# UP Board Class 12 Biology 2026 (Set 348 EL) Question Paper with Solutions

## General Instructions

**(i)** This booklet contains 9 questions, each provided with a complete, step-by-step solution.

**(ii)** It comprises 4 single-correct multiple-choice questions.

**(iii)** Attempt each question on your own before reviewing the given solution.

**1(a).** Testosterone hormone is synthesized and secreted by:

(A) Epididymis

(B) Sertoli cells

(C) Sperm

(D) Leydig cells

**Correct Answer:** (D) Leydig cells

**Solution:**

**Step 1:** Understanding the Concept:

Inside each testis, the seminiferous tubules carry the sperm-forming cells, and the loose tissue between the tubules is called the interstitial space. This space holds small clusters of Leydig cells (interstitial cells).

**Step 2:** Recall what Leydig cells do.

Leydig cells are the main site of male sex hormone production. They make and release testosterone directly into the blood, and this hormone controls sperm formation and the male secondary sexual

traits.

**Step 3:** Why the other options are wrong.
The epididymis stores and matures sperm; it does not make hormones. Sertoli cells sit inside the seminiferous tubule and nourish the developing sperm cells, but they do not secrete testosterone. Sperm are the male gametes themselves, not a hormone-producing tissue.

**Final Answer:**
Testosterone is made and released by the Leydig cells, option (D).

**Quick Tip:** Think about which cell type sits between the seminiferous tubules, not inside them.

**1(b).** The phenotypic ratio of classical Mendelian dihybrid cross is:

(A) 1 : 2 : 1

(B) 3 : 1

(C) 9 : 7

(D) 9 : 3 : 3 : 1

**Correct Answer:** (D) 9 : 3 : 3 : 1

**Solution:**

**Step 1:** Understanding the Concept:
A dihybrid cross follows two genes at once, each with a dominant and a recessive allele, for example seed shape (round R, wrinkled r) and seed colour (yellow Y, green y). Crossing two double heterozygotes

RrYy x RrYy gives the classical dihybrid cross.

**Step 2:** Key Formula or Approach:
Each gene independently gives a 3 : 1 ratio at the phenotype level (Mendel's law of independent assortment). Multiplying the two 3 : 1 ratios together gives the combined phenotypic ratio: (3 : 1) x (3 : 1).

**Step 3:** Detailed Explanation:
Expanding (3+1)(3+1) = 9 + 3 + 3 + 1 out of 16 total offspring: 9 show both dominant traits (round, yellow), 3 show the first dominant with the second recessive (round, green), 3 show the first recessive with the second dominant (wrinkled, yellow), and 1 shows both recessive traits (wrinkled, green).

**Final Answer:**
The classical dihybrid phenotypic ratio is 9 : 3 : 3 : 1, option (D).

**Quick Tip:** Multiply the monohybrid 3:1 ratio by itself for two independent genes.

**1(c).** The enzyme that makes a cut at a specific position within the DNA is called:

(A) Exonuclease

(B) Endonuclease

(C) Ligase

(D) Polymerase

**Correct Answer:** (B) Endonuclease

**Solution:**

**Step 1:** Understanding the Concept:
Genetic engineering needs a tool that cuts DNA at one exact, recognisable sequence rather than chopping it randomly from the ends. That tool is a restriction endonuclease.

**Step 2:** Recall how it works.
A restriction endonuclease scans the DNA strand, finds its specific short recognition sequence, and cuts the sugar-phosphate backbone right at (or near) that internal site, inside the molecule.

**Step 3:** Why the other options are wrong.
An exonuclease removes nucleotides one at a time from the free ends of DNA, not from an internal site. Ligase does the opposite job, it joins (seals) two DNA fragments together. Polymerase builds a new DNA strand by adding nucleotides; it does not cut DNA.

**Final Answer:**
The enzyme that cuts DNA at a specific internal site is the endonuclease, option (B).

**Quick Tip:** Remember 'endo' means inside; this enzyme cuts inside the DNA molecule, not at its ends.

**1(d).** Which of the following is an attribute characteristic of a population?

(A) Birth rate

(B) Death rate

(C) Sex ratio

(D) All of the above

**Correct Answer:** (D) All of the above

**Solution:**

**Step 1:** Understanding the Concept:
A population is a group of individuals of one species living in a given area at a given time. A single organism can be born or die once, but a population shows group-level, statistical properties that no lone individual can show.

**Step 2:** Check each attribute.
Birth rate (natality) is the number of births per member of the population over a period, so it is a group property, not a trait of one animal. Death rate (mortality) is the same idea for deaths. Sex ratio, the proportion of males to females, also only makes sense when counted across many individuals.

**Step 3:** Put it together.
Since birth rate, death rate and sex ratio are all properties that exist only at the level of the whole population, none of them can be singled out as more correct than the others.

**Final Answer:**
Birth rate, death rate and sex ratio are all population attributes, so the answer is (D), all of the above.

**Quick Tip:** Ask which of these values could ever be measured for a single, lone organism.

**2(a).** Name the type of pollination found in cleistogamous flowers. Give one example.

**Correct Answer:** —

**Solution:**

**Step 1:** Recall what a cleistogamous flower is.
A cleistogamous flower never opens at all; the petals stay shut through the whole process of pollen release and pollen landing on the stigma.

**Step 2:** Work out which pollination type this forces.
Since the flower never opens, no outside pollen (from wind, insects or any other agent) can reach the stigma. The anther and stigma lie so close together inside the closed flower that pollen from the same flower falls directly on its own stigma. This is autogamy, self-pollination within the same flower.

**Step 3:** Give an example.
Viola (the common pansy relative) and Commelina benghalensis both produce cleistogamous flowers that self-pollinate this way, alongside their normal open flowers.

**Final Answer:**
Cleistogamous flowers show autogamy (self-pollination); Viola is a common example.

**Quick Tip:** Think about whether the flower ever opens, and what that means for where the pollen can travel.

**2(b).** How many chromosomes are found in primary spermatocytes and secondary oocytes of a human being?

**Correct Answer:** —

**Solution:**

**Step 1:** Recall the human chromosome number and meiosis.
A normal human body cell has 46 chromosomes (23 pairs, diploid, 2n). Gamete-forming cells go through meiosis, which happens in two divisions, meiosis I and meiosis II, and only the second division actually splits the chromosome number in half.

**Step 2:** Place the primary spermatocyte in this timeline.
A primary spermatocyte is the cell just before it enters meiosis I; it has not yet divided, so it still carries the full diploid number.

**Step 3:** Place the secondary oocyte in this timeline.
A secondary oocyte is formed right after meiosis I is complete (the first meiotic division has already separated homologous chromosomes), so its chromosome number has already been halved to the haploid number.

**Final Answer:**
A primary spermatocyte has 46 chromosomes (diploid); a secondary oocyte has 23 chromosomes (haploid).

**Quick Tip:** Check whether meiosis I has already happened for each named cell.

**2(c).** Write the two general laws of inheritance proposed by Mendel.

**Correct Answer:** —

**Solution:**

**Step 1:** Recall Mendel's experimental base.
Mendel worked out the rules of inheritance from his pea plant crosses, and from the results he stated general laws that describe how factors (now called genes) pass from parents to offspring.

**Step 2:** State the Law of Dominance.
In a hybrid carrying two different alleles of a gene, one allele (the dominant one) hides the effect of the other (the recessive one) in the F1 generation, so only the dominant trait shows up.

**Step 3:** State the Law of Segregation.
The two alleles of a gene in a parent separate (segregate) from each other during gamete formation, so each gamete carries only one of the two alleles, never both.

**Final Answer:**
Mendel's two general laws are the Law of Dominance and the Law of Segregation.

**Quick Tip:** Think about what happens to a gene's two alleles when gametes form, and what shows up when they are different.

**2(d).** Name any two autosome linked recessive disorders.

**Correct Answer:** —

**Solution:**

**Step 1:** Understand what 'autosome linked recessive' means.
An autosome is any chromosome other than the X and Y sex chromosomes. A recessive disorder only shows up when a person inherits the faulty allele from both parents (is homozygous recessive).

**Step 2:** Give the first example, sickle cell anaemia.
Sickle cell anaemia is caused by a mutated allele of the gene for the beta chain of haemoglobin, carried on an autosome. A person needs the mutant allele from both parents to show the disease.

**Step 3:** Give the second example, phenylketonuria.
Phenylketonuria is caused by a recessive allele, also on an autosome, that fails to make the enzyme needed to break down the amino acid phenylalanine, and it too only appears when both copies of the gene are faulty.

**Final Answer:**
Sickle cell anaemia and phenylketonuria are two autosome linked recessive disorders.

**Quick Tip:** Look for disorders carried on a non sex chromosome that need two copies of the faulty gene.

**2(e).** Give an example of an ecosystem where the pyramid of biomass is inverted.

**Correct Answer:** —

**Solution:**

**Step 1:** Recall what an inverted pyramid of biomass means.
A pyramid of biomass normally narrows as it goes up, since producers usually outweigh the consumers that eat them. An inverted pyramid happens when the producer level has a smaller total mass than the consumers feeding on it, at the moment it is measured.

**Step 2:** Apply this to a pond ecosystem.
In a pond, the producers are tiny, fast reproducing phytoplankton, so their standing crop (mass present at one time) is small, even though they are eaten and replaced very quickly. The zooplankton and fish feeding on them build up a larger standing biomass than the phytoplankton they depend on.

**Step 3:** State the result.
So if you weigh all the organisms at each level at a single moment, the pond's producer level looks lighter than the consumer levels above it, giving an inverted, top heavy pyramid shape.

**Final Answer:**
A pond (or a marine) ecosystem is a standard example of an inverted pyramid of biomass.

**Quick Tip:** Think about producers that are tiny and short-lived but still support a heavier population of consumers.

**3(a).** Name the two strands of the structural gene DNA of a transcription unit.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
A transcription unit is a stretch of double stranded DNA that gets copied into RNA. Because DNA is double stranded, only one of the two strands is actually read to build the RNA.

**Step 2:** Name the strand that gets copied.
The strand that RNA polymerase actually reads and uses as its template is called the template strand, or sometimes the antisense strand. RNA polymerase moves along it in the 3' to 5' direction while building RNA in the 5' to 3' direction.

**Step 3:** Name the other strand.
The second strand, which is not read, is called the coding strand or sense strand. It is not copied directly, but its base sequence matches the RNA transcript, except that DNA has thymine where RNA has uracil.

**Final Answer:**
The two strands are the template (antisense) strand and the coding (sense) strand.

**Quick Tip:** One strand is actually read by RNA polymerase; the other just matches the RNA sequence.

**3(b).** Explain two phenomena which lead to variation in DNA.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
DNA is copied with very high accuracy at each cell division, but it is not copied perfectly. The small errors and rearrangements that do occur are what create variation between individuals.

**Step 2:** Explain mutation.
A mutation is a permanent change in the DNA base sequence, for example a base being wrongly copied, added, or deleted during replication, or damage from radiation or chemicals. This directly changes the genetic information at that spot, sometimes changing the protein it codes for.

**Step 3:** Explain recombination.
During meiosis, homologous chromosomes pair up and can exchange corresponding segments in a process called crossing over. This shuffles existing alleles into new combinations on the same chromosome, without changing the DNA sequence of any single gene.

**Final Answer:**
Mutation (a direct change in DNA sequence) and recombination (crossing over during meiosis) are the two main phenomena that create DNA variation.

**Quick Tip:** One phenomenon changes the DNA letters themselves; the

other reshuffles existing alleles.

**3(c).** Name the pathogenic organisms of the following diseases: (i) Pneumonia (ii) Amoebiasis (iii) Ascariasis (iv) Filaria.

**Correct Answer:** —

**Solution:**

**Step 1:** Pneumonia.
Pneumonia in humans is commonly caused by the bacterium Streptococcus pneumoniae, which infects the alveoli of the lungs and fills them with fluid.

**Step 2:** Amoebiasis.
Amoebiasis is caused by the protozoan parasite Entamoeba histolytica, which infects the large intestine and causes dysentery.

**Step 3:** Ascariasis.
Ascariasis is caused by the roundworm (nematode) Ascaris lumbricoides, a common intestinal helminth parasite.

**Step 4:** Filaria.
Filaria (filariasis) is caused by the thread-like nematode worms Wuchereria bancrofti and Wuchereria malayi, which lodge in the lymphatic vessels.

**Final Answer:**
Pneumonia: Streptococcus pneumoniae; Amoebiasis: Entamoeba

histolytica; Ascariasis: Ascaris lumbricoides; Filaria: Wuchereria bancrofti/malayi.

**Quick Tip:** Two of these four pathogens are worms, one is a bacterium, and one is a protozoan.

**3(d).** Why is the pyramid of energy never inverted? Explain.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
A pyramid of energy plots the rate of energy flow (energy per unit area per unit time) through each trophic level, from producers up to top consumers, unlike a biomass pyramid which just measures mass at one instant.

**Step 2:** Key rule that governs it.
Energy transfer between trophic levels obeys the second law of thermodynamics: whenever energy is transformed (for example, food eaten and used for movement, growth, or heat), some of it is always lost as heat, so the amount passed on is always less than what was received.

**Step 3:** Apply this level by level.
Only about 10 percent of the energy at one trophic level is typically available to the next level (the 10 percent law); the rest is used up in respiration or lost as heat. This means every higher trophic level must receive less energy than the one below it, with no exceptions.

**Final Answer:**

Because energy is always lost as heat at each transfer, and flow is one directional, energy at a level can never exceed the level below it, so the energy pyramid is always upright, never inverted.

**Quick Tip:** Recall the 10 percent law and where the missing 90 percent of energy actually goes.

**3(e).** What do you mean by detritus and detritivores?

**Correct Answer:** —

**Solution:**

**Step 1:** Define detritus.

Detritus is the layer of dead organic matter built up in an ecosystem, made of things like fallen leaves, dead plant parts, animal remains, and faecal matter that have not yet been fully broken down.

**Step 2:** Define detritivores.

Detritivores are organisms that feed directly on this detritus, physically breaking it into smaller fragments. Common examples include earthworms, millipedes, some beetles, and other soil invertebrates.

**Step 3:** Connect the two ideas.

By feeding on detritus and fragmenting it, detritivores increase its surface area, which speeds up the later chemical breakdown of that matter by decomposers like bacteria and fungi.

**Final Answer:**
Detritus is dead organic matter (like fallen leaves and animal remains); detritivores are the organisms, such as earthworms, that feed on and break down this detritus.

**Quick Tip:** Detritus is the material itself; detritivores are the organisms that eat that material.

**4(a).** With the help of a suitable diagram, describe the functions of the vegetative and generative cells of mature pollen grains.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
A mature pollen grain of a flowering plant is not a single uniform cell. When it is shed from the anther, it is already two celled: a large vegetative cell and a smaller generative cell lying inside the cytoplasm of the vegetative cell.

**Step 2:** Function of the vegetative cell.
The vegetative cell is bigger, has abundant food reserves, and an irregular nucleus. After the pollen lands on a compatible stigma, this cell absorbs water and germinates, growing out as the pollen tube that carries the male gametes down through the style toward the ovule.

**Step 3:** Function of the generative cell.
The generative cell is small, spindle shaped, and floats in the

cytoplasm of the vegetative cell. It divides mitotically, either before the pollen is shed or inside the growing pollen tube, to form the two male gametes needed for double fertilisation.

**Step 4:** Diagram description.
A simple diagram would show an oval pollen grain with a thick outer exine wall (with germ pores) and thin intine wall, containing a large vegetative cell with a diffuse nucleus, and a small crescent shaped generative cell lying within it.

**Final Answer:**
The vegetative cell forms the pollen tube for gamete delivery, while the generative cell divides to produce the two male gametes used in double fertilisation.

**Quick Tip:** One cell builds the delivery tube, the other one divides to make the male gametes.

**4(b).** Write a short note on polyembryony.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
Normally, one fertilised egg (zygote) inside one ovule develops into exactly one embryo. Polyembryony is the occurrence of more than one embryo inside a single seed.

**Step 2:** Explain how it happens.

It can arise in more than one way: sometimes more than one archesporial cell or nucellar cell starts forming an embryo-like structure without fertilisation (adventive embryony), and sometimes the true zygotic embryo splits early into more than one embryo.

**Step 3:** Give an example and its use.
It is common in citrus fruits (like orange), where nucellar cells around the embryo sac develop into extra embryos alongside the normal zygotic one. This trait is used commercially, since nucellar embryos are genetically identical to the mother plant, giving true to type saplings.

**Final Answer:**
Polyembryony is the presence of more than one embryo in a single seed, seen well in citrus, and it is valuable in horticulture for producing genetically uniform, disease free planting material.

**Quick Tip:** Think about a seed that ends up with more than one embryo, and where the extra ones come from.

**4(c).** Define linkage. Explain the effect of linkage on inheritance of two genes.

**Correct Answer:** —

**Solution:**

**Step 1:** Define linkage.
Linkage is the tendency of two or more genes located close together on the same chromosome to be inherited together, as a group, rather

than independently, because they travel together on that one chromosome during gamete formation.

**Step 2:** Contrast with Mendel's independent assortment.
Mendel's law of independent assortment holds only for genes on different chromosomes (or far apart on the same one); it predicts free recombination and a 9:3:3:1 dihybrid ratio. Linked genes break this rule because they mostly move together.

**Step 3:** Explain the effect on inheritance.
Because linked genes are usually passed on together, the parental combinations of traits show up in the offspring far more often than the new (recombinant) combinations. Only occasional crossing over between the linked genes creates some recombinant offspring, so the observed ratio deviates sharply from the free 9:3:3:1 ratio, skewed toward the parental types.

**Final Answer:**
Linkage is co-inheritance of genes lying close on the same chromosome; it makes parental trait combinations appear far more often than recombinant ones, distorting the expected dihybrid ratio.

**Quick Tip:** Genes that sit close together on one chromosome do not assort independently; think about what that does to the offspring ratios.

**4(d).** Explain transfer RNA (tRNA) as an adaptor molecule.

**Correct Answer:** —

**Solution:**

**Step 1:** State the problem tRNA solves.
The genetic code on messenger RNA (mRNA) is written in three letter codons of nucleotides, but the actual protein being built is made of amino acids. Nucleotides and amino acids cannot recognise each other directly, so a go-between molecule is needed.

**Step 2:** Describe how tRNA bridges the two.
Each tRNA molecule has an anticodon loop, a set of three bases that can base pair with a specific mRNA codon, and at its other end it carries the one specific amino acid that corresponds to that codon. So a tRNA physically links a codon on mRNA to the correct amino acid.

**Step 3:** Explain why this makes it an 'adaptor'.
Since tRNA reads the nucleotide language on one end (via its anticodon) and carries the protein language on the other end (its bound amino acid), it adapts, or converts, information from one chemical language into the other during translation.

**Final Answer:**
tRNA is called an adaptor molecule because its anticodon end reads the mRNA codon while its other end carries the matching amino acid, translating the nucleotide code into the amino acid sequence of a protein.

**Quick Tip:** One end of tRNA reads the mRNA codon; the other end carries the amino acid. That is exactly what an adaptor does.

**5(a).** Comment upon the following: (i) Addiction (ii) Autoimmune disease.

**Correct Answer:** —

**Solution:**

**Step 1:** Addiction, what it is.
Addiction is a strong, often uncontrollable psychological and physical dependence on a substance (like alcohol, tobacco, or drugs) or a behaviour, where the person feels compelled to keep using it despite harmful effects.

**Step 2:** Addiction, why it happens.
Repeated use of the substance affects certain brain reward pathways so that stopping causes withdrawal symptoms, and the body develops tolerance, needing larger doses over time for the same effect.

**Step 3:** Autoimmune disease, what it is.
An autoimmune disease occurs when the body's own immune system fails to recognise some of its own tissues as 'self' and starts attacking them as if they were foreign, causing damage to those tissues.

**Step 4:** Autoimmune disease, an example.
Rheumatoid arthritis, where the immune system attacks the tissue lining the joints, is a common example of an autoimmune disease.

**Final Answer:**
Addiction is compulsive dependence on a substance or behaviour despite harm; an autoimmune disease is the immune system wrongly attacking the body's own tissue, as in rheumatoid arthritis.

**Quick Tip:** Addiction is about the brain's reward pathway; autoimmune disease is about the immune system attacking 'self'.

**5(b).** What are lymphocytes? Comment upon two special types of lymphocytes present in our body.

**Correct Answer:** —

**Solution:**

**Step 1:** Define lymphocytes.
Lymphocytes are a type of white blood cell that forms the core of the body's specific (adaptive) immune response, meaning they target particular pathogens rather than attacking everything in a general way.

**Step 2:** Describe B-lymphocytes.
B-lymphocytes (B-cells) mature in the bone marrow. When they meet a matching antigen, they multiply and turn into plasma cells that secrete large amounts of antibodies into the blood, giving humoral immunity.

**Step 3:** Describe T-lymphocytes.
T-lymphocytes (T-cells) mature in the thymus gland. Rather than releasing free antibodies, they act directly, for example by killing infected body cells or by helping to activate other immune cells, giving cell mediated immunity.

**Final Answer:**
Lymphocytes are white blood cells driving adaptive immunity; B-lymphocytes produce antibodies (humoral immunity), and T-lymphocytes act directly on infected cells (cell mediated immunity).

**Quick Tip:** One type releases antibodies into the blood; the other type acts directly on infected cells.

**5(c).** What is cancer? Mention its prevention and cure.

**Correct Answer:** —

**Solution:**

**Step 1:** Define cancer.
Cancer is a disease in which some body cells lose their normal growth control, divide uncontrollably, and can invade and damage neighbouring tissue, and in the case of malignant tumours, spread (metastasise) to other parts of the body through blood or lymph.

**Step 2:** State prevention measures.
Prevention includes avoiding known cancer-causing agents (carcinogens) such as tobacco, alcohol and excess sun exposure, eating a healthy diet, keeping a regular exercise routine, and going for regular medical checkups so any early signs are caught quickly.

**Step 3:** State the main treatment (cure) options.
Depending on the type and stage, cancer is treated with surgery to remove the tumour, radiotherapy to kill cancer cells with radiation, and chemotherapy using drugs that stop rapidly dividing cells, often using more than one of these together.

**Final Answer:**
Cancer is the uncontrolled, invasive growth of body cells; it is best

prevented by avoiding carcinogens and getting regular checkups, and treated with surgery, radiotherapy and chemotherapy.

**Quick Tip:** Prevention is about avoiding the causes; cure usually combines three main treatments.

**5(d).** What is sewage? Describe the biological treatment of sewage in short.

**Correct Answer:** —

**Solution:**

**Step 1:** Define sewage.
Sewage is the used, waste water that comes from homes and towns, called municipal waste water; it is rich in organic matter and carries large numbers of microorganisms, including harmful pathogens, so it cannot be released untreated into water bodies.

**Step 2:** Primary treatment.
The sewage first goes through physical steps: filtration and sedimentation remove floating debris and settleable solids (called sludge), leaving behind the effluent, which still contains dissolved and suspended organic material.

**Step 3:** Secondary (biological) treatment.
This effluent is passed into large aeration tanks and constantly agitated with air, letting aerobic bacteria and other microbes grow as flocs and consume most of the remaining organic matter. This significantly cuts the biochemical oxygen demand (BOD) of the water.

**Step 4:** Final step.
The settled microbial floc (activated sludge) is allowed to sink, most of it is recycled back into the aeration tank to keep the process going, and the clarified water (with lowered BOD) is finally released into a natural water body.

**Final Answer:**
Sewage is used municipal waste water; its biological treatment mainly happens in the aeration tank, where aerobic microbes break down the organic matter before the treated water is safely released.

**Quick Tip:** The key biological step happens in an aeration tank, where microbes feed on the organic pollutants.

**6(a).** Comment upon the following: (i) Cloning (ii) Transgenic plants.

**Correct Answer:** —

**Solution:**

**Step 1:** Cloning, what it means.
Cloning is the production of a genetically identical copy of an organism, a cell, or a DNA segment, without the usual sexual reproduction process, so the copy carries the exact same genetic material as the original.

**Step 2:** Cloning, an example.
Dolly the sheep, produced by transferring the nucleus of an adult mammary cell into an egg cell whose own nucleus had been removed,

is the best known example of animal cloning.

**Step 3:** Transgenic plants, what they are.
A transgenic plant is one into which a foreign gene (from a different species) has been deliberately inserted using genetic engineering techniques, so it now carries and expresses that foreign gene along with its own.

**Step 4:** Transgenic plants, an example and use.
Bt cotton is a well known transgenic plant, carrying a gene from the bacterium Bacillus thuringiensis that makes the plant resistant to certain insect pests, cutting the need for chemical pesticides.

**Final Answer:**
Cloning produces a genetically identical copy of an organism (as with Dolly the sheep); transgenic plants carry a foreign gene inserted by genetic engineering, as in pest resistant Bt cotton.

**Quick Tip:** Cloning is about making an identical copy; transgenic plants are about adding a foreign gene.

**6(b).** Describe the method of separation and isolation of fragments generated on cutting of DNA by restriction endonuclease.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
When a restriction endonuclease cuts a DNA sample, it does not

produce one piece, it produces many fragments of different lengths, since the recognition sequence occurs at several places along the DNA. These fragments must be separated by size before they can be studied or used further.

**Step 2:** Key technique, gel electrophoresis.
The cut DNA mixture is loaded into wells of an agarose gel, and an electric current is passed through the gel. Since DNA carries a negative charge (from its phosphate groups), the fragments move toward the positive electrode through the pores of the gel.

**Step 3:** Why the fragments separate by size.
Smaller DNA fragments slip through the gel's pores more easily and move faster, travelling further from the well, while larger fragments move more slowly and stay closer to the well. This creates a set of distinct bands arranged by size along the gel.

**Step 4:** Visualising and isolating the fragments.
The bands are stained (commonly with ethidium bromide) and seen as fluorescent bands under UV light. A chosen band of the right size can then be cut out of the gel and the DNA eluted (extracted) from that gel piece for further use, a step called elution.

**Final Answer:**
DNA fragments from a restriction digest are separated by size using agarose gel electrophoresis, visualised by staining, and the desired fragment is then cut out and eluted from the gel.

**Quick Tip:** Think about what property of DNA lets an electric field sort fragments by size in a gel.

**6(c).** Explain the application of biotechnology in agriculture.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
Agricultural biotechnology uses genetic engineering tools to give crop plants new, useful traits that they do not have naturally, aiming to raise yield, cut losses, and reduce the need for chemical inputs.

**Step 2:** Pest resistance.
Bt crops, such as Bt cotton and Bt brinjal, carry a gene from the bacterium Bacillus thuringiensis that makes a protein toxic to specific insect larvae, protecