# Chapter 7

# Plant Tissue Culture

## EXERCISES

### 1. What is plant tissue culture?

**Ans:** Plant tissue culture is a collection of techniques used to grow and manipulate plant cells, tissues, or organs under controlled in vitro conditions. This means outside a living plant, typically in a laboratory environment using artificial nutrient media and specific environmental conditions. These techniques allow for:

***Propagation:** Producing multiple plants from a single explant (plant part), often faster and more efficiently than traditional methods like seeds.

***Selection:** Selecting for desired traits in plants by culturing specific tissues or manipulating genes.

***Conservation:** Preserving rare or endangered plants by storing and multiplying their tissues.

***Production of virus-free plants:** Eliminating viruses from plants by using meristem culture from disease-free tissues.

***Studying plant development and physiology:** Examining plant growth and responses to various stimuli in a controlled environment.

Overall, plant tissue culture is a versatile and powerful tool used in plant research, agriculture, and biotechnology, offering numerous benefits and applications for plant science and beyond.

### 2. Describe the various components of plant tissue culture media.

**Ans:** Plant tissue culture media plays a crucial role in providing the necessary nutrients and environment for successful growth and development of plant cells, tissues, or organs. It typically consists of several key components:

**1. Macronutrients:** Elements required in large quantities, like Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sulfur (S), are supplied as salts or nitrates to support basic plant metabolism and growth.

**2. Micronutrients:** Elements needed in smaller amounts, like Iron (Fe), Manganese (Mn), Zinc (Zn), Boron (B), Copper (Cu), Molybdenum (Mo), and Cobalt (Co), are crucial for enzyme function and various physiological processes. These are also provided as salts or chelates.

**3. Carbon source:** Sugars, primarily sucrose, are the main energy source for cultured plant cells. They provide carbon skeletons for various cellular components and fuel metabolic processes.
**4. Vitamins:** Small organic molecules like thiamine, biotin, and niacin are essential for cell division, growth, and various metabolic pathways.
**5. Plant growth regulators (PGRs):** Hormones like auxins, cytokinins, gibberellins, and abscisic acid regulate various aspects of plant development, including cell division, shoot and root growth, and bud formation. Their specific concentrations and combinations influence the desired morphogenesis in the cultured tissues.
**6. Solidifying agents:** Agar is the most common gelling agent in plant tissue culture media, providing a solid support for plant growth and preventing excessive water loss. Alternatives like gellan gum or alginate may also be used depending on specific needs.
**7. Additional components:** Depending on the plant species and experimental requirements, other additives like amino acids, antioxidants, activated charcoal, and anti-browning agents might be included in the media to optimize growth and prevent tissue browning or contamination.

The specific composition of the media is carefully formulated based on the target plant species, explant type, desired morphogenesis, and other experimental considerations. Understanding the roles and interactions of these various components is crucial for successful plant tissue culture practices.

## 3. What are the general steps of plant tissue culture?

**Ans:** While specific steps may vary depending on the plant species and desired outcome, the general process of plant tissue culture typically involves the following stages:

**1. Explant selection and preparation:**

*Choose a suitable plant part (explant) like shoot tips, stem segments, leaves, or embryos.
*Sterilize the explant to eliminate surface contaminants, often using bleach or alcohol solutions.
*Trim and prepare the explant for efficient culture, sometimes removing unwanted parts or making incisions.

**2. Media preparation:**

*Select or prepare the appropriate nutrient media based on the plant species and desired outcome.

*Adjust the pH and sterilize the media to ensure optimal growth conditions and prevent contamination.

*Pour the sterilized media into culture vessels like test tubes, flasks, or Petri dishes.

**3. Inoculation and incubation:**

*Aseptically transfer the sterilized explant onto the prepared media.

*Maintain the culture vessels in a controlled environment with suitable temperature, light, and humidity.

*Monitor the cultures for signs of growth, contamination, or abnormalities.

**4. Subculture and maintenance:**

*As the cultured tissues grow and multiply, they may need to be transferred (subcultured) to fresh media to provide adequate nutrients and space.

*This subculturing process may be repeated several times depending on the desired outcome and growth rate.

**5. Regeneration and acclimatization:**

*Once the cultured tissues reach the desired stage of development (shoots, roots, embryos, etc.), they need to be induced to form complete plantlets.

*This involves adjusting the hormone balance in the media or employing specific techniques like organogenesis or somatic embryogenesis.

*The regenerated plantlets are then gradually acclimatized to the greenhouse or outdoor environment by reducing humidity and adjusting light and temperature conditions.

**6. Transplanting and establishment:**

*Finally, the fully acclimatized plantlets are transplanted into potting soil or other suitable substrates.

*These regenerated plants are then monitored for their growth and development, sometimes requiring additional care until they establish themselves independently.

*Remember, this is a general overview, and specific details within each stage might vary considerably depending on the specific plant tissue culture technique and research goals.

## 4. Describe various applications of plant tissue culture.

**Ans:** Plant tissue culture (PTC) is a powerful tool that has revolutionized plant propagation and improvement. It involves growing plant cells, tissues, or organs under controlled conditions in a nutrient medium. PTC offers a wide range of applications, from mass propagation of desirable plants to genetic engineering and conservation. Here are some of the most important applications of PTC:

**1. Mass propagation:** PTC allows for the rapid production of large numbers of genetically identical plants (clones) from a single parent plant. This is particularly useful for commercially important plants like bananas, orchids, and strawberries. PTC can produce thousands of plants in a short period, compared to traditional methods like seed propagation, which can be slow and unreliable.

**2. Disease-free plants:** PTC can be used to produce disease-free plants by selecting healthy explants (plant tissues) from diseased plants. This is especially important for plants that are susceptible to viruses, bacteria, and fungi. In traditional propagation methods, diseases can be easily transmitted from parent plants to offspring, but PTC provides a clean slate for starting new, healthy plants.

**3. Germplasm conservation:** PTC can be used to preserve germplasm (genetic material) of endangered or rare plants. This is done by storing plant cells or tissues in culture collections, where they can be maintained for long periods without losing their viability. PTC has become an essential tool for preserving plant biodiversity in the face of habitat loss and climate change.

**4. Plant improvement:** PTC can be used to create new varieties of plants with desirable traits, such as increased yield, disease resistance, or improved nutritional value. This is achieved through techniques like somatic hybridization, where cells from different plant species are fused to create new hybrids with unique combinations of traits. PTC also plays a role in genetic engineering, where genes can be added or removed from plant cells to create plants with specific characteristics.

**5. Production of secondary metabolites:** PTC can be used to produce valuable secondary metabolites, such as alkaloids, pigments, and essential oils, from plants. These compounds are often used in medicines, cosmetics, and food products. PTC provides a controlled environment for optimizing the production of these valuable chemicals, making it a cost-effective and sustainable alternative to traditional extraction methods.

**6. Cryopreservation:** PTC can be used to cryopreserve plant cells, tissues, and organs. This involves storing them at very low temperatures (-196°C or -319°F) for long periods. Cryopreservation is a valuable tool for preserving the genetic diversity of plants, especially those that are difficult to propagate or store conventionally.

In conclusion, PTC is a versatile and powerful technology with a wide range of applications in plant science. It has revolutionized the way we propagate, improve, and conserve plants, and its importance is likely to continue to grow in the years to come.

## 5. How are somatic hybrids developed?

**Ans:** Somatic Hybrid Development: Combining Cells to Create New Plants
Somatic hybridization, a fascinating technique in plant science, allows creation of hybrid plants with unique combinations of traits by fusing protoplasts (cells without cell walls) from different plant species. Here's how it unfolds:

**1. Protoplast Isolation:**

*The journey begins with extracting protoplasts from desired plant tissues. Enzymes digest the cell walls, liberating protoplasts.

*These naked cells retain the nucleus and other organelles containing the genetic material.

**2. Protoplast Fusion:**

*The fun part! Protoplasts from the chosen parent plants are gently mixed in a specific solution.

*Chemical or electrical stimuli are applied to promote fusion of these protoplasts, forming a hybrid cell called a heterokaryon.

**3. Selection and Regeneration:**

*The heterokaryon is cultured in a nutrient medium suitable for plant cell growth and division.

*Only heterokaryons that successfully regenerate a cell wall and start dividing further develop into complete plants.

*Selective media may be used to eliminate unfused protoplasts or non-hybrid cells.

**4. Identification and Evaluation:**

*The regenerated plantlets are analyzed using molecular markers to confirm their hybrid status and assess the presence of desired traits from both parent plants.

*Further evaluation includes monitoring growth, yield, and resistance to diseases or pests.

**Challenges and Future:**

*Somatic hybridization can be challenging due to low fusion rates, unstable chromosome numbers in hybrid cells, and unpredictable inheritance of traits.

*Despite these challenges, the potential to overcome sexual hybridization barriers and introduce valuable traits from distantly related species makes it a valuable tool for plant breeders.

**Applications:**

*Somatic hybrids have been used to develop potato varieties resistant to late blight disease.

*Hybrids combining desirable traits like high yield and stress tolerance in crops like sugarcane and brassicas are being explored.

*The technique holds promise for introducing valuable secondary metabolites or medicinal properties into new plant lines.

Overall, somatic hybridization, with its unique capabilities and challenges, opens doors for innovative plant breeding strategies and creation of novel plant varieties with enhanced characteristics.

## 6. What are somaclonal variations?

**Ans:** Somaclonal Variations: Unexpected Twists in Plant Cells

Somaclonal variations are the unexpected genetic or epigenetic changes that arise in plants regenerated from tissue culture. These "twists" in the plant's genetic makeup can lead to a fascinating array of new characteristics, both desirable and unexpected.

**Sources of Somaclonal Variations:**

***Stress factors:** The controlled, but artificial, environment of tissue culture can be stressful for plant cells. Hormonal imbalance, exposure to chemicals, and even the act of wounding can trigger various stress responses, sometimes leading to mutations.

***Errors during cell division:** During the rapid cell division in tissue culture, errors in DNA replication or cell wall formation can occur, resulting in changes in chromosome number (polyploidy or aneuploidy) or structure (deletions, duplications, rearrangements).

**Impacts of Somaclonal Variations:**

***Visible changes:** Somaclonal variations can manifest in various ways, such as altered plant morphology (leaf shape, flower color), growth patterns, fruit quality, and even disease resistance.

***Hidden changes:** Sometimes, the changes are not immediately obvious but affect biochemical levels, metabolic pathways, or gene expression, potentially influencing yield, nutrient content, or stress tolerance.

**Benefits and Challenges:**

***Breeding tool:** Somaclonal variations can be a valuable source of novel traits for plant breeding. Breeders can screen regenerated plants for desirable changes and use them to develop new varieties with improved characteristics.

***Unpredictability:** However, the unpredictable nature of somaclonal variations is also a challenge. It's difficult to control the type and frequency of changes, making it a more "hit-and-miss" approach compared to targeted genetic engineering techniques.

***Stability:** Additionally, ensuring the stability of the variations across generations is crucial for successful breeding programs. Somaclonal variations can sometimes be epigenetic and not heritable, requiring careful screening and selection.

**Applications of Somaclonal Variations:**

***Disease resistance:** Development of potato varieties resistant to late blight disease using somaclonal variations.

***Improved yield:** Creation of high-yielding rice varieties with increased grain size and number.

***Stress tolerance:** Developing drought-resistant crop varieties by selecting plants with altered water-use efficiency.

***Secondary metabolites:** Enhanced production of valuable compounds like pigments or essential oils in medicinal plants.

In conclusion, somaclonal variations offer a unique opportunity for plant improvement, but their unpredictable nature requires careful research and selection strategies. With continued advancements in understanding and harnessing these variations, this fascinating phenomenon holds immense potential for shaping the future of agriculture.

## 7. Define explant and list five most commonly used explants for plant tissue culture.

**Ans:** Explant: The Starting Point for Plant Tissue Culture

An explant is a small piece of plant tissue used as the starting material for plant tissue culture. It can be any part of the plant, such as a stem, leaf, root, bud, or even an embryo. These tiny "seeds" of potential hold the key to creating new plants through various tissue culture techniques like regeneration, cloning, and genetic engineering.

**Five Most Commonly Used Explants:**

**1. Shoot tips:** The apical meristem, or growing tip of a shoot, is often used because it contains highly totipotent cells capable of developing into all plant organs. This explant is ideal for rapid propagation and clonal selection.

**2. Leaf discs:** Leaves are readily available and contain both mesophyll and epidermal cells, offering potential for regeneration pathways depending on the species and culture conditions. They are commonly used for micropropagation and studies on secondary metabolite production.

**3. Nodal segments:** Segments containing a node (where a leaf joins the stem) are frequently used. This explant retains both shoot and root bud potential, allowing for direct regeneration of plantlets in some species.

**4. Embryos:** Immature embryos isolated from seeds offer a unique advantage of bypassing seed dormancy and providing a readily available source of totipotent cells for regeneration and genetic manipulation.

**5. Root segments:** While less common than shoot explants, root segments can be used for clonal propagation or studies on root development and secondary metabolite production. They often require specific culture conditions and hormones to initiate regeneration.

**Beyond these five, the choice of explant depends on several factors, including:**

***Species:** Different plants have different regeneration potential from various tissues.

***Purpose of culture:** Regeneration, propagation, metabolite production, or genetic modification may favor specific explants.

***Availability and ease of collection:** Some explants, like seeds or easily accessible leaves, are more practical than others.

The selection of the right explant is crucial for the success of plant tissue culture experiments. Understanding the potential and limitations of different tissues allows scientists to tailor their techniques and unlock the fascinating possibilities of growing plants from tiny fragments.

## 8. Describe somatic embryogenesis and their application for the development of synthetic seeds.

**Ans:** Somatic Embryogenesis: Growing Tiny Plant Babies from Cells

Somatic embryogenesis is a captivating process in plant tissue culture where plant embryos develop directly from somatic cells, not via fertilization. These miniature plant embryos, resembling seeds in structure, hold immense potential for plant propagation and improvement. Let's delve into the magic of this process and its exciting application in creating synthetic seeds.

**The Stages of Somatic Embryogenesis:**

**1. Induction:** Specialized plant cells, often from shoot or leaf tissues, are exposed to plant hormones and specific nutrients in a controlled culture environment. This triggers the cells to lose their normal growth patterns and enter a "embryogenic state."

**2. Embryo development:** The initiated cells undergo multiple rounds of cell division and differentiation, forming recognizable structures with distinct root and shoot poles, just like true embryos.

**3. Maturation:** The embryos accumulate storage molecules and dehydration tolerance, mimicking the dormant stage of mature seeds.

**4. Germination:** Under appropriate conditions, the somatic embryos emerge from their dormancy and start growing into whole plantlets, completing the transformation.

**Benefits of Somatic Embryogenesis:**

***Rapid propagation:** Large numbers of identical plantlets can be produced efficiently from a single explant, ideal for commercially important crops and clonal lines.

***Disease-free plants:** Embryos bypass the seed coat, avoiding seed-borne diseases and ensuring healthy plant production.

***Genetic manipulation:** Embryos are ideal targets for genetic engineering techniques, allowing for the introduction of desirable traits like disease resistance or improved yield.

**Synthetic Seeds: Putting Embryos to Work:**

Somatic embryos can be encapsulated in a protective coating containing nutrients and germination aids, creating synthetic seeds with several advantages:

***Precise handling and sowing:** These tiny, uniform "seeds" are easier to handle, store, and sow than natural seeds, enabling efficient use in mechanized agriculture.

***Improved storage and transport:** Synthetic seeds can be stored for longer periods under controlled conditions, improving seed stability and facilitating shipment over long distances.

***Germination control:** Encapsulation allows for controlled release of nutrients and hormones, regulating germination timing and optimizing plant establishment.

Challenges and Future:

While promising, somatic embryogenesis and synthetic seed technology face challenges like optimizing embryo production protocols, ensuring efficient coating materials, and managing costs. However, with ongoing research and technological advancements, these hurdles are being overcome, paving the way for their wider adoption in agriculture and plant biotechnology.

In conclusion, somatic embryogenesis provides a fascinating glimpse into the power of plant regeneration, and its application in synthetic seeds offers exciting possibilities for revolutionizing plant propagation and improving agricultural practices. As this technology continues to evolve, tiny plant embryos hold the potential to grow into a greener and more sustainable future.

## 9. Describe briefly the role of pH in nutrient media.

**Ans:** pH plays a crucial role in nutrient media for two main reasons:

**1. Enzyme activity:** The pH directly affects the activity of enzymes, which are the workhorses of metabolism in cells. Most plant and animal cells prefer a slightly acidic to neutral pH (around 5.5-7.4) for optimal enzyme function. If the pH deviates significantly from this range, enzymes can become inactive or denatured, leading to impaired growth and development.

**2. Nutrient availability and uptake:** The solubility and availability of various nutrients in the media are pH-dependent. For example, some ions become less

soluble and therefore less available to cells at extreme pH values. Additionally, the transport of ions across cell membranes is influenced by pH gradients. A stable and appropriate pH ensures efficient nutrient uptake and utilization by the cells.

**Here are some specific consequences of improper pH in nutrient media:**

***Acidic environment:** Increased uptake of toxic ions like aluminum, decreased nutrient availability, and reduced enzyme activity.

***Alkaline environment:** Reduced solubility of iron and phosphorus, protein precipitation, and disruption of membrane transport.

Maintaining a stable and optimal pH is crucial for successful cell culture and plant tissue culture. This is often achieved through the use of buffer solutions that resist changes in pH and can be adjusted to the specific needs of the cultured cells or tissues.

## 10. Describe the method of somatic hybridization and its advantages.

**Ans:** Somatic hybridization is a fascinating technique in plant biotechnology that allows the combination of genetic material from two different plant species by fusing their protoplasts (cells without cell walls) to create hybrid plants with novel traits. Here's how it works:

**1. Protoplast Isolation:**

*Plant tissues from the desired parent species are treated with enzymes to dissolve their cell walls, releasing naked protoplasts.

*These protoplasts retain the nucleus and other organelles containing the genetic material.

**2. Protoplast Fusion:**

*Protoplasts from the chosen parent plants are mixed in a specific solution.

*Chemical or electrical stimuli are applied to promote fusion of these protoplasts, forming a hybrid cell called a heterokaryon.

**3. Selection and Regeneration:**

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**4. Identification and Evaluation:**

*The regenerated plantlets are analyzed using molecular markers to confirm their hybrid status and assess the presence of desired traits from both parent plants.

*Further evaluation includes monitoring growth, yield, and resistance to diseases or pests.

**Advantages of Somatic Hybridization:**

***Overcoming sexual incompatibility:** Unlike traditional hybridization, somatic hybridization can combine the genomes of plants from different species or genera that cannot sexually reproduce, even if they are distantly related. This allows for the introduction of valuable traits from incompatible plant species.

***Combining desirable traits:** The hybrid plants can inherit beneficial traits from both parent species, such as disease resistance from one parent and high yield from the other, creating novel combinations with improved characteristics.

***Cytoplasmic male sterility:** Somatic hybridization can introduce desirable cytoplasmic traits like male sterility, which is useful for hybrid seed production in crops like maize.

***Studying cytoplasmic genes:** This technique allows the study of cytoplasmic genes and their interaction with nuclear genes, furthering our understanding of plant cell biology.

**Despite its advantages, somatic hybridization also has some challenges:**

***Low fusion rates:** Protoplast fusion can be inefficient, requiring specialized techniques and optimization protocols.

***Unstable chromosome numbers:** The hybrid cells may have unstable chromosome numbers, leading to reduced viability or abnormal growth.

***Unpredictable trait inheritance:** Predicting which traits will be expressed in the hybrid plants can be difficult due to complex interactions between genes from both parents.

Overall, somatic hybridization is a powerful tool for plant breeding and genetic engineering, offering opportunities to create novel plant varieties with enhanced characteristics. With continued research and refinement of techniques, its potential for revolutionizing agriculture and creating food security for a growing population is immense.

## 11. What are somaclonal variations and discuss their role for improving crops.

**Ans:** Somaclonal Variations: Unexpected Twists in Plants

Somaclonal variations are the genetic or epigenetic changes that arise in plants regenerated from tissue culture. These unexpected "twists" in the plant's genetic makeup can lead to a fascinating array of new characteristics, both desirable and unexpected, offering both challenges and opportunities for crop improvement.

**Sources of Somaclonal Variations:**

***Stress factors:** The controlled, but artificial, environment of tissue culture can be stressful for plant cells. Hormonal imbalance, exposure to chemicals, and even the act of wounding can trigger various stress responses, sometimes leading to mutations.

***Errors during cell division:** During the rapid cell division in tissue culture, errors in DNA replication or cell wall formation can occur, resulting in changes in chromosome number (polyploidy or aneuploidy) or structure (deletions, duplications, rearrangements).

**Impacts of Somaclonal Variations:**

***Visible changes:** Somaclonal variations can manifest in various ways, such as altered plant morphology (leaf shape, flower color), growth patterns, fruit quality, and even disease resistance.

***Hidden changes:** Sometimes, the changes are not immediately obvious but affect biochemical levels, metabolic pathways, or gene expression, potentially influencing yield, nutrient content, or stress tolerance.

**Role in Crop Improvement:**

***Source of novel traits:** Somaclonal variations can be a valuable source of novel traits for plant breeding. Breeders can screen regenerated plants for desirable changes and use them to develop new varieties with improved characteristics.

**Examples:**

**.Potato:** Somaclonal variations led to the development of potato varieties resistant to late blight disease.

**.Rice:** High-yielding rice varieties with increased grain size and number were created using this technique.

**.Brassica:** Drought-resistant brassica varieties were developed by selecting plants with altered water-use efficiency.

***Secondary metabolites:** Enhanced production of valuable compounds like pigments or essential oils in medicinal plants.

**Challenges and Considerations:**

***Unpredictability:** The unpredictable nature of somaclonal variations is a challenge. It's difficult to control the type and frequency of changes, making it a more "hit-and-miss" approach compared to targeted genetic engineering techniques.

***Stability:** Ensuring the stability of the variations across generations is crucial for successful breeding programs. Somaclonal variations can sometimes be epigenetic and not heritable, requiring careful screening and selection.

***Cost and labor:** Identifying and characterizing desirable variations can be a time-consuming and expensive process.

Overall, somaclonal variations offer a unique opportunity for crop improvement. While its unpredictable nature requires careful research and selection strategies, this fascinating phenomenon holds immense potential forh shaping the future of agriculture. With continued advancements in understanding and harnessing these variations, we can unlock new avenues for developing resilient and productive crops to meet the needs of a growing global population.

## Multiple Choice Questions

**12. Which of the following tissues can be used as explant for regenerating complete plant through tissue culture?**

**(a) Shoot apical meristem**

**(b) Embryo**

**(c) Leaf segments**

**(d) All of the above**

**Ans:** (d) All of the above.

**13. Which of the following explants are suitable for the production of virus free plants?**

**(a) Leaf segments**

**(b) Seeds**

**(c) Apical meristem**

**(d) Stem cuttings**

**Ans:** (c) Apical meristem.

**14. The process of combining the nuclear genomes of one parent with the cytoplasmic genome of the other parent is called as:**
**(a) Cybridization**
**(b) Micropropagation**
**(c) Regeneration**
**(d) None of them**
**Ans:** (a) Cybridization.

**15. Which of the following components is not essential for Murashige and Skoog media?**
**(a) Inorganic nutrients**
**(b) Carbon source**
**(c) Antibiotics**
**(d) Organic Nutrients**
**Ans:** (c) Antibiotics.

**16. Decrease in the pH of the media may result in:**
**(a) Increase in hardiness of the solidified medium.**
**(b) May interfere with the solubility of media salts.**
**(c) Interfere with solidification of the medium and results in poor solidification.**
**(d) All of the above.**
**Ans:** (d) All of the above.

**17. Somatic clonal variation can be present in which of the following plants?**
**(a) Plants regenerated through tissue culture**
**(b) Plant generated through seeds**
**(c) Plant generated through sexual reproduction which includes fertilisation of egg with pollen nuclei.**
**(d) None of the above.**
**Ans:** (a) Plants regenerated through tissue culture.

**18. In vitro tissue culture can be used for the generation of:**
**(a) Virus free plants**
**(b) Somatic hybrid plants**
**(c) Synthetic seeds**
**(d) None of the above.**
**Ans:** (d) None of the above.

**19. Assertion: Somatic seeds are encapsulated by a layer called seed coat.**
**Reason: Seed coat is the protective layer which prevents water desiccation.**
**(a) Both assertion and reason are true and the reason is the correct explanation of the assertion.**
**(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.**
**(c) Assertion is true but reason is false.**
**(d) Both assertion and reason are false.**
**Ans:** (c) Assertion is true but reason is false.

**20. Assertion: Virus free plants can be produced by growing apical/axillary meristem of virus infected plants.**
**Reason: Apical/axillary meristems lack vascular bundle which is required by the virus to replicate.**
**(a) Both assertion and reason are true and the reason is the correct explanation of the assertion.**
**(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.**
**(c) Assertion is true but reason is false.**
**(d) Both assertion and reason are false.**
**Ans:** (c) Assertion is true but reason is false.

## SUMMARY

• Plant tissue culture (PTC) refers to the cultivation of undifferentiated mass of plant cells, tissues or organs on artificial media under aseptic and controlled environmental conditions.
• Any plant organ like leaf, apical meristem, embryo, cotyledon, hypocotyl, etc., can be used as an explant and whole plants can be regenerated in vitro.
• Plant tissue culture media used for in vitro cultures is mainly composed of inorganic and organic supplements, carbon source, plant growth hormones, vitamins, gelling agents, antibiotics, etc.
• Tissue culture can be categorised as organ culture, explant culture, callus culture, cell suspension culture, protoplast culture or single cell culture.
• Plant tissue culture is routinely used for several applications in plant science, such as in micropropagation, synthetic seed formation, protoplast culture, haploid or triploid culture, virus free plants production, secondary metabolites production, etc.
• Plant growth hormones play a vital role in plant tissue culture especially, different ratios of auxin and cytokinin are employed for either root or shoot regeneration depending upon the need or objective.
• Somatic hybridisation in plant tissue culture can be exploited to produce distantly related plants as well.
• Cultured cells or tissues may accumulate a higher concentration of secondary metabolites than its parents, under optimum environmental and nutritional conditions.
• Several compounds of industrial importance have been successfully produced in tissue culture, like taxol, azadirachtin, shikonin.