids, proteins, and nucleic acids. Animals then get nitrogen by eating plants. This is the step where nitrogen becomes part of the living biomass.

4. **E. Ammonification:** When plants and animals die, or when animals excrete waste, decomposers (bacteria and fungi) break down the organic nitrogen compounds in the dead organic matter and convert it back into ammonium (NH_4^+). This process returns nitrogen to the soil pool.
5. **C. Denitrification:** This is the final step that completes the cycle. Denitrifying bacteria, under anaerobic conditions, convert nitrates (NO_3^-) back into atmospheric nitrogen gas (N_2), which is released into the atmosphere.

Following this logic, the most coherent sequence is: Nitrogen Fixation → Nitrification → Assimilation → Ammonification (of dead assimilated matter) → Denitrification. This corresponds to the sequence A, B, D, E, C.

Step 3: Final Answer:
The correct logical sequence of processes in the nitrogen cycle is A, B, D, E, C.

Quick Tip

To remember the nitrogen cycle sequence, think of it as a story: Nitrogen gas is 'fixed' to enter the living world (Fixation), then 'prepared' for plants (Nitrification), 'used' by life (Assimilation), 'recycled' from waste (Ammonification), and finally 'returned' to the air (Denitrification).

---

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:
Systemic viral infections in plants are a major problem in agriculture, as they spread throughout the plant via the vascular system (phloem). These infections are passed on through vegetative propagation. The question asks for a specific plant tissue culture technique that is reliably used to produce plants completely free of these viruses, even when the parent plant is infected.

Step 2: Detailed Explanation:
Let's evaluate the options:
1. **Embryo culture:** This involves culturing embryos, usually to rescue them from failing seeds. While seeds can sometimes be virus-free, this is not the primary or most reliable method

for eliminating a systemic viral infection from a specific plant variety.
2. **Apical meristem culture:** This is the correct and standard method. The **apical meristem** (the growing tip of a shoot) is a region of rapidly dividing, undifferentiated cells. This region is often free of viruses, even in a systemically infected plant, for several reasons:
- The rate of cell division in the meristem is faster than the rate of virus movement and replication.
- The meristematic region lacks a fully developed vascular system, which hinders the transport of virus particles to the very tip.
- A high metabolic activity and high endogenous auxin concentration in the meristem can inhibit virus multiplication.
By excising this tiny, virus-free apical dome (often with a few leaf primordia) and culturing it in vitro, a complete, virus-free plantlet can be regenerated. This technique is also known as meristemming.
3. **Callus culture:** This involves growing an undifferentiated mass of cells. If the explant used to generate the callus is from an infected plant, the callus cells will also be infected with the virus.
4. **Organ culture:** This involves culturing an entire organ, like a leaf or root. If the parent plant is infected, these differentiated organs will certainly contain the virus.

Step 3: Final Answer:
Apical meristem culture is the most effective and widely used technique for producing virus-free plants from an infected parent stock.

Quick Tip

Remember the key reason: The apical meristem grows faster than the virus can invade it. This "outrunning" of the virus, combined with a lack of vascular connections, makes the meristem the ideal tissue for virus elimination.

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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 terms from plant biology and biotechnology (List-I) with their correct definitions or associated concepts (List-II). A clear understanding of each term is necessary to make the correct pairings.

Step 2: Detailed Explanation:
Let's match each term in List-I individually:
- **A. Somatic hybridization:** As explained previously, this is a technique to create hybrid plants by bypassing sexual reproduction. It involves the **fusion of protoplasts (naked cells) from somatic (body) cells** of two different species. This directly matches with **II**.
- **B. Parthenocarpy:** This is a biological phenomenon, either natural or artificially induced, where fruits develop **without prior fertilization** of the ovules. Because fertilization does not occur, the resulting fruits are typically **seedless**. This matches perfectly with **III**.
- **C. Micropropagation:** This is a broad term for a variety of in vitro techniques used for the rapid vegetative **multiplication of plants without sexual reproduction**. Its goal is to produce a large number of genetically identical clones from a single parent plant. This is an exact match with **IV**.
- **D. Single cell production:** The technique used to grow large quantities of individual, undifferentiated plant cells in a liquid medium is known as a **Cell suspension culture**. This method is often used to produce secondary metabolites or for research on single cells. This matches with **I**.

Combining these matches, we get the following pairs:
A $\rightarrow$ II
B $\rightarrow$ III
C $\rightarrow$ IV
D $\rightarrow$ I

Step 3: Final Answer:
The correct set of matches is A-II, B-III, C-IV, D-I, which corresponds to option (B).

Quick Tip

For matching questions, work through the terms you are most confident about first. This can help you eliminate incorrect options quickly and narrow down the possibilities for the terms you are less sure about.

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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:
Plant tissue culture is a meticulous laboratory procedure that requires a series of steps to be performed in a specific, sterile order to successfully grow a plant or plant cells in vitro. This question asks for the correct chronological sequence of these fundamental steps.

Step 2: Detailed Explanation:
Let's analyze the steps and arrange them logically:
1. **A. Selection of desired material and suitable nutrient media for P. T. C.:** This is the preparatory and planning phase. Before any practical work begins, one must first choose the parent plant (the source of the explant) and prepare the appropriate sterile nutrient medium with the correct hormones and nutrients for the specific objective. This is logically the first step.
2. **C. Surface sterilization of explant:** The piece of plant tissue to be cultured (the explant) is covered with microorganisms (bacteria, fungi). To prevent contamination of the sterile culture medium, the explant's surface must be thoroughly sterilized, usually with chemicals like bleach or alcohol, while keeping the tissue itself alive. This must be done before placing it on the medium.
3. **B. Inoculation of explants:** Inoculation is the aseptic (sterile) transfer of the now surface-sterilized explant onto the prepared sterile nutrient medium in a culture vessel. This step initiates the in vitro culture. It logically follows sterilization.
4. **D. Transfer of growing cultures:** As the culture (e.g., callus or shoots) grows, it depletes the nutrients in the medium and releases metabolic wastes. Therefore, it needs to be periodically transferred to fresh medium to sustain its growth. This process is known as **subculturing**. This happens during the 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 moved from the sterile, high-humidity, and nutrient-rich environment of the culture vessel to the external environment (soil). This process, called **hardening** or acclimatization, is the final step in producing a whole plant.

The correct sequence is therefore: Preparation (A) $\rightarrow$ Sterilization (C) $\rightarrow$ Inoculation (B) $\rightarrow$ Subculturing (D) $\rightarrow$ Hardening (E).

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

Quick Tip

Think of plant tissue culture like performing a sterile surgery. First, you prepare the 'operating room' and tools (A), then you sterilize the 'patient' (C), perform the 'operation' (B), provide 'post-operative care' (D), and finally discharge the 'patient' to the real world (E).

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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:
Ammonification is a crucial step in the nitrogen cycle that involves the recycling of nitrogen within an ecosystem. It is the process by which nitrogen locked in dead organic matter is returned to the soil in an inorganic form that can be used by plants or be further processed by nitrifying bacteria. The question asks for the source material that is broken down during ammonification.

Step 2: Detailed Explanation:
The nitrogen in living organisms is primarily found in complex organic molecules. The most abundant of these are **proteins** (which are polymers of amino acids) and **nucleic acids** (DNA and RNA). When these organisms die, their remains, along with waste products like urea, become the substrate for decomposer organisms (mainly bacteria and fungi).
These decomposers secrete enzymes that break down the complex organic polymers. Proteins are broken down into their constituent **amino acids**. The amino acids are then further catabolized by the microbes for energy. During this catabolism, the amino group ($-NH_2$) is removed from the amino acid molecules and released as ammonia (NH_3) or, in the aqueous soil environment, as the ammonium ion (NH_4^+).
Let's look at the other options:
- **Nitrates (NO_3^-) and Nitrites (NO_2^-):** These are involved in the processes of nitrification and denitrification. They are the products of ammonification, not the source.
- **Nitrogen (N_2):** Atmospheric nitrogen is the source for nitrogen fixation, not ammonification.

Step 3: Final Answer:
Ammonification is the process of generating ammonia by the decomposition of organic nitrogen compounds, of which amino acids are the primary building blocks.

Quick Tip

Associate **Ammonification** with the decomposition of **Amino** acids and other organic matter from dead organisms. The name itself gives a clue: making ammonia from the stuff of life.

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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 / Cas 9
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 strategies and tools used in gene therapy and genetic engineering with their correct descriptions. Understanding the specific goal of each term is key.

Step 2: Detailed Explanation:
Let's match each term in List-I with its description in List-II:
- **A. Gene inhibition:** This strategy is used when a faulty gene produces a harmful product (e.g., in many dominant negative disorders). The goal is not to fix the gene, but to stop it from being expressed or to disable its product. This can be done using techniques like RNA interference (RNAi) or antisense oligonucleotides. Therefore, it aims to **disarm the product of a faulty gene**. This matches with **II**.
- **B. Gene editing:** This is a broad term for a group of technologies that allow scientists to change an organism's DNA. These technologies allow genetic material to be added, removed, or altered at particular locations in the genome. The most famous and versatile tool for this is **CRISPR/Cas9**. This matches with **III**.
- **C. Gene targeting:** This is a specific type of gene editing where a particular gene is modified. A very common goal of gene targeting is to achieve homologous recombination, allowing

the **replacement of a non-functional gene with a normal gene** at its exact chromosomal location. This matches with **IV**.
- **D. Gene Augmentation therapy:** This is the most common gene therapy strategy, used for diseases caused by the loss of function of a gene (typically autosomal recessive diseases). The strategy involves the **addition of a functional copy of the gene** to the patient's cells. This new gene provides the missing product, compensating for the faulty gene. This is a direct match with **I**.

Combining these matches, we get:
A $\rightarrow$ II
B $\rightarrow$ III
C $\rightarrow$ IV
D $\rightarrow$ I

Step 3: Final Answer:
The correct set of matches is A-II, B-III, C-IV, D-I, which corresponds to option (B).

Quick Tip

Remember the key verbs for gene therapy: **Augmentation** = ADD a gene. **Inhibition** = SILENCE a gene. **Editing/Targeting** = CHANGE/REPLACE a gene. CRISPR/Cas9 is the primary tool for editing.

---

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 specific term for a key process within the nitrogen cycle where ammonia (or ammonium ions) is oxidized into nitrates, the form of nitrogen most readily absorbed by plants.

Step 2: Detailed Explanation:
Let's define each process:
1. **Ammonification:** The conversion of organic nitrogen (from dead organisms) into ammonia. This is not the correct answer.

2. **Assimilation:** The uptake of inorganic nitrogen (like ammonia or nitrates) by plants and its incorporation into organic molecules. This is the use of nitrates, not their formation from ammonia.
3. **Nitrification:** This is the biological oxidation of ammonia to nitrite, followed by the oxidation of the nitrite to nitrate. It is a two-step process carried out by different groups of specialized bacteria:
- **Step 1:** Ammonia (NH_3) / Ammonium (NH_4^+) is oxidized to Nitrite (NO_2^-) by ammonia-oxidizing bacteria (e.g., *Nitrosomonas*).
- **Step 2:** Nitrite (NO_2^-) is oxidized to Nitrate (NO_3^-) by nitrite-oxidizing bacteria (e.g., *Nitrobacter*).
The overall conversion of ammonia to nitrates is collectively called nitrification. This is the correct answer.
4. **Denitrification:** The reduction of nitrates back into inert nitrogen gas (N_2), returning it to the atmosphere. This is the opposite process.

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

Quick Tip

To distinguish the terms, focus on the product: Ammoni**fication** makes ammoni**a**. Nitri**fication** makes nitr**ates**. Denitri**fication** is the opposite, it removes nitrates.

---

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: None of the options are correct.

Solution:

Step 1: Understanding the Concept:
This question requires a thorough understanding of the principles and terminology of plant

tissue culture. We need to critically evaluate each statement to determine its accuracy.

Step 2: Detailed Explanation:
Let's analyze each statement one by one:
- A. Organogenesis is inducing the formation of various vegetative organs from cells or tissues.
This statement is **CORRECT**. This is the precise definition of organogenesis in the context of plant tissue culture. It is the in vitro development of organs like shoots, roots, or leaves from an explant or callus.

- B. Formation of mass of undifferentiation cells from callus redifferentiation.
This statement is **INCORRECT**. The formation of a mass of undifferentiated cells (a callus) from a differentiated explant is called **dedifferentiation**. **Redifferentiation** is the opposite process, where the undifferentiated callus cells differentiate to form organs. The statement incorrectly links callus formation with redifferentiation.

- C. Cytoplasmic hybrids are prepared by taking the nucleus from one parent and cytoplasm from both the parents.
This statement is **INCORRECT**. A cytoplasmic hybrid, or **cybrid**, is specifically formed by combining the nucleus from one parent with the cytoplasm from the **other** parent. The statement incorrectly claims that cytoplasm from both parents is used.

- D. Relative concentration of growth hormones play important role in organogenesis.
This statement is **CORRECT**. The ratio of auxins to cytokinins in the culture medium is the critical factor that determines the developmental pathway in organogenesis. Typically, a high auxin-to-cytokinin ratio induces root formation (rhizogenesis), while a high cytokinin-to-auxin ratio induces shoot formation (caulogenesis).

Evaluation of Options:
Based on the analysis, only statements A and D are correct. Let's examine the given options:
1. A, B, and C Only (Incorrect)
2. B, C and D Only (Incorrect)
3. A and B Only (Incorrect)
4. A, C and D Only (Incorrect)

None of the provided options list the correct combination of true statements (A and D only).

Step 3: Final Answer:
The question is flawed as none of the options accurately represent the correct statements. The only correct statements are A and D.

Quick Tip

When encountering a potentially flawed question in an exam, carefully re-read each statement and definition. Confirm your understanding of the core concepts (dedifferentiation vs. redifferentiation, cybrid definition, hormone ratios). If no option matches your logical conclusion, the question itself may be incorrect.

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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 full form of the acronym CRISPR, which is central to the revolutionary gene-editing technology, often referred to as CRISPR-Cas9. The name itself describes a specific feature found in the DNA of bacteria and archaea.

Step 2: Detailed Explanation:
The acronym CRISPR stands for **Clustered Regularly Interspaced Short Palindromic Repeats**. Let's break down what this means:
- **Clustered:** The sequences are found grouped together in specific locations within the bacterial genome.
- **Regularly Interspaced:** The repeats are separated by unique sequences called "spacers" in a regular pattern. These spacers are fragments of DNA from past invading viruses.
- **Short:** The repeating sequences are themselves brief in length.
- **Palindromic:** The repeat sequences have a palindromic nature, meaning they read the same forwards and backwards on opposite DNA strands, which allows them to form hairpin-like secondary structures.
- **Repeats:** The same short palindromic sequence is repeated multiple times in the cluster.

This natural system functions as an adaptive immune system for bacteria, allowing them to recognize and destroy the DNA of invading viruses. Scientists have harnessed this system, particularly the DNA-cutting enzyme Cas9 guided by a guide RNA, to create a powerful and precise tool for editing the genomes of other organisms.

Option (A) perfectly matches this definition. The other options use incorrect words like "Cumulative," "routinely," or "slight," which alter the meaning and are incorrect.

Step 3: Final Answer:
The full form of CRISPR is Clustered Regularly Interspaced Short Palindromic Repeats.

Quick Tip

To remember the full form of CRISPR, focus on the key descriptive words: **Clustered** (grouped), **Regularly Interspaced** (patterned), **Short Palindromic Repeats** (the sequence itself). Each word describes a specific characteristic of the genomic locus.

---

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:
This question is about the production and characteristics of homozygous diploid plants, a key outcome of haploid culture in plant breeding. A homozygous organism has two identical alleles for a particular gene (e.g., AA or aa), while a diploid organism has two sets of chromosomes (2n).

Step 2: Detailed Explanation:
Let's evaluate each statement:
- A. They are produced by doubling the chromosome number of haploids.
This statement is **CORRECT**. Haploid plants (n), produced via anther or ovule culture, have only one copy of each chromosome. By inducing chromosome doubling, each chromosome is duplicated, resulting in a diploid plant (2n) where every gene locus has two identical alleles. This is the primary method for creating fully homozygous diploid lines, often called doubled haploids (DH).

- B. Doubling of chromosome enables the recessive traits to express too.
This statement is **CORRECT**. In a haploid plant, there is no concept of dominance or recessiveness because there is only one allele for each gene. If the allele present is for a recessive trait

(e.g., 'a' for white flowers), the plant will have white flowers. When this haploid's chromosomes are doubled, the resulting diploid plant will have the genotype 'aa', and it will continue to express the recessive white flower trait. Therefore, any trait visible in the haploid will be fixed in the homozygous state after doubling.

- C. Chromosome doubling is done by Ozone treatment.
This statement is **INCORRECT**. Ozone (O_3) is a powerful oxidizing agent and is used for sterilization, but it is not used to induce polyploidy or chromosome doubling. It would likely be toxic to the plant cells.

- D. Chromosome doubling is done by colchicine treatment.
This statement is **CORRECT**. Colchicine is an alkaloid chemical that is widely used to induce chromosome doubling in plants. It functions as a mitotic inhibitor by disrupting the formation of spindle fibers during cell division. This prevents the separation of sister chromatids, leading to a cell with double the original chromosome number (e.g., a haploid 'n' cell becomes a diploid '2n' cell).

Step 3: Final Answer:
The correct statements are A, B, and D. This combination corresponds to option (A).

Quick Tip

Remember that doubled haploid (DH) technology is a major shortcut in plant breeding. The key steps are: 1. Create haploids (e.g., via anther culture). 2. Double the chromosomes using a chemical like **colchicine**. The result is a 100% homozygous diploid line in a single generation.

---

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:
This question is about a very famous application of genetic engineering in agriculture: the creation of Bt crops. It asks about the specific type of resistance conferred by the introduction of the *Bt* gene into plants.

Step 2: Detailed Explanation:
The *Bt* gene originates from a common soil bacterium called ***Bacillus thuringiensis***. This bacterium naturally produces a class of proteins called **Cry proteins** (crystal proteins). These proteins are harmless to humans, mammals, and most other organisms, but they are highly toxic to the larvae of specific orders of insects.
The mechanism of action is as follows:
1. An insect pest (like a caterpillar) ingests the plant tissue containing the Bt protein.
2. In the alkaline environment of the insect's midgut, the insoluble protein crystal dissolves and is cleaved by proteases into its active, toxic form.
3. This active toxin binds to specific receptors on the surface of the insect's gut epithelial cells.
4. It then creates pores in the cell membranes, leading to cell lysis, gut paralysis, and ultimately the death of the insect from septicemia and starvation.

By transferring the gene that codes for this Cry protein into crop plants (creating transgenic or genetically modified crops like Bt cotton, Bt corn, and Bt brinjal), the plants themselves can produce the insecticidal protein. This provides them with inherent, built-in protection against targeted **insect pests**, reducing the need for external chemical insecticide sprays.

Step 3: Final Answer:
The introduction of the *Bt* gene into crops provides resistance to insect pests.

Quick Tip

Remember the mnemonic: **B**t stands for ***B****acillus* ***t****huringiensis*, which kills **B**ugs (**t**argeted insect pests). This helps distinguish its function from resistance to viruses, fungi, or abiotic stress like heat.

---

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 focuses on a specific step within the process of nitrification. Nitrification is the two-stage oxidation of ammonia to nitrate. The question asks to identify the genus of bacteria responsible for the second stage of this process.

Step 2: Detailed Explanation:
As previously discussed, nitrification involves two distinct steps, carried out by two different groups of chemosynthetic bacteria:
- **Step 1: Ammonia Oxidation.** In this step, ammonia (NH_3) or ammonium (NH_4^+) is oxidized to nitrite (NO_2^-). This process is performed by ammonia-oxidizing bacteria. Key examples of this group are bacteria from the genera ***Nitrosomonas*** and ***Nitrococcus***. So, options (C) and (D) are responsible for the first step, not the second.
- **Step 2: Nitrite Oxidation.** In this step, the nitrite (NO_2^-) produced in the first step is further oxidized to nitrate (NO_3^-). This is performed by nitrite-oxidizing bacteria. The most well-known and classic example of this group is the genus ***Nitrobacter***.

Clostridium (Option A) is a diverse genus of bacteria, some species of which are capable of nitrogen fixation (converting N_2 to NH_3), but they are not involved in nitrification.

Therefore, the bacterium that converts nitrites to nitrates is *Nitrobacter*.

Step 3: Final Answer:
The conversion of nitrites (NO_2^-) to nitrates (NO_3^-) is carried out by *Nitrobacter*.

Quick Tip

A useful way to remember the nitrification bacteria is: Nitro**so**monas works with ammonia (**so**urce), and Nitro**bac**ter works on the product to bring it **bac**k to the final form, nitrate. Or remember that 'a' in Nitrob**a**cter comes after 'o' in Nitros**o**monas, just as nitrate comes after nitrite.

---

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 question is about another method of producing haploid plants, known as **gynogenesis**. While androgenesis uses the male gametophyte (pollen), gynogenesis uses the female gametophyte (the embryo sac, containing the egg cell). It involves culturing unfertilized ovules or ovaries to induce the egg cell, synergids, or antipodal cells to develop into a haploid embryo

and plant. The question asks for the plant species in which this was first successfully achieved.

Step 2: Detailed Explanation:
The pioneering work in in vitro gynogenesis was conducted by a scientist named **San Noeum**. In a groundbreaking paper published in **1976**, San Noeum reported the successful production of haploid plants from the culture of unpollinated ovaries and ovules of **Barley** (*Hordeum vulgare*).
This discovery was significant because it provided an alternative method for producing haploids, which is particularly useful for species where anther culture (androgenesis) is difficult or results in a high frequency of albino plants, as is common in cereals like barley. Following this initial success in barley, the technique of gynogenesis has been extended to various other crop species.

Step 3: Final Answer:
The first successful culture of gynogenic haploid plants was achieved by San Noeum using the unfertilized ovaries of barley.

Quick Tip

For historical questions in biotechnology, link the scientist, the technique, and the model organism. Just as **Guha & Maheshwari** → **Androgenesis** → ***Datura***, you should remember **San Noeum** → **Gynogenesis** → **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:
This question asks to identify which of the listed plants engage in symbiotic nitrogen fixation.

This process primarily involves plants from the legume family (Fabaceae), which form a specialized relationship with nitrogen-fixing bacteria called rhizobia. These bacteria live in nodules on the plant's roots, where they convert atmospheric nitrogen into ammonia for the plant.

Step 2: Detailed Explanation:
We need to identify which of the plants in the list are legumes.
- **A. Pea (*Pisum sativum*):** The pea is a classic example of a **legume**. It forms root nodules in symbiosis with *Rhizobium leguminosarum*. **(Correct)**
- **B. Lettuce (*Lactuca sativa*):** Lettuce belongs to the daisy family (Asteraceae). It is **not a legume** and does not form nitrogen-fixing nodules.
- **C. Beans (e.g., *Phaseolus vulgaris*):** Beans are another well-known example of a **legume** that readily forms root nodules with rhizobia. **(Correct)**
- **D. Tomato (*Solanum lycopersicum*):** The tomato belongs to the nightshade family (Solanaceae). It is **not a legume**.
- **E. Black gram (*Vigna mungo*):** Black gram, also known as urad dal, is a type of pulse crop. It is a member of the **legume** family and actively fixes nitrogen. **(Correct)**

Therefore, the plants from the list that perform symbiotic nitrogen fixation are Pea, Beans, and Black gram.

Step 3: Final Answer:
The correct combination of plants is A, C, and E.

Quick Tip

To answer questions like this, you need to be able to recognize common crop plants that belong to the legume family (Fabaceae). Remember that most "beans," "peas," "lentils," and "grams" are legumes and are involved in symbiotic nitrogen fixation.

---

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:
This question asks for the specific enzyme responsible for the central reaction in biological nitrogen fixation (BNF). BNF is the process where atmospheric nitrogen (N_2), which is chemically

inert, is converted into ammonia (NH_3), a form that can be used by living organisms. This incredibly energy-intensive reaction is only possible due to a unique enzyme complex found in certain microorganisms.

Step 2: Detailed Explanation:
Let's analyze the function of each enzyme listed:
1. **Hydrogenase:** This enzyme is involved with hydrogen. Specifically, 'uptake hydrogenase' is often found in nitrogen-fixing organisms to recycle the H_2 gas that is produced as a byproduct of the nitrogen fixation reaction, thus improving efficiency. However, it does not act on the dinitrogen molecule itself.
2. **Dehydrogenase:** This is a very broad class of enzymes that catalyze the removal of hydrogen atoms (oxidation) from a substrate. While dehydrogenases are crucial in metabolic pathways that supply electrons to the nitrogen fixation process, they are not the enzyme that directly converts N_2 to NH_3.
3. **Nitrogenase:** This is the correct answer. The nitrogenase enzyme complex is the only known biological catalyst capable of breaking the powerful triple bond of the dinitrogen molecule ($N \equiv N$) and reducing it to ammonia. It is a highly complex enzyme, extremely sensitive to oxygen, and requires a massive input of ATP and electrons to function. Its action is the defining feature of biological nitrogen fixation.
4. **Nitrate reductase:** This enzyme is important in the nitrogen cycle, but it works in the opposite direction of what is asked. It catalyzes the reduction of nitrate (NO_3^-) to nitrite (NO_2^-), a key step in nitrogen assimilation by plants and also in denitrification. It does not act on dinitrogen.

Step 3: Final Answer:
The conversion of dinitrogen into ammonia is catalyzed exclusively by the enzyme nitrogenase.

Quick Tip

Associate the substrate with the enzyme name. **Nitrogen**ase works on di**nitrogen**. **Nitrate** reductase works on **nitrate**. This simple association can help you quickly identify the correct enzyme for the reaction.

---

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:
This question tests knowledge about the cytology (the study of cells, especially their structure and chromosome behavior) of haploid organisms. A haploid has only one set of chromosomes (n). This has specific consequences for its chromosome number and its behavior during meiosis. We also need to know the basic chromosome numbers of two model plants, *Arabidopsis* and maize.

Step 2: Detailed Explanation:
Let's evaluate each statement:
- A. A haploid in Arabidopsis will have 5 chromosomes.
The model plant *Arabidopsis thaliana* is a diploid with a somatic chromosome number of 2n = 10. A haploid organism has half this number. Therefore, a haploid Arabidopsis plant will have n = 5 chromosomes. This statement is **CORRECT**.

- B. Haploids are found as bivalents at metaphase-I of meiosis.
During prophase-I of meiosis, homologous chromosomes pair up to form **bivalents**. This pairing is essential for proper segregation. A haploid organism, by definition, has only one of each type of chromosome and lacks homologous pairs. Therefore, bivalents cannot be formed. This statement is **INCORRECT**.

- C. Haploids are found as univalent at metaphase-I of meiosis.
Since a haploid lacks homologous chromosomes to pair with, each chromosome remains as a single, unpaired entity during meiosis-I. These unpaired chromosomes are called **univalents**. At metaphase-I, these univalents align randomly at the metaphase plate. This statement is **CORRECT**.

- D. The haploids in maize will have 10 chromosomes.
Maize (*Zea mays*) is a diploid plant with a somatic chromosome number of 2n = 20. A haploid maize plant would have half this number. Therefore, a haploid in maize will have n = 10 chromosomes. This statement is **CORRECT**.

- E. The haploids in maize will have 20 chromosomes.
This is incorrect. 20 is the diploid (2n) number for maize, not the haploid (n) number. This statement is **INCORRECT**.

Step 3: Final Answer:
The correct statements are A, C, and D. This combination corresponds to option (C).

Quick Tip

Remember the key meiotic feature of haploids: **No homologous chromosomes** → **No pairing** → **No bivalents**. Instead, you find **univalents**. This leads to irregular segregation and sterility, which is a hallmark of haploid organisms.

---

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:
This question asks to identify the established methods used to artificially create haploid plants. Haploid production is a valuable tool in plant breeding, and several techniques have been developed to achieve this.

Step 2: Detailed Explanation:
Let's analyze each option:
- **A. Colchicine doubling:** This is a method used to **produce diploids from haploids**, not the other way around. Colchicine induces chromosome doubling. This is incorrect.

- **B. X-ray treatment:** X-rays are a form of ionizing radiation that can cause extensive chromosome damage. One method of haploid production involves pollinating a plant with pollen that has been heavily irradiated (e.g., with X-rays). The radiation destroys the genetic material in the male gametes, but the pollen grain is still able to germinate and stimulate the egg cell to begin development *parthenogenetically* into a haploid embryo. This technique is known as **irradiated pollen technique**. This is a correct method.

- **C. Pollen culture:** This is a major and widely used technique of androgenesis. Immature pollen grains (microspores) are cultured in vitro, where they are induced to switch from their gametophytic pathway to a sporophytic pathway, developing into haploid embryos and plants.

This is a correct method.

- **D. Distant hybridization:** This refers to crossing between two different species or genera. In some specific wide crosses (e.g., in barley, crossing *Hordeum vulgare* with *Hordeum bulbosum*), fertilization occurs, but during the early development of the embryo, the chromosomes of one of the parents (e.g., *H. bulbosum*) are selectively eliminated. This process of **chromosome elimination** results in a haploid embryo containing only the chromosomes of the other parent (*H. vulgare*). This is a correct method.

- **E. Infrared radiation:** This is a form of non-ionizing radiation, primarily associated with heat. It is not used to induce haploidy.

Step 3: Final Answer:
The correct methods for artificially producing haploids from the list are X-ray treatment, Pollen culture, and Distant hybridization. Therefore, the correct option is B, C, and D.

Quick Tip

Remember the main categories of haploid production: **Androgenesis** (pollen/anther culture), **Gynogenesis** (ovule/ovary culture), and **Chromosome Elimination** (through distant hybridization or irradiated pollen).

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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:
This question asks for the specific term that describes a naturally occurring piece of DNA with a particular set of characteristics: it exists outside the main chromosome, it is usually circular, and it can replicate independently of the host chromosome. This is a fundamental concept in molecular biology and genetics, especially in bacteria.

Step 2: Detailed Explanation:
Let's define each term:
1. **Recombinant DNA:** This is a broad term for any DNA molecule that has been artificially created by combining genetic material from different sources. It is an engineered molecule, not

necessarily circular, extrachromosomal, or naturally occurring.
2. **Cybrid:** A cybrid is a eukaryotic hybrid **cell** containing the nucleus from one species and the cytoplasm from another. It is a cell, not a DNA molecule.
3. **Plasmid:** This is the correct answer. Plasmids are small, circular, double-stranded DNA molecules that are physically separate from, and can replicate independently of, the chromosomal DNA within a cell. They are most commonly found in bacteria as extrachromosomal DNA, and they often carry genes for traits such as antibiotic resistance. This definition perfectly matches the description in the question.
4. **Yeast artificial chromosome (YAC):** A YAC is an engineered DNA molecule used to clone very large DNA sequences in yeast cells. It is a **linear** (not circular) cloning vector that is constructed to mimic a yeast chromosome, containing a centromere, telomeres, and an origin of replication. It is an artificial construct, not a naturally occurring entity as implied by the general definition.

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

Quick Tip

Associate the word **plasmid** with bacteria and the key features: **small, circular, extrachromosomal, self-replicating**. Plasmids are the workhorses of molecular cloning.

---

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:
This question asks to identify the host plant for a specific and well-known symbiotic relationship involving the nitrogen-fixing cyanobacterium *Anabaena*. It also has a slight inaccuracy in the question itself, which needs to be addressed for a complete explanation.

Step 2: Detailed Explanation:
The symbiosis between the aquatic fern ***Azolla*** and the cyanobacterium ***Anabaena azollae*** is a classic example of nitrogen fixation in a non-legume.
- ***Azolla*** is a small, free-floating fern that thrives in freshwater environments like ponds and

rice paddies.
- It has specialized cavities or pores on the dorsal lobes of its leaves. These cavities are inhabited by filaments of the cyanobacterium *Anabaena azollae*.
- Inside these cavities, the *Anabaena* fixes atmospheric nitrogen, providing a crucial nutrient source to the fast-growing fern.
- The question incorrectly states that *Anabaena* is found in "root pockets". *Azolla* has simple roots, but the symbiotic association occurs in its **leaf cavities**. Despite this minor error in the question's wording, *Azolla* is the only correct host plant among the options.

Let's look at the other options:
- ***Pistia*** (water lettuce) and ***Salvinia*** (water moss) are other free-floating aquatic plants, but they are not known to form this type of symbiotic relationship with *Anabaena*.
- ***Marsilea*** is a rooted aquatic fern, also not associated with this symbiosis.

Step 3: Final Answer:
The nitrogen-fixing cyanobacterium *Anabaena* is found in a symbiotic relationship within the leaf cavities of the aquatic fern *Azolla*.

Quick Tip

Even if a question has a minor inaccuracy (like "root pockets" instead of "leaf cavities"), focus on the core biological association being tested. The link between ***Azolla*** and ***Anabaena*** is a very strong and famous one that you should commit to memory.

---

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 foundation of recombinant DNA technology and genetic engineering is the ability to manipulate DNA molecules in a precise and predictable way. A critical first step in this process is the ability to cut large DNA molecules into smaller, manageable fragments at specific sites. This question asks for the biological tool that made this possible.

Step 2: Detailed Explanation:
Let's examine the roles of the options provided:

1. **Reverse transcriptase:** This is an enzyme that synthesizes a DNA copy from an RNA template (cDNA synthesis). It is crucial for working with mRNA (e.g., in creating cDNA libraries), but it does not cut DNA.
2. **Restriction endonuclease:** This is the correct answer. Restriction endonucleases, also known as restriction enzymes, are bacterial enzymes that act as a defense mechanism against invading viral DNA. Each restriction enzyme recognizes a specific, short DNA sequence (called a recognition site) and cuts the DNA backbone at or near that site. Because these recognition sites appear at specific locations in a genome, these enzymes act like "molecular scissors," allowing scientists to cut DNA at precise, reproducible locations. This discovery was a cornerstone of the genetic engineering revolution.
3. **Bacteriophage:** This is a virus that infects bacteria. While some phages (like Lambda phage) are used as cloning vectors to carry DNA into bacteria, the phage itself is a carrier, not the tool for cutting DNA.
4. **P. C. R. (Polymerase Chain Reaction):** This is a technique used to *amplify* or make millions of copies of a specific DNA segment. It uses a heat-stable DNA polymerase, not an enzyme that cuts DNA at specific sites.

Step 3: Final Answer:
The discovery of restriction endonucleases made it possible to cut DNA at specific locations.

Quick Tip

Think of the names: "endo-" means within, and "-nuclease" means to cut nucleic acid. A restriction "endonuclease" is an enzyme that cuts DNA from within the strand at a restricted, specific site.

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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:
This question asks for the logical sequence of steps involved in creating a genetically modified organism (GMO). The process involves identifying a useful gene, inserting it into a host organism, ensuring it functions correctly, and then passing it on to future generations.

Step 2: Detailed Explanation:
Let's arrange the steps in a logical workflow:
1. **B. Identification of DNA with desired genes:** This is the absolute first step. Before anything else, you must identify a gene that codes for a desirable trait (e.g., insect resistance, herbicide tolerance) and isolate it from the source organism.
2. **C. Introduction of the DNA into the host:** Once the desired gene is isolated (and often inserted into a vector), the next step is to introduce this recombinant DNA into the cells of the host organism you want to modify (e.g., a plant cell, a bacterium). This process is called transformation.
3. **D. Maintenance of introduced DNA in the host:** It's not enough to just get the DNA into the host cell. The introduced DNA must be stably integrated into the host's genome and maintained so that it is copied every time the cell divides. This ensures that the new gene becomes a permanent part of the organism's genetic makeup.
4. **A. Transfer of DNA with desired genes to its progeny:** The ultimate goal of creating a GMO, especially in agriculture, is to have a stable line of organisms that possess the new trait. Therefore, the final step is to ensure that the introduced gene (transgene) is passed on to the offspring through normal reproduction, following the rules of inheritance.

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

Step 3: Final Answer:
The correct sequence to develop a GMO is Identification (B), Introduction (C), Maintenance (D), and Transfer to progeny (A).

Quick Tip

Think of the GMO process like building with LEGOs: First, you **find** the special brick you want (B). Then, you **put** it into your creation (C). You make sure it **sticks** there securely (D). Finally, you confirm that if you copy the creation, the special brick is still there in the copy (A).

---

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:
A biocontrol agent is a living organism, or a natural product derived from one, that is used to suppress the population of a pest organism. This question asks to identify a specific microorganism used to control butterfly caterpillars, which are a major group of insect pests in agriculture.

Step 2: Detailed Explanation:
Let's analyze the options:
1. **Bacillus thuringiensis (Bt):** This is the correct answer. As discussed in a previous question, this soil bacterium produces Cry proteins that are specifically toxic to the larvae (caterpillars) of many species of butterflies and moths (Order: Lepidoptera), as well as some beetles and flies. Spores and protein crystals of Bt are formulated into organic biopesticides that are sprayed on plants. When caterpillars eat the sprayed leaves, they ingest the toxin and are killed. This is a highly effective and widely used microbial biocontrol agent.
2. **Streptococcus sps.:** This is a genus of bacteria known for causing various diseases in humans, such as strep throat and pneumonia. They are not used as biocontrol agents.
3. **Saccharomyces cerevisiae:** This is baker's or brewer's yeast, a fungus used extensively in the food and beverage industry for fermentation. It has no biocontrol properties against insects.
4. **Trichoderma polysperum:** Species of the fungus *Trichoderma* are important biocontrol agents, but they are used to control **plant-pathogenic fungi** in the soil, not insect pests. They act by parasitizing other fungi or outcompeting them for resources.

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

Quick Tip

Remember the famous biocontrol agents and their targets: **Bt** → Caterpillars (Insects), **Trichoderma** → Pathogenic Fungi, **Ladybugs** → Aphids (Insects), **Baculoviruses** → Insects.

---

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:
This question asks about the function of a specific protein, leghemoglobin, found within the root nodules where symbiotic nitrogen fixation occurs. There is a fundamental conflict that must be resolved in the nodule: the nitrogen-fixing bacteria (*Rhizobium*) are aerobic and need oxygen for respiration to produce ATP, but the nitrogenase enzyme they use to fix nitrogen is irreversibly inactivated by oxygen.

Step 2: Detailed Explanation:
Leghemoglobin is the solution to this "oxygen paradox". It is a pinkish-red, oxygen-carrying protein, structurally similar to the hemoglobin in animal blood. Its function is to act as an oxygen buffer or scavenger.
- It has a very high affinity for oxygen.
- It binds to free oxygen within the nodule, keeping the concentration of free oxygen extremely low. This creates an anaerobic or microaerobic environment right around the nitrogenase enzyme, protecting it from inactivation.
- At the same time, it facilitates the diffusion of a steady supply of oxygen to the bacterial respiratory chain, allowing the bacteria to respire efficiently and produce the large amounts of ATP needed for nitrogen fixation.
In essence, it keeps oxygen away from the nitrogenase but delivers it to the bacterial respiration machinery.
Let's analyze the options:
1. Inhibition of nitrogenase activity: It does the opposite; it protects nitrogenase.
2. Removal of oxygen: This is the correct function. It scavenges free oxygen to protect the enzyme.
3. Nodule differentiation: Nodule formation is controlled by a complex signaling between the plant and bacteria (Nod factors, etc.), not by leghemoglobin.
4. Expression of nif gene: The *nif* genes (nitrogen fixation genes) are expressed by the bacteria, but their expression is regulated by low oxygen levels, which leghemoglobin helps to create, but it doesn't directly regulate the gene expression.

Step 3: Final Answer:
The function of leghemoglobin is the removal of free oxygen to create a microaerobic environment that protects the oxygen-sensitive nitrogenase enzyme.

Quick Tip

Think of **Leg**hemoglobin as the **leg**ume's version of **hemoglobin**. Just like hemoglobin carries oxygen in your blood, leghemoglobin carries oxygen in the nodule, but its main job is to keep the free oxygen concentration very low to protect the delicate nitrogenase enzyme. The pink color of a sliced-open, active nodule is due to leghemoglobin.

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:
This question asks to classify the CRISPR-Cas9 system based on its primary application in molecular biology. The CRISPR-Cas9 system has revolutionized biotechnology due to its ability to manipulate DNA with unprecedented precision.

Step 2: Detailed Explanation:
The CRISPR-Cas9 system works like a "search and replace" function for DNA. It has two main components:
1. **Cas9:** A nuclease enzyme that acts as "molecular scissors" to make a double-strand break in the DNA.
2. **Guide RNA (gRNA):** A small piece of RNA that is engineered to be complementary to a specific target DNA sequence in the genome. It guides the Cas9 enzyme to the exact location where the cut should be made.

Once the DNA is cut at the target site, the cell's natural DNA repair mechanisms take over. Scientists can exploit these mechanisms to achieve different outcomes:
- The cell might repair the break imperfectly, leading to a small insertion or deletion (indel) that can **knock out** the gene's function.
- If a template DNA sequence is provided along with the CRISPR-Cas9 system, the cell can use it to repair the break, allowing scientists to **replace**, **delete**, or **insert** specific sequences.

This entire process of precisely modifying the DNA sequence at a targeted location is known as **gene editing** or genome editing.
- **Sequencing** is determining the order of nucleotides in a DNA molecule.
- **Labelling** is attaching a fluorescent or radioactive marker to a molecule.
- **Locating** is a part of the process (the gRNA locates the target), but the overall technique is editing.

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

Quick Tip

Remember CRISPR-Cas9 as a "cut-and-paste" or "find-and-replace" tool for DNA. These actions are all forms of **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:
This question requires knowledge of the key characteristics of *Agrobacterium tumefaciens*, a bacterium that is extremely important in plant biotechnology. We need to evaluate statements about its biology and its unique interaction with plants.

Step 2: Detailed Explanation:
Let's analyze each statement:
- **A. It is a gram positive round shaped bacterium:** This is incorrect. *Agrobacterium* is Gram-negative, and it is rod-shaped (a bacillus), not round (a coccus).

- **B. It is a gram negative rod shaped bacterium:** This statement is **CORRECT**. This is the correct microbiological description of *Agrobacterium tumefaciens*.

- **C. It is a photosynthetic spiral bacterium:** This is incorrect. *Agrobacterium* is not photosynthetic, and it is rod-shaped, not spiral-shaped (a spirillum).

- **D. It is also known as 'Natural genetic Engineer':** This statement is **CORRECT**. *Agrobacterium* has earned this nickname because of its unique, natural ability to transfer a segment of its own DNA into the plant genome, effectively genetically engineering the plant for its own benefit (to produce nutrients called opines that only the bacterium can use).

- **E. It is capable of naturally transferring DNA into plant genome:** This statement is **CORRECT**. This is the mechanism that earns it the title "natural genetic engineer". During infection, the bacterium transfers a specific segment of DNA, called the T-DNA (transfer DNA), from its Ti (tumor-inducing) plasmid into the nucleus of a plant cell, where it integrates into the plant's chromosomes. Scientists have harnessed this ability by replacing the tumor-inducing genes on the T-DNA with genes of interest, using the bacterium as a vehicle to create transgenic plants.

Step 3: Final Answer:
The correct statements are B, D, and E. This combination corresponds to option (B).

Quick Tip

For *Agrobacterium tumefaciens*, remember these key facts: It's a Gram-negative rod, it causes crown gall disease, it contains the Ti plasmid, and it's the "Natural Genetic Engineer" because it transfers its T-DNA into the plant genome.

---

42. Source organism of cry genes is -

(A) Bacillus thuringiensis
(B) Agrobacterium tumefaciens
(C) Rhizobium
(D) Staphylococcus

Correct Answer: (A) Bacillus thuringiensis

Solution:

Step 1: Understanding the Concept:
This question asks for the origin of the *cry* genes. These genes are the basis for one of the most widely used traits in agricultural biotechnology, providing insect resistance to crops.

Step 2: Detailed Explanation:
The *cry* genes are a group of genes that code for the family of insecticidal proteins known as **Cry proteins**, or crystal proteins. These proteins are produced naturally by the common soil bacterium ***Bacillus thuringiensis***, often abbreviated as Bt.
During the sporulation phase of its life cycle, the bacterium produces these proteins, which accumulate in the cell as crystalline inclusions. It is these protein crystals that give the genes their name (*cry* from **cry**stal). These proteins are the active ingredient in Bt-based biopesticides and are the products of the *cry* genes that are transferred into plants to create insect-resistant GM crops like Bt cotton and Bt corn.
The other options are incorrect:
- *Agrobacterium tumefaciens* is the source of the T-DNA transfer mechanism, not *cry* genes.
- *Rhizobium* is a nitrogen-fixing bacterium.

- *Staphylococcus* is a genus of bacteria known for causing infections in humans.

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

Quick Tip

Connect the terms: The *cry* genes code for **cry**stal proteins. These proteins are produced by ***B***acillus ***t***huringiensis (**Bt**). This connection is fundamental to understanding GM insect-resistant crops.

---

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:
This question is about the biochemical requirements of the nitrogenase enzyme complex, which is responsible for biological nitrogen fixation. Like many enzymes, nitrogenase requires specific inorganic cofactors, particularly metal ions, to be catalytically active. The question asks to identify a key metallic element that is a component of this enzyme.

Step 2: Detailed Explanation:
The nitrogenase enzyme complex consists of two main protein components:
1. **The Fe protein (or dinitrogenase reductase):** This smaller protein contains an iron-sulfur cluster (Fe-S).
2. **The MoFe protein (or dinitrogenase):** This larger protein is where the actual reduction of N_2 takes place. Its active site contains a complex and unique metal cofactor called the Iron-Molybdenum Cofactor (FeMoco).

As the name **MoFe** protein implies, this critical component contains both **iron (Fe)** and **Molybdenum (Mo)**. Molybdenum is located at the heart of the FeMoco cluster and is believed to be the site where the dinitrogen molecule binds and is reduced. Therefore, molybdenum is an absolutely essential micronutrient for nitrogen-fixing organisms. While there are alternative nitrogenases that use vanadium (V) or only iron (Fe) in place of molybdenum, the primary and most efficient form of nitrogenase is the molybdenum-dependent one.
The other elements listed are also important plant micronutrients but are not the key metal

cofactor in the most common form of nitrogenase:
- **Zinc (Zn)** is a cofactor for many enzymes, like carbonic anhydrase.
- **Copper (Cu)** is involved in redox reactions, for example, in plastocyanin.
- **Manganese (Mn)** is famously part of the oxygen-evolving complex in photosystem II.

Step 3: Final Answer:
Molybdenum plays a key role in nitrogen fixation as an essential component of the nitrogenase enzyme's active site cofactor.

Quick Tip

Remember the name of the main component of nitrogenase: the **MoFe** protein. This name directly tells you the two key metals involved: **Mo**lybdenum and Iron (**Fe**).

---

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 process of introducing foreign DNA into a host cell is called **transformation** (for bacteria) or **transfection** (for animal cells). There are several physical and chemical methods to achieve this, which are collectively known as gene transfer methods. This question asks to identify which of the given options is not one of these methods.

Step 2: Detailed Explanation:
Let's analyze the given options:
1. **Microinjection:** This is a physical method where a very fine glass micropipette is used to directly inject a DNA solution into the nucleus of a target cell. It is a precise but labor-intensive method commonly used for creating transgenic animals. This is a gene transfer method.
2. **Denaturation:** This is a process where a molecule, such as a protein or DNA, loses its native three-dimensional structure. For DNA, denaturation refers to the separation of the two strands of the double helix, typically by applying heat or high pH. While DNA denaturation is a crucial step in techniques like PCR, it is **not a method for introducing DNA into a cell**. It is a process that happens to DNA, not a tool for gene transfer.
3. **Gene gun (or Biolistics):** This is a physical method where microscopic particles of a

heavy metal (like gold or tungsten) are coated with the DNA of interest. These "bullets" are then fired at high velocity into target cells or tissues, physically piercing the cell walls and membranes to deliver the DNA inside. This is a common method for transforming plant cells.
4. **Heat shock method:** This is a common chemical/physical method used to transform bacteria like *E. coli*. First, the bacterial cells are made "competent" by treating them with calcium chloride ($CaCl_2$), which neutralizes the negative charges on the cell membrane and DNA. The cells are then mixed with the plasmid DNA and subjected to a brief, sudden increase in temperature (a heat shock, typically at 42°C). This creates transient pores in the cell membrane, allowing the plasmid DNA to enter the cell. This is a standard gene transfer method.

Step 3: Final Answer:
Microinjection, gene gun, and heat shock are all methods for introducing DNA into a host cell. Denaturation is a process of separating DNA strands and is not a gene transfer tool.

Quick Tip

Gene transfer methods are about getting DNA **across the cell membrane**. Think about what each term means: micro**injection** (injecting in), **gene gun** (shooting in), and **heat shock** (creating pores to let things in). **Denaturation** is about changing DNA structure, not moving it into a cell.

---

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:
Somatic hybridization is a multi-step laboratory procedure for creating a hybrid plant from the fusion of somatic cells. This question requires arranging the key steps of this complex process

into a logical and chronological order, from the initial cells to the final hybrid plant.

Step 2: Detailed Explanation:
Let's break down the process and order the steps:
1. **C. Protoplast isolation and its treatment with fusion chemical.:** This is the necessary first step. You must start by isolating the plant cells and enzymatically removing their cell walls to create protoplasts. Then, these protoplasts from the two parent species are mixed and treated with a fusogen (like PEG) to induce them to fuse together.
2. **A. Plating of fused protoplasts:** After the fusion treatment, the mixture of fused and unfused protoplasts is plated onto a suitable culture medium. Here, the protoplasts will begin to regenerate their cell walls and start dividing to form microcalli.
3. **B. Selection of hybrid cells:** The fusion process is not 100% efficient. The culture will contain unfused protoplasts of both parents, self-fused protoplasts, and the desired hybrid protoplasts. Therefore, a selection system must be applied to identify and selectively grow only the true hybrid cells while eliminating the others. This is a critical step.
4. **D. Transfer of callus to differentiation medium:** The selected hybrid cells will proliferate to form a callus. Once a sufficient mass of callus has grown, it is transferred to a differentiation or regeneration medium, which contains specific hormones (auxins and cytokinins) to induce the formation of shoots and roots (organogenesis).
5. **E. Selection of somatic hybrid plants:** Not all regenerated plantlets may be true, stable hybrids. The final step is to grow the regenerated plantlets and analyze them morphologically and genetically to confirm their hybrid nature and select the desired somatic hybrid plants.

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

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

Quick Tip

Think of the somatic hybridization workflow as a funnel: Start with a large population of cells (**Isolate & Fuse** - C), grow everything together (**Plate** - A), then narrow it down by picking the right cells (**Select Cells** - B), grow them up into plants (**Differentiate** - D), and finally pick the best plant (**Select Plants** - E).

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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: (D) Sugarcane - Scarlet

Solution:

Step 1: Understanding the Concept:
Somaclonal variation refers to the genetic variations that arise in plants regenerated from in vitro tissue culture. Plant breeders can screen these variants for desirable traits, and successful variants can be developed and released as new commercial cultivars. This question asks to identify a correct example of a commercial cultivar that originated as a somaclonal variant. This is a factual recall question based on the history of crop improvement.

Step 2: Detailed Explanation:
Let's analyze the given options:
1. **Barley - Andro:** This is likely a distractor. The term "Andro" might allude to androgenesis (haploid production), which is a different technique, though it can also be a source of variation. It is not a well-known somaclonal variant cultivar.
2. **Geranium - Velvet Rose:** While somaclonal variation has been studied in ornamental plants like Geranium, 'Velvet Rose' is not a widely cited example of a major commercial release from this technique.
3. **Tomato - DAMA:** 'DAMA' is a variety of tomato, but it is not famous for being a product of somaclonal variation. Many tomato improvements have come from traditional breeding and mutation breeding.
4. **Sugarcane - Scarlet:** This is a historically significant example. In the late 1970s and early 1980s, researchers in Fiji screened somaclones of a sugarcane variety that was susceptible to Fiji disease virus. They identified a variant that showed high levels of resistance to the disease. This resistant variant was named 'Ono' in some contexts and was part of a program that released disease-resistant cultivars. The development of disease-resistant sugarcane lines through somaclonal variation is one of the earliest and most successful commercial applications of the technology. The name 'Scarlet' might be a specific cultivar from such a program. Given the context, this is the most plausible correct answer representing a major success story of somaclonal variation in crop improvement.

Step 3: Final Answer:
The development of disease-resistant sugarcane varieties is a classic example of the successful application of somaclonal variation, making 'Sugarcane - Scarlet' the most likely correct combination.

Quick Tip

For exam questions on applications of biotechnology, remember the "poster child" examples. For somaclonal variation, the most famous success story is **disease resistance in sugarcane**. This association will help you identify the correct option even if the specific cultivar name is less familiar.

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47. K. J. Kasha and coworkers found that following the cross between *Hordeum vulgare* X *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 biological process for producing haploid plants. It involves a cross between two different species, followed by a unique event where the chromosomes from one parent are lost during early embryo development. We need to identify the correct term for this overall technique.

Step 2: Detailed Explanation:
Let's break down the process described:
- **Cross between *Hordeum vulgare* (barley) and *Hordeum bulbosum*:** This is a cross between two different species. Such a cross between individuals from different species or genera is known as **distant hybridization** or wide crossing.
- **Chromosomes of *H. bulbosum* were eliminated:** After fertilization, a zygote is formed containing chromosomes from both parents. However, during the first few cell divisions of the embryo, the entire set of chromosomes from *H. bulbosum* is selectively discarded.
- **Embryos can be cultured to get haploids:** The resulting embryo now contains only the chromosome set from *Hordeum vulgare*, making it a haploid embryo. This embryo is then "rescued" using embryo culture techniques before it aborts, and grown into a haploid barley plant.

This entire process, where haploidy is achieved through a wide cross followed by chromosome elimination, is a well-established method. The overarching term for the initial step that enables this phenomenon is **distant hybridization**.
- **Delayed pollination** is an unrelated technique.
- **Nucellus culture** is a method for producing clones, not haploids.
- **Androgenesis** is the production of haploids from male gametes (pollen), which is a different mechanism.

Step 3: Final Answer:
The method described, involving a cross between two different species followed by chromosome elimination to produce haploids, is a specific application of distant hybridization.

Quick Tip

Remember that "distant hybridization" or "wide crossing" can have several outcomes. One of the most important in biotechnology is **haploid production via chromosome elimination**, famously known as the "Bulbosum method" in barley breeding.

---

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:
This question asks for the purpose of the antisense RNA technique, a tool in molecular biology. The key is to understand how an "antisense" molecule interacts with the normal "sense" molecule involved in gene expression. The central dogma of molecular biology states that a gene (DNA) is transcribed into messenger RNA (mRNA), which is then translated into a protein.

Step 2: Detailed Explanation:
- The normal mRNA molecule that carries the genetic code from the nucleus to the ribosome is called the **"sense" strand**.
- **Antisense RNA** is a single-stranded RNA molecule that is complementary in sequence to the sense mRNA.
- When an antisense RNA molecule is introduced into a cell, it can bind to its complementary sense mRNA molecule, forming a double-stranded RNA hybrid.
- This double-stranded RNA molecule cannot be translated by the ribosome. Additionally, the cell often recognizes this double-stranded RNA as foreign and degrades it.
- The overall result is that the protein encoded by that specific mRNA is not produced. This effectively **silences** or **knocks down** the expression of that particular gene.

This technique was famously used to create the Flavr Savr tomato, where the expression of the gene for polygalacturonase (an enzyme that softens the fruit) was silenced, leading to delayed ripening.
The other options are incorrect:
- It does not enhance gene expression; it does the opposite.
- It is a method to control gene expression, not a method for gene transfer.
- It is unrelated to DNA fingerprinting, which is a technique for identifying individuals based on their DNA profiles.

Step 3: Final Answer:
The antisense RNA technique is used to silence the expression of a specific gene.

> Quick Tip
>
> Think of it like this: The mRNA is a "message" that the cell needs to read. Antisense RNA is a complementary message that sticks to the original, scrambling it and making it unreadable. This **silences** the message.

---

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:
This question asks for the specific term used to describe a method of pest and pathogen control that relies on using other living organisms. This approach is a cornerstone of integrated pest management (IPM) and is considered an environmentally friendly alternative to synthetic pesticides.

Step 2: Detailed Explanation:
Let's define the different types of control methods:
1. **Physical Control:** This involves using mechanical or physical barriers and traps to manage pests. Examples include using screens to keep insects out, tilling the soil to disrupt pest life cycles, or using heat treatment to kill pathogens.
2. **Biological Control (or Biocontrol):** This is the correct answer. It is the use of one living organism (the "natural enemy") to control the population of another (the "pest" or "pathogen"). The question specifically mentions using **natural predators**, which is a classic example of biological control. Other examples include using parasitoids (insects that lay eggs in other insects) or pathogens (like bacteria or fungi) that specifically target the pest species.
3. **Chemical Control:** This involves the use of synthetic or naturally derived chemicals (pesticides, fungicides, herbicides) to kill or inhibit pests and pathogens.
4. **Enzymatic Control:** This is not a standard category of pest control. While some biocontrol agents might use enzymes to attack pathogens, the overall strategy of using a living organism is classified as biological control.

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

Quick Tip

Remember the core idea: **Bio**logical control uses **bio**logy (life) to control other life. For example, using ladybugs (a living organism) to control aphids (a living pest) is biological control.

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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 question asks for the optimal pH range for the successful in vitro culture of plant protoplasts. Protoplasts are plant cells that have had their cell walls removed, making them very fragile. The pH of the culture medium is a critical parameter that affects membrane stability, nutrient uptake, and overall cell viability.

Step 2: Detailed Explanation:
The culture media for most plant tissues, including calli, shoots, and protoplasts, are generally slightly acidic. A pH that is too low (highly acidic) or too high (alkaline) can damage cell membranes and inhibit the function of enzymes and nutrient transporters.
For plant protoplast culture specifically, the established optimal pH range is typically between **5.5 and 5.9**. This slightly acidic condition is found to be most favorable for:
- Maintaining the integrity and stability of the plasma membrane of the fragile protoplasts.
- Facilitating the efficient uptake of nutrients from the medium.
- Supporting the regeneration of a new cell wall, which is the first crucial step towards cell division and callus formation.

Let's look at the other ranges:
- 4.5 to 4.9 is generally too acidic and can be detrimental to the cells.
- 6.5 to 7.0 is approaching neutral, which is suboptimal for most plant tissue cultures.
- 7.5 to 7.9 is alkaline and would be harmful to the protoplasts.

Step 3: Final Answer:
The optimum pH for protoplast culture is in the slightly acidic range of 5.5 to 5.9.

Quick Tip

Remember that most standard plant tissue culture media (like MS medium) are adjusted to a pH of around **5.7 to 5.8** before autoclaving. This value falls squarely in the 5.5 to 5.9 range and is a good number to remember for almost all plant tissue culture applications.

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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 different types of plant tissue culture techniques (List-I) with their primary application or use in biotechnology and agriculture (List-II).

Step 2: Detailed Explanation:
Let's analyze and match each culture type:
- **A. Embryo culture:** This technique is often used in plant breeding to rescue embryos from wide crosses that would normally abort due to endosperm incompatibility. By rescuing the embryo and growing it in vitro, a hybrid plant can be obtained. This allows breeders to make crosses that would otherwise fail, thereby **shortening the breeding cycle** by overcoming breeding barriers. This matches with **III**.
- **B. Meristem culture:** As discussed previously, the apical meristem of a plant is typically free of viruses. Culturing this small piece of tissue is the standard method for producing **virus-free plants** from an infected parent stock. This is a direct match with **IV**.
- **C. Protoplast culture:** Protoplasts (cells without walls) are the starting material for **somatic hybridization**, where protoplasts from two different species are fused to create a hybrid. Culturing these fused protoplasts is essential to regenerate a whole hybrid plant. This matches with **I**.
- **D. Anther culture:** This is the primary technique for androgenesis, which is the development of plants from pollen grains. Since pollen grains are male gametes and are haploid, this

technique is used for the **production of haploids**. This is a perfect match with **II**.

Combining these matches, we get:
A $\rightarrow$ III
B $\rightarrow$ IV
C $\rightarrow$ I
D $\rightarrow$ II

Step 3: Final Answer:
The correct set of matches is A-III, B-IV, C-I, D-II, which corresponds to option (D).

Quick Tip

Create mental links for these techniques: **Meristem** $\rightarrow$ **Virus-free** (meristems outrun viruses). **Anther/Pollen** $\rightarrow$ **Haploid** (from male gametes). **Protoplast** $\rightarrow$ **Fusion/Somatic Hybridization** (naked cells can fuse). **Embryo** $\rightarrow$ **Rescue** (save babies from bad crosses).

---

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:
This question asks for the definition of a prion, which is a unique type of infectious agent, distinct from bacteria, viruses, and fungi. The name itself provides a clue to its composition.

Step 2: Detailed Explanation:
The term "prion," coined by Stanley Prusiner, is a portmanteau of "**pro**teinaceous **in**fectious particle".
- Prions are essentially misfolded versions of a normal host protein (called PrP^{C}).
- This misfolded form (called PrP^{Sc}) is infectious because it can induce other, correctly folded PrP^{C} proteins to change their conformation and become misfolded as well.
- This sets off a chain reaction, leading to the accumulation of these abnormal, aggregated proteins in the brain, which causes neurodegenerative diseases like Creutzfeldt-Jakob disease in humans, scrapie in sheep, and bovine spongiform encephalopathy ("mad cow disease") in cattle.

- Critically, prions are composed solely of protein and contain no nucleic acid (DNA or RNA) genome. This makes them unique among infectious agents.

Let's look at the other options:
- **DNA without protein coat:** This describes a plasmid or a similar naked DNA molecule, not a prion.
- **RNA without protein coat:** This is the definition of a **viroid**, an infectious agent that affects plants.
- **Protozoans:** These are unicellular eukaryotic organisms, like amoeba or paramecium. They are complete cells, far more complex than prions.

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

Quick Tip

Break down the word: **PRION** = **PRO**teinaceous **IN**fectious particle. This directly gives you the definition. Also, distinguish it from a **Viroid**, which is an infectious RNA particle.

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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 question asks for the meaning of the acronym "CPW" as it is used in the context of plant protoplast culture. This is a specific piece of terminology related to the solutions and media used in the laboratory procedure.

Step 2: Detailed Explanation:
In protoplast isolation and culture, after the initial enzymatic digestion to remove the cell walls, the resulting protoplasts are very fragile and need to be carefully handled. They must be separated from the debris of the original tissue and the enzyme solution. This is done by a series of washing and centrifugation steps.
Special washing solutions are used for this purpose to maintain the osmotic balance and prevent the protoplasts from bursting. One such widely used salt solution is called **CPW salt solution**. The acronym CPW stands for the last names of the scientists who developed it:

Cocking, **P**ower, and **W**eakley.
Therefore, CPW refers to a specific formulation of a salt solution used for **Cell and Protoplast Washing**. It is designed to be isotonic and non-toxic to the delicate protoplasts. The other options are incorrect interpretations of the acronym.

Step 3: Final Answer:
CPW stands for a salt solution used for Cell and Protoplast Washing.

Quick Tip

While you might not always know the origin of every acronym, in tissue culture, many acronyms refer to either media formulations (like MS for Murashige and Skoog) or specific solutions. In the context of handling delicate cells like protoplasts, "Washing" is a very common and critical step, making "Cell and Protoplast Washing" the most logical choice.

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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:
Western blotting (or immunoblotting) is a core technique in molecular biology used to detect a specific protein in a complex mixture of proteins. It involves separating proteins by size, transferring them to a solid support, and then using an antibody to detect the protein of interest. This question asks for the correct chronological sequence of the main steps in this technique.

Step 2: Detailed Explanation:
Let's arrange the steps in the logical order of the experiment:
1. **D. Protein denaturation in loading dye.:** This is the very first step of sample preparation. The protein sample is mixed with a loading buffer (dye) that contains a detergent like SDS (sodium dodecyl sulfate) and a reducing agent. This mixture is usually heated. The SDS

denatures the proteins, giving them a uniform negative charge, and the reducing agent breaks disulfide bonds. This ensures that proteins will separate based only on their size, not their shape or charge.
2. **A. Protein resolution by PAGE:** The denatured protein samples are loaded into the wells of a polyacrylamide gel. An electric field is applied (**P**oly**A**crylamide **G**el **E**lectrophoresis - PAGE), causing the negatively charged proteins to migrate through the gel towards the positive electrode. Smaller proteins move faster and further than larger proteins, thus separating the proteins by size.
3. **C. Transfer onto nitrocellulose membrane:** The separated proteins are invisible and trapped inside the fragile gel. To make them accessible for antibody detection, they are transferred (blotted) from the gel onto a solid support, which is typically a nitrocellulose or PVDF membrane. This creates a stable replica of the protein separation pattern from the gel.
4. **B. Primary antibody binding:** The membrane is then incubated with a solution containing a **primary antibody**. This antibody is specifically chosen because it recognizes and binds only to the target protein of interest. After this, a secondary antibody (linked to a detection enzyme) is added, which binds to the primary antibody, allowing for visualization of the target protein band. The binding of the primary antibody is the key detection step.

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

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

Quick Tip

Remember the Western Blot workflow with the mnemonic **S-T-D** (Separation, Transfer, Detection), but with sample prep first: **Prep** (Denature - D) $\rightarrow$ **Separate** (PAGE - A) $\rightarrow$ **Transfer** (Blot - C) $\rightarrow$ **Detect** (Antibody - B).

---

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:
This question addresses a fundamental aspect of the biology of cyanobacteria (blue-green algae). Many species of cyanobacteria can perform both oxygenic photosynthesis (which produces

oxygen) and nitrogen fixation (which is inhibited by oxygen). To solve this conflict, filamentous cyanobacteria have evolved specialized cells to carry out nitrogen fixation. The question asks to identify these specialized cells.

Step 2: Detailed Explanation:
Let's examine the different cell types and structures listed:
1. **Heterocyst:** This is the correct answer. A heterocyst is a specialized, thick-walled cell found in the filaments of some cyanobacteria, such as *Nostoc* and *Anabaena*. These cells are the exclusive sites of nitrogen fixation. They have several adaptations to protect the oxygen-sensitive nitrogenase enzyme:
- They have a thick cell wall that limits the diffusion of oxygen into the cell.
- They lack Photosystem II, the part of the photosynthetic machinery that produces oxygen.
- They have a high rate of respiration to consume any oxygen that does enter.
They are connected to neighboring vegetative cells, from which they receive carbohydrates and to which they supply fixed nitrogen.
2. **Akinetes:** These are thick-walled, dormant resting spores that allow the cyanobacteria to survive harsh environmental conditions. They are not involved in nitrogen fixation.
3. **Nodules:** Nodules are specialized structures found on the **roots of leguminous plants**, where symbiotic bacteria like *Rhizobium* fix nitrogen. They are not a part of the cyanobacterium itself.
4. **Hormogonia:** These are short, motile filaments that break off from the main filament and are involved in vegetative reproduction and dispersal. They do not typically fix nitrogen.

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

Quick Tip

Associate **Heterocyst** with nitrogen fixation in cyanobacteria. The heterocyst is an anaerobic factory for the nitrogenase enzyme, existing within an oxygen-producing filament.

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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 a technology designed for the mass propagation of plants that are difficult to propagate by conventional seeds. The core idea is to use a somatic embryo (an embryo produced in vitro from somatic cells) as the "embryo" of the seed and then coat it with a protective, gel-like substance that acts as an artificial seed coat and endosperm. This question asks for the chemical commonly used as this coating agent.

Step 2: Detailed Explanation:
The most widely used and effective encapsulating agent for producing synthetic seeds is **sodium alginate**.
The process works as follows:
1. Somatic embryos are produced in large numbers via tissue culture.
2. They are mixed into a solution of sodium alginate.
3. Droplets of this mixture, each containing a somatic embryo, are then extruded into a solution of calcium chloride ($CaCl_2$).
4. The calcium ions (Ca^{2+}) cause the sodium alginate to cross-link and polymerize, forming a solid, insoluble gel of calcium alginate around the embryo.
This creates a small, manageable bead that protects the embryo and can be handled and planted much like a real seed. The gel matrix can also be enriched with nutrients, growth regulators, and protective agents.
The other sodium salts listed do not have this gelling property and are simple salts, not suitable for encapsulation.

Step 3: Final Answer:
Synthetic seeds are produced by encapsulating somatic embryos with sodium alginate.

Quick Tip

Remember the key reaction for synthetic seeds: **Sodium alginate + Calcium chloride** $\rightarrow$ Calcium alginate gel. This is the same gelling principle used in molecular gastronomy to make small spheres or "caviar."

---

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:
This question concerns the role of plant hormones (phytohormones) in controlling development and differentiation in plant tissue culture, specifically in the process of organogenesis. The two most important classes of hormones for this are auxins and cytokinins. The balance between these two hormones is the critical factor that directs the undifferentiated callus cells to form specific organs.

Step 2: Detailed Explanation:
The classic model of hormonal control of organogenesis from callus was established by Skoog and Miller. They demonstrated that the **ratio of auxin to cytokinin** in the culture medium determines the developmental outcome:
- **High Auxin-to-Cytokinin Ratio:** A relatively higher concentration of auxin compared to cytokinin promotes the formation of roots. This is called **rhizogenesis**.
- **High Cytokinin-to-Auxin Ratio:** A relatively higher concentration of cytokinin compared to auxin promotes the formation of shoots. This is called **caulogenesis**.
- **Intermediate Ratio:** An intermediate or balanced ratio of the two hormones typically promotes the proliferation of undifferentiated callus.

Therefore, a higher concentration of cytokinin generally promotes **shoot regeneration**. Leaf primordia would develop from the shoot apical meristem after the shoot itself is initiated. Flower initiation is a more complex process and is not the primary outcome of a high cytokinin level in this context.

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

Quick Tip

A simple mnemonic to remember the hormone effects: **A**uxin = **A**dventitious roots (promotes rooting from the bottom). **C**ytokinin = **C**ell division and shoots (promotes growth at the top). So, High Cytokinin → Shoots. High Auxin → Roots.

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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:
This question asks for the specific chemical agent that is standardly used in plant breeding and biotechnology to induce polyploidy, specifically to double the chromosome number of haploid cells to create fertile, homozygous diploid plants (doubled haploids).

Step 2: Detailed Explanation:
Let's analyze the options:
1. **Sorbitol** and 4. **Mannitol**: These are sugar alcohols. In plant tissue culture, they are primarily used as **osmotic agents** or osmolytes. They are added to the culture medium to increase its osmotic potential, which is particularly important for preventing the bursting of fragile cells like protoplasts. They are also sometimes used as a carbon source, but they do not induce chromosome doubling.
2. **Mannose**: This is a simple sugar (a monosaccharide). It can be used as a carbon source in some media but is not a chromosome doubling agent.
3. **Colchicine**: This is the correct answer. Colchicine is an alkaloid extracted from the autumn crocus (*Colchicum autumnale*). It is a potent **mitotic inhibitor** or "spindle poison." It acts by binding to tubulin, the protein subunit of microtubules. This prevents the formation of the spindle fibers that are necessary to separate the sister chromatids during anaphase of mitosis. As a result, the cell undergoes chromosome replication, but the duplicated chromosomes fail to segregate into two daughter cells. When the cell re-enters interphase, it has double the original number of chromosomes (e.g., n $\rightarrow$ 2n). This property makes it the most widely and effectively used chemical for chromosome doubling in plants.

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

Quick Tip

Associate **Colchicine** directly with **Chromosome doubling**. It is the classic and most famous chemical for this purpose. It works by breaking the mitotic spindle, trapping the cell with a duplicated set of chromosomes.

---

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:
This question asks to identify the strategies that form the basis of *in vivo* haploid induction. The key phrase here is "*in vivo*," which means "within the living." This distinguishes these methods from *in vitro* techniques, which are performed in a lab setting (e.g., in a test tube or culture dish).

Step 2: Detailed Explanation:
Let's analyze each strategy in the context of *in vivo* vs. *in vitro*:
- **A. Induction of parthenogenesis:** Parthenogenesis is the development of an embryo from an unfertilized egg cell. This occurs *in vivo* within the ovule on the parent plant and results in a haploid embryo. This is an *in vivo* strategy.

- **B. culture of anthers or ovules:** This is the very definition of an *in vitro* technique. It involves excising plant parts and growing them in an artificial laboratory environment. Therefore, this strategy does **not** form the basis of *in vivo* haploid induction.

- **C. use of paternal inducer lines:** This is a cornerstone of modern *in vivo* haploid induction, particularly in maize. Special "inducer" lines are used as the pollen parent in a cross. When these lines fertilize a normal plant, they induce the development of a haploid embryo from the egg cell (parthenogenesis) while the hybrid zygote aborts. The entire process happens *in vivo* on the mother plant.

- **D. uniparental genome elimination:** This is the mechanism behind haploid induction through distant hybridization (the Bulbosum method) and is also a proposed mechanism for how inducer lines work. After fertilization occurs *in vivo*, the genome of one parent (usually the paternal one from the inducer line or distant species) is selectively eliminated from the zygote, leaving a haploid embryo. This is an *in vivo* event.

Therefore, the strategies that are part of *in vivo* technologies are parthenogenesis induction, the use of inducer lines, and uniparental genome elimination. Strategy B is *in vitro*.

Step 3: Final Answer:
The correct combination of strategies for *in vivo* haploid induction is A, C, and D.

Quick Tip

The key to this question is the distinction between *in vivo* (on the plant) and *in vitro* (in the lab). Anther/ovule culture is the classic *in vitro* method. The use of special "inducer" lines to create haploid seeds directly on the plant is the modern *in vivo* method.

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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). This tests knowledge of the microbiology of the nitrogen cycle.

Step 2: Detailed Explanation:
Let's match each process with the correct bacterium:
- **A. Biological nitrogen fixation:** This is the conversion of N_2 gas to ammonia. The classic example of a bacterium that does this in symbiosis with legumes is ***Rhizobium***. This matches with **III**.

- **B. Conversion of ammonia to nitrite:** This is the first step of nitrification. It is carried out by ammonia-oxidizing bacteria. The most common example given for this process is the genus ***Nitrosomonas***. This matches with **IV**.

- **C. Conversion of nitrite to nitrate:** This is the second step of nitrification. It is carried out by nitrite-oxidizing bacteria. The classic textbook example for this process is the genus ***Nitrobacter***. This matches with **I**.

- **D. Denitrification:** This is the anaerobic conversion of nitrate back to N_2 gas. This process is carried out by a wide range of facultative anaerobic bacteria. A common example of a denitrifying bacterium is ***Paracoccus denitrificans***. This matches with **II**.

Combining these matches, we get:
A $\rightarrow$ III
B $\rightarrow$ IV
C $\rightarrow$ I
D $\rightarrow$ II

Step 3: Final Answer:
The correct set of matches is A-III, B-IV, C-I, D-II, which corresponds to option (B).

Quick Tip

To master the nitrogen cycle bacteria: - Fixation: *Rhizobium* (symbiotic), *Azotobacter* (free-living) - Nitrification (Step 1: $NH_3 \rightarrow NO_2^-$): *Nitrosomonas* - Nitrification (Step 2: $NO_2^- \rightarrow NO_3^-$): *Nitrobacter* - Denitrification: *Pseudomonas*, *Paracoccus* Commit these key players to memory.

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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 is the process of removing the plant cell wall to get a "naked" plant cell. This requires a cocktail of enzymes that can digest the different components of the cell wall. The plant cell wall is primarily composed of cellulose, hemicellulose, and pectin. This question asks to correctly match one of the digestive enzymes with its common commercial source.

Step 2: Detailed Explanation:
Let's analyze each option:
1. **Cellulase - *Helix pomatia*:** Cellulase is the enzyme that digests cellulose. While some sources might mention the gut of snails like *Helix pomatia* as containing cellulases, the most common and popular commercial sources of cellulase for plant tissue culture are fungi, particularly species like ***Trichoderma viride*** or ***Aspergillus niger***. So this combination is not

the most popular one.
2. **Hemicellulase - *Tricoderma viride*:** Hemicellulase digests hemicellulose. Fungi are excellent producers of a wide range of cell wall degrading enzymes. ***Trichoderma viride*** is indeed a very common and popular industrial source for both cellulase and hemicellulase. This is a correct combination.
3. **Macerozyme R - 10 - *Rhizopus arrhizus*:** Macerozyme is a commercial enzyme preparation rich in pectinase, which digests the middle lamella's pectin, thus macerating the tissue and separating the cells. The common source for Macerozyme is not *Rhizopus arrhizus*, but rather another fungus. *Rhizopus* is more commonly associated with other enzymes.
4. **Zymolyase - *Aspergillus niger*:** Zymolyase is a commercial name for an enzyme preparation that is particularly effective at lysing yeast cell walls (which are made of glucans and chitin), not primarily plant cell walls. While *Aspergillus niger* is a source for many enzymes, Zymolyase is typically sourced from *Arthrobacter luteus*.

Based on the common knowledge of commercial enzyme sources for plant biotechnology, the most accurate and popular combination listed is Hemicellulase from *Trichoderma viride*.

Step 3: Final Answer:
The correct combination is Hemicellulase sourced from the fungus *Tricoderma viride*.

Quick Tip

When thinking about industrial enzymes for digesting plant matter (cellulase, hemicellulase, pectinase), the fungi ***Trichoderma*** and ***Aspergillus*** are the most frequent and important sources. Remembering this general rule can help you identify the most plausible answer.

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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 (Note: There is a likely error in the intended question and options. Logical solution provided below)

Solution:

Step 1: Understanding the Concept:
This question asks to match categories of biocontrol agents or related terms (List-I) with specific examples (List-II). Biological control involves using living organisms to manage pests.

Step 2: Detailed Explanation:
Let's analyze the lists and find the logical matches. There seems to be an error in the question's premise as presented in the options, but let's find the best possible matches first.
- **A. Bacterium:** A bacterium used in biocontrol. *Bacillus thuringiensis* (I) is a bacterium. *Clostridium* (II) is also a bacterium. So A could match I or II.
- **B. Fungus:** A fungus used in biocontrol. *Trichoderma* (III) is a well-known biocontrol fungus used against pathogenic fungi. This is a strong match: B $\rightarrow$ III.
- **C. Insect:** An insect. Cotton aphid (IV) is an insect, but it is a **pest**, not a biocontrol agent. A biocontrol insect would be something like a ladybug. This part of the question is flawed. If we assume it's just asking for an example of an insect, then C $\rightarrow$ IV.
- **D. Biopesticide:** A pesticide derived from a natural source. The insecticidal Cry protein from *Bacillus thuringiensis* is the most famous example of a biopesticide. This is a very strong match: D $\rightarrow$ I.

Now let's reconstruct based on the strongest matches:
B $\rightarrow$ III (*Trichoderma* is a biocontrol fungus)
D $\rightarrow$ I (*Bacillus thuringiensis* is the source of a major biopesticide)

This leaves us with A (Bacterium) and C (Insect) to match with II (*Clostridium*) and IV (Cotton aphid).
- A (Bacterium) could match II (*Clostridium*). Some species of *Clostridium* are studied for biocontrol, though it's less famous than Bt.
- C (Insect) must match IV (Cotton aphid), as it's the only insect listed.

So a logical pairing is: A-II, B-III, C-IV, D-I. Let's check the options. Option (C) is A-II, B-III, C-IV, D-I. This perfectly aligns with our logical deduction.

Revisiting the strong matches: - A. Bacterium $\rightarrow$ II. *Clostridium* - B. Fungus $\rightarrow$ III. *Trichoderma* - C. Insect $\rightarrow$ IV. Cotton aphid - D. Biopesticide $\rightarrow$ I. *Bacillus thuringiensis* (The bacterium itself is the source of the biopesticide).

This combination A-II, B-III, C-IV, D-I is present as option (C).

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

Quick Tip

In matching questions, identify the most certain and unambiguous pairs first. Here, *Trichoderma* as a fungus (B-III) and Bt as a biopesticide (D-I) are very strong links. Use these to navigate the options. Be aware that questions can sometimes be flawed (e.g., listing a pest as an example for a biocontrol agent category).

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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:
Polymerase Chain Reaction (PCR) is a laboratory technique used to make millions to billions of copies of a specific target DNA sequence. The question asks for the specific name given to these copies that are produced during the reaction.

Step 2: Detailed Explanation:
The core function of PCR is to **amplify** a target DNA segment. The word "amplify" in this context means to greatly increase the number of copies. The product of this amplification process is a massive population of identical DNA fragments, all corresponding to the original target sequence.
The technical term for these product DNA molecules is **amplicons**. The word is derived from the phrase "amplified-icon," meaning an identical copy that has been amplified.
The other terms are distractors and not standard terminology in molecular biology:
- Multicons, Polycons, and Monocons are not used to describe PCR products.

Step 3: Final Answer:
The copies of DNA strands generated during a PCR are known as amplicons.

Quick Tip

Connect the verb to the noun: The process is called DNA **ampli**fication. The product is called an **ampli**con.

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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:
This question delves into the molecular genetics of the shoot apical meristem (SAM) in plants. The SAM is a small region of undifferentiated cells at the tip of the shoot that is responsible for all above-ground growth. Its size and activity are tightly controlled by a feedback loop involving several key genes. The *WUSCHEL* (*WUS*) gene is a central player that promotes stem cell identity. The question asks which gene acts to restrict or negatively regulate *WUS*.

Step 2: Detailed Explanation:
The maintenance of the stem cell population in the SAM is governed by a negative feedback loop between the *WUSCHEL* (*WUS*) gene and the *CLAVATA* (*CLV*) signaling pathway.
- ***WUS*** is expressed in the organizing center (OC), a small group of cells below the stem cells. The WUS protein moves up into the stem cell layer and promotes their identity and proliferation.
- As the stem cell population grows, it leads to increased expression of the *CLAVATA3* (*CLV3*) gene. *CLV3* encodes a small signaling peptide.
- This CLV3 peptide diffuses back down and binds to a receptor complex in the OC, which includes the proteins CLV1 and CLV2.
- This binding of CLV3 to its receptor initiates a signaling cascade that ultimately **represses** or **negatively regulates** the expression of the *WUS* gene.
- As *WUS* expression decreases, the signal to produce more stem cells weakens, and the size of the meristem is kept in check.

This *WUS-CLV* feedback loop is a classic example of developmental regulation. Therefore, the *CLV* genes negatively regulate *WUS* expression.
The other genes have different roles:
- ***STM* (*SHOOT MERISTEMLESS*):** is a master regulator required for the very formation and maintenance of the SAM, but it does not act as the primary negative regulator of *WUS* in this loop.
- ***AP1* (*APETALA1*):** is a floral meristem identity gene involved in the transition to flowering.
- ***TAB1*** is not a standard gene in this core pathway.

Step 3: Final Answer:
The *CLAVATA* (*CLV*) gene pathway negatively regulates *WUS* expression in the shoot apical

meristem.

Quick Tip

Remember the SAM feedback loop: ***WUS*** promotes stem cells → More stem cells make more ***CLV3*** → ***CLV3*** signals back to inhibit ***WUS***. It's a perfect self-regulating system to maintain meristem size.

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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 DH5	III.	epspr 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 (Note: There is a likely error in the intended question, specifically with B and III. The most logical solution is provided.)

Solution:

Step 1: Understanding the Concept:
This question requires matching specific organisms (List-I) with their key contribution or use in the field of biotechnology (List-II).

Step 2: Detailed Explanation:
Let's match each organism with its primary biotechnological use:
- **A. *Thermus aquaticus*:** This is a thermophilic bacterium that lives in hot springs. Its major contribution to biotechnology is being the source of a heat-stable **DNA polymerase** called *Taq* polymerase. This enzyme's ability to withstand high temperatures is what made the Polymerase Chain Reaction (PCR) possible. This is a very strong match: A → II.

- **B. *Agrobacterium tumefaciens*:** This bacterium is the "natural genetic engineer" used to create transgenic plants. One of the most important traits introduced into plants is herbicide resistance. The ***epsps* gene** (note the typo in the question, should be *epsps*) provides resistance to the herbicide glyphosate (Roundup). This gene is often transferred into plants using *Agrobacterium*. So, this is a plausible, though indirect, match: B → III.

- **C. *E. coli* DH5:** This is a specific laboratory strain of *E. coli* that is engineered to be highly efficient for transformation and replication of plasmids. It is the workhorse host organism for routine **DNA cloning** and plasmid amplification. This is a very strong match: C $\rightarrow$ IV.

- **D. *Bacillus thuringiensis* (Bt):** As established previously, this bacterium is the source of the insecticidal **Cry proteins**, which are used as biopesticides and in transgenic Bt crops. This is a very strong match: D $\rightarrow$ I.

Combining the most logical matches:
A $\rightarrow$ II
B $\rightarrow$ III (associating the vector with the gene it often carries)
C $\rightarrow$ IV
D $\rightarrow$ I

This combination, A-II, B-III, C-IV, D-I, is listed as option (B).

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

Quick Tip

For biotechnology questions, memorize the "star organism" for each major technique: - **PCR** $\rightarrow$ *Thermus aquaticus* (*Taq* polymerase) - **Cloning Host** $\rightarrow$ *E. coli* (e.g., DH5) - **Plant Transformation** $\rightarrow$ *Agrobacterium tumefaciens* - **Insect Resistance** $\rightarrow$ *Bacillus thuringiensis* (Cry proteins)

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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 requires matching the names of four major blotting techniques used in molecular biology with the type of molecule they are designed to detect. The names (Southern, Northern, Western) are a classic source of confusion, but a simple mnemonic can help.

Step 2: Detailed Explanation:
Let's define each blotting technique:
- **B. Southern blotting:** This was the first blotting technique, developed by Edwin Southern. It is used **to detect a specific DNA sequence** in a complex mixture of DNA. The name of the founder is the key here. This matches with **IV**.
- **A. Northern blotting:** Named as a pun on "Southern," this technique is analogous to Southern blotting but is used **to detect a specific RNA molecule** in a mixture of RNA. It is often used to study gene expression by measuring the amount of a specific mRNA. This matches with **III**.
- **C. Western blotting:** Continuing the geographic joke, this technique is used **to detect specific proteins** in a sample. It uses antibodies to identify the target protein after separation by gel electrophoresis. This matches with **I**.
- **D. Eastern blotting:** This is a less common technique, but it is used to analyze protein post-translational modifications (PTMs). It involves separating proteins and then using probes that can detect specific modifications like glycosylation or phosphorylation. Therefore, it is used for the **detection of specific post-translational modifications of proteins**. This matches with **II**.

Combining these matches, we get:
A $\rightarrow$ III
B $\rightarrow$ IV
C $\rightarrow$ I
D $\rightarrow$ II

Step 3: Final Answer:
The correct set of matches is A-III, B-IV, C-I, D-II, which corresponds to option (B).

Quick Tip

Use the mnemonic **SNoW DRoP**: - **S**outhern $\rightarrow$ **D**NA - **N**orthern $\rightarrow$ **R**NA - **W**estern $\rightarrow$ **P**rotein This will help you keep the three main blotting techniques straight. Eastern is for post-translational modifications.

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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 in plants where the plant is unable to produce functional pollen. The term "cytoplasmic" is key, as it indicates that the genes responsible for this trait are located outside the nucleus, in the cytoplasm. The question asks to identify the specific organelle where these genes are found.

Step 2: Detailed Explanation:
The cytoplasm of a plant cell contains two main organelles with their own genomes: the mitochondria and the chloroplasts. Both are inherited maternally (through the egg cell's cytoplasm). Research has shown that in the vast majority of cases, Cytoplasmic Male Sterility is caused by specific novel genes or rearrangements that arise in the **mitochondrial genome**. These CMS-associated mitochondrial genes often produce unusual proteins that interfere with the normal development of the tapetum (a nutritive tissue in the anther) or the microspores themselves. This disruption prevents the formation of viable pollen, leading to male sterility.
While some cases of cytoplasmic inheritance involve the chloroplasts, CMS is overwhelmingly linked to the mitochondria. The nucleus contains "restorer of fertility" (Rf) genes that can counteract the effects of the CMS genes, but the CMS genes themselves are mitochondrial.
Peroxisomes do not have their own genome.

Step 3: Final Answer:
The genes causing cytoplasmic male sterility (CMS) are generally located in and transcribed from the mitochondrial genome.

Quick Tip

Remember the link: **CMS** → **C**ytoplasmic → **M**itochondria → Male **S**terility. The high energy demands of pollen development make the mitochondria a critical organelle, and defects in its genome can easily disrupt this process.

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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 tests knowledge of the history of biotechnology by asking to match key scientists with their landmark discoveries or contributions.

Step 2: Detailed Explanation:
Let's match each scientist with their famous contribution:
- **A. Karl Ereky:** A Hungarian agricultural engineer. In 1919, he is credited with having **coined the term 'Biotechnology'** to describe processes where raw materials are converted into more useful products with the help of living organisms. This matches with **II**.
- **B. Joshua Lederberg:** An American molecular biologist who won the Nobel Prize for his work on bacterial genetics. In 1952, he **discovered plasmids**, the small, circular extrachromosomal DNA molecules in bacteria, and called them "extrachromosomal inheritance factors." This matches with **III**.
- **C. Kary Mullis:** An American biochemist who received the Nobel Prize for his invention of the **Polymerase Chain Reaction (PCR)** technique in 1983. This method revolutionized molecular biology by allowing for the amplification of DNA. This matches with **IV**.
- **D. Sir Alec Jefferys:** A British geneticist who, in 1984, developed the techniques of genetic profiling, which he named **DNA fingerprinting**. This technique uses variations in DNA sequences (minisatellites) to identify individuals. This matches with **I**.

Combining these matches, we get:
A $\rightarrow$ II
B $\rightarrow$ III
C $\rightarrow$ IV
D $\rightarrow$ I

Step 3: Final Answer:
The correct set of matches is A-II, B-III, C-IV, D-I, which corresponds to option (A).

Quick Tip

For historical matching, create strong keyword associations: **Ereky** $\rightarrow$ Biotechnology (term). **Lederberg** $\rightarrow$ Plasmids. **Mullis** $\rightarrow$ PCR. **Jefferys** $\rightarrow$ DNA Fingerprinting. These are foundational names and discoveries in biotechnology.

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 concilia

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 (List-I) with their correct definitions (List-II).

Step 2: Detailed Explanation:
Let's define each term and find its match:
- **A. Protoplast:** A protoplast is a plant cell from which the cell wall has been completely removed, usually by enzymatic digestion. It is therefore a **naked cell**, bounded only by the plasma membrane. This matches with **III**.
- **B. Explant:** An explant is **any piece of plant tissue or organ** that is taken from the parent plant and used to initiate a culture in vitro. Examples include a piece of leaf, stem, root, or an anther. This matches with **IV**.
- **C. Totipotency:** This is a fundamental concept in plant biology. It is the inherent potential or **ability of a single, differentiated plant cell to develop and regenerate into a whole new plant** under suitable conditions. This matches with **I**.
- **D. Callus:** A callus is a growing mass of **unorganized, undifferentiated parenchyma cells** that is produced when an explant is cultured on a suitable medium, often in the presence of plant hormones. This matches with **II**.

Combining these matches, we get:
A $\rightarrow$ III
B $\rightarrow$ IV
C $\rightarrow$ I
D $\rightarrow$ II

Step 3: Final Answer:
The correct set of matches is A-III, B-IV, C-I, D-II, which corresponds to option (C).

Quick Tip

Master the basic vocabulary of plant tissue culture: - **Explant**: The STARTING material. - **Callus**: The UNORGANIZED growth. - **Protoplast**: The NAKED cell. - **Totipotency**: The POTENTIAL to become a whole plant.

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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 tissue culture and physiology (List-I) with their definitions or related chemical examples (List-II).

Step 2: Detailed Explanation:
Let's match each term in List-I:
- **A. Auxin:** This is a class of plant hormones that regulate cell elongation and root formation, among other things. The most important natural auxin is **Indole-3-Acetic Acid (IAA)**. This is a direct match with **III**.
- **B. Protoplast:** A protoplast is a plant cell without its cell wall. To isolate protoplasts, one must digest the cell wall. The middle lamella, which cements cells together, is made of pectin and is digested by the enzyme **Pectinase** (often found in Macerozyme). So, pectinase is an enzyme associated with protoplast isolation. This matches with **IV**.
- **C. Callus:** A callus is an **undifferentiated mass of cells** that grows from an explant in tissue culture. This is a direct definition match with **I**.
- **D. Cytokinin:** This is a class of plant hormones that promote cell division and shoot formation. **6-Furfurylaminopurine**, also known as Kinetin, was one of the first cytokinins to be discovered. It is a synthetic cytokinin widely used in tissue culture. This is a direct match with **II**.

Combining these matches, we get:
A $\rightarrow$ III
B $\rightarrow$ IV
C $\rightarrow$ I
D $\rightarrow$ II

Step 3: Final Answer:
The correct set of matches is A-III, B-IV, C-I, D-II, which corresponds to option (D).

Quick Tip

Memorize the chemical names of the primary natural auxin and a key cytokinin: - **Auxin = Indole-3-Acetic Acid (IAA)** - **Cytokinin = Kinetin (6-Furfurylaminopurine)** or Zeatin This knowledge is frequently tested.

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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.	Androgensis	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 various terms and techniques in plant tissue culture with their specific examples or associated methods.

Step 2: Detailed Explanation:
Let's match each term in List-I:
- **A. Gynogenesis:** This is the process of producing haploid plants from the female gametophyte. This is achieved by culturing unfertilized ovules or whole ovaries. Therefore, **Ovary culture** is a method of gynogenesis. This matches with **II**.
- **B. Culturing in liquid medium:** When plant cells or small aggregates are grown in a

constantly agitated liquid medium, the technique is known as a **Suspension culture**. This matches with **III**.
- **C. Androgenesis:** This is the process of producing haploid plants from the male gametophyte. This is achieved by culturing either whole anthers or isolated microspores, which is also known as **Pollen culture**. This matches with **IV**.
- **D. Culturing on agar medium:** When an explant is grown on a solid or semi-solid medium gelled with agar, it typically produces an unorganized mass of cells known as a callus. This is the basis of **Callus culture**. This matches with **I**.

Combining these matches, we get:
A $\rightarrow$ II
B $\rightarrow$ III
C $\rightarrow$ IV
D $\rightarrow$ I

Step 3: Final Answer:
The correct set of matches is A-II, B-III, C-IV, D-I, which corresponds to option (A).

Quick Tip

Remember the gender associations for haploid production: - **Andro**genesis = Male (from Greek 'andros' for man) $\rightarrow$ **Anther/Pollen** culture. - **Gyno**genesis = Female (from Greek 'gyno' for woman) $\rightarrow$ **Ovary/Ovule** culture. Also, Liquid medium = Suspension culture, Solid medium = Callus culture.

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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:
This question refers to a specific technique for haploid production known as the "bulbosum method," which was also described in a previous question (Q47). The method involves a distant cross between barley (*Hordeum vulgare*) and its wild relative (*Hordeum bulbosum*). The key to answering this question is understanding what happens to the chromosomes of the two

parents after fertilization.

Step 2: Detailed Explanation:
The "bulbosum method" works as follows:
1. A cross is made between a female plant (A), which is the crop species like *Hordeum vulgare*, and a male plant (B), which is the wild relative *Hordeum bulbosum*.
2. Fertilization occurs, and a zygote is formed. This initial zygote is a true hybrid, containing one set of chromosomes from A and one set from B. So, initially, it has homologous chromosomes of A and B.
3. However, during the very early cell divisions of this F_1 zygote, a process of **uniparental genome elimination** takes place. The chromosomes from the male parent B (*H. bulbosum*) are selectively and progressively eliminated from the dividing cells.
4. The resulting multicellular embryo, after a few divisions, will therefore contain **only the chromosomes of the female parent A**.
5. This embryo is haploid (since it only has the gametic set of chromosomes from the female parent) and must be rescued via embryo culture to develop into a plant.

Therefore, the multicellular embryo that is cultured will contain only the chromosomes of plant A. Recombinant chromosomes would only form after meiosis in a stable hybrid, which is not what happens here.

Step 3: Final Answer:
The F_1 multicellular embryo derived through the "bulbosum method" will contain only the chromosomes of the female parent (A).

Quick Tip

For the "bulbosum method" or any haploid induction via chromosome elimination, remember the key event: one parent's chromosomes are **eliminated** or **kicked out** after fertilization. The embryo that survives is left with only the chromosomes of the other parent (usually the desired crop species).

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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: (D) D, B, C, A

Solution:

Step 1: Understanding the Concept:
This question asks for the correct sequence of steps specifically for the process of fusing plant protoplasts using the chemical fusogen Polyethylene Glycol (PEG). This is a standard laboratory protocol, and arranging the steps requires understanding the role of each component and action.

Step 2: Detailed Explanation:
Let's analyze the steps and put them in a logical experimental order:
1. **D. Selection of protoplasts of different strains / species.:** Before any fusion can occur, you must first have the starting materials. This involves isolating and selecting the healthy protoplasts from the two parent plants that you wish to fuse. This is the initial step.

2. **B. Protoplast aggregation.:** The protoplasts are typically gently centrifuged to form a pellet at the bottom of the tube. This brings them into close physical contact, which is a prerequisite for fusion. The PEG solution is then added carefully to this pellet of aggregated protoplasts. So, aggregation comes after selection and before the main fusion treatment.

3. **C. Washing of protoplast (alkaline medium pH 9-10), and high Ca^{2+} concentration:** The high pH and high calcium ion concentration are critical components of the fusion buffer used during and after PEG treatment. The Ca^{2+} ions help to reduce the negative surface charge of the protoplasts, and the alkaline pH helps to induce membrane fusion. This step is performed to elute or wash away the PEG while the membranes are fusing. This step is concurrent with or immediately follows the PEG treatment.

4. **A. Treatment of protoplast mixture with 28-50% PEG for 15-30 minutes.:** This seems out of order. The PEG treatment (A) is what causes the aggregation (B) and membrane destabilization that leads to fusion. The high pH/Ca^{2+} solution (C) is used to wash out the PEG and complete the fusion process. Let's re-evaluate the sequence.
A more logical laboratory flow would be:
1. **D. Selection of protoplasts...** (Get your materials)
2. Mix the protoplasts and spin down to get aggregation. Then add PEG. **A. Treatment with PEG...**

3. The PEG itself causes further **B. Protoplast aggregation** and membrane instability.
4. Elute/wash the PEG with the high pH/high calcium solution to induce fusion and stabilize the cells. **C. Washing of protoplast...**

So the sequence should be D $\rightarrow$ A $\rightarrow$ B $\rightarrow$ C. This is option (B).
Let's re-examine the question and options, as sometimes the wording implies a different flow. Some protocols describe a distinct aggregation step before adding the main PEG solution. Let's consider the sequence D $\rightarrow$ B $\rightarrow$ A $\rightarrow$ C. 1. (D) Select protoplasts. 2. (B) Induce aggregation

by spinning them down or using a pre-fusion solution. 3. (A) Add the PEG solution to the aggregated protoplasts to induce fusion. 4. (C) Wash out the PEG with the elution buffer. This sequence D, B, A, C is not an option.
Let's consider the option given as correct: D, B, C, A. 1. (D) Select protoplasts. 2. (B) Protoplast aggregation. 3. (C) Washing of protoplast (alkaline medium...). 4. (A) Treatment with PEG... This sequence does not make sense, as the PEG treatment (A) should come before or during the washing step (C) that induces the final fusion. There appears to be a significant ambiguity or error in the question or options provided.
Let's try one more interpretation based on the given options. Let's assume the question lists general phenomena rather than strict procedural steps. (D) must be first. You need the protoplasts. After selection, what happens? Let's look at option (B) D,A,B,C.

D. Select protoplasts. $\rightarrow A. Treat with PEG. \rightarrow B. Aggregation occurs. \rightarrow C. Wash to finalize fusion.$

This is the most logical sequence.
Let's reconsider option D: D, B, C, A. D. Select. B. Aggregate. C. Wash with high pH/Ca++. A. Treat with PEG. This seems highly illogical.

Given the standard protocols, the most correct sequence of events is D, A, B, C. This is option (2). If we must choose from the options, and recognizing the ambiguity, let's review. Let's assume B (aggregation) happens before the main fusion-inducing steps. So D $\rightarrow B$.

The fusion itself is induced by PEG (A) and the subsequent elution with high pH/Ca++ (C). Logically, A comes before C. So D, B, A, C is the best sequence. This is not an option.

There is a high probability the question or options are flawed. Let's assume the correct answer key indicates (D). The sequence is D $\rightarrow$ B $\rightarrow$ C $\rightarrow$ A. This would mean: Select protoplasts $\rightarrow$ Aggregate them $\rightarrow$ Treat with high pH/Ca++ solution $\rightarrow$ Treat with PEG. This protocol is backwards. The high pH/Ca++ wash is for eluting the PEG.

Let's assume the intended answer is (B) D, A, B, C as it represents the most logical scientific process: 1. (D) Selection of protoplasts... 2. (A) Treatment with PEG... (This causes membranes to become fluid and stick) 3. (B) Protoplast aggregation (This is the visible result of PEG action) 4. (C) Washing... (This removes PEG and allows membranes to fuse and stabilize) This sequence is the most scientifically sound.

Step 3: Final Answer:
The most logical sequence of events for PEG-induced fusion is D (Selection), A (PEG Treatment), B (Aggregation), and C (Washing/Elution), which corresponds to option (B). The provided answer key may be flawed. Assuming option (B) is the intended answer.

Quick Tip

For procedural questions, think like a scientist in the lab. What do you need first? (The cells - D). What is the main chemical that causes the event? (PEG - A). What does that chemical do? (Causes aggregation - B). How do you finish the process? (Wash and stabilize - C). This D-A-B-C order is the most logical flow.

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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 scientists in the history of plant physiology and biotechnology with their significant discoveries or contributions.

Step 2: Detailed Explanation:
Let's match each scientist with their discovery:
- **A. Van Overbeek:** In 1941, Johannes van Overbeek made a crucial discovery for plant tissue culture. He found that adding **coconut water (liquid endosperm)** to the culture medium could stimulate the growth of very young embryos that would otherwise fail to develop. This was a major breakthrough in embryo culture. This matches with **II**.
- **B. Philip R. White:** P.R. White was a pioneer in plant tissue culture. In the 1930s, he developed one of the **first synthetic plant tissue culture media** (White's medium) with a defined chemical composition, which allowed for the long-term culture of excised roots. This matches with **III**.
- **C. Frits Went:** A Dutch biologist who, in the 1920s, conducted classic experiments with oat coleoptiles. He demonstrated that a chemical substance produced in the tip of the coleoptile was responsible for phototropic bending. He isolated this substance and named it auxin, which was later identified as Indole-3-Acetic Acid (IAA). He is credited with the discovery of the **first plant growth hormone**. This matches with **IV**.

- **D. Monsanto:** This is a large agrochemical and agricultural biotechnology company. They were pioneers in developing and commercializing genetically modified crops, including the **transgenic Bt-cotton** (Bollgard), which produces an insecticidal protein. This matches with **I**.

Combining these matches, we get:
A $\rightarrow$ II
B $\rightarrow$ III
C $\rightarrow$ IV
D $\rightarrow$ I

Step 3: Final Answer:
The correct set of matches is A-II, B-III, C-IV, D-I, which corresponds to option (D).

Quick Tip

Remember these historical links: - **Went** $\rightarrow$ **Went** looking for what makes plants bend $\rightarrow$ found **Auxin**. - **Van Overbeek** $\rightarrow$ **Overcame** embryo abortion $\rightarrow$ using **coconut water**. - **White** $\rightarrow$ Made a "clean" or **white** medium $\rightarrow$ first **synthetic medium**. - **Monsanto** $\rightarrow$ Major GMO company $\rightarrow$ **Bt-cotton**.

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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 terms and materials related to the technique of agarose gel electrophoresis of DNA with their correct descriptions or functions.

Step 2: Detailed Explanation:
Let's match each term in List-I:
- **A. Sea weeds:** Agarose, the polysaccharide that forms the gel matrix for separating DNA, is extracted from certain types of red **seaweeds**, such as those from the genera *Gracilaria* and *Gelidium*. Therefore, seaweeds are the **source of agarose**. This matches with **III**.
- **B. Staining of DNA:** After electrophoresis, the DNA fragments in the gel are invisible. To visualize them, the gel is soaked in a staining solution. The most common stain used is **Ethidium bromide (EtBr)**. EtBr intercalates between the DNA bases and fluoresces bright orange when exposed to UV light, revealing the position of the DNA bands. This matches with **IV**.
- **C. Elution:** This is a general term for the process of extracting or removing a substance from a solid matrix by washing it with a solvent. In this context, it specifically refers to the **isolation of a specific DNA fragment from an agarose gel slice** after electrophoresis. This matches with **I**.
- **D. Separation of DNA fragments:** The core principle of electrophoresis is to separate molecules based on size and charge in an electric field. The technique used to separate DNA fragments (usually after being cut by restriction enzymes) is **gel electrophoresis**. This matches with **II**.

Combining these matches, we get:
A $\rightarrow$ III
B $\rightarrow$ IV
C $\rightarrow$ I
D $\rightarrow$ II

Step 3: Final Answer:
The correct set of matches is A-III, B-IV, C-I, D-II, which corresponds to option (B).

Quick Tip

To remember the components of gel electrophoresis: - The **Gel** itself is **Agarose**, which comes from **Seaweed**. - The **Technique** is **Gel Electrophoresis**. - The **Stain** is **Ethidium Bromide**. - The **Extraction** process is **Elution**.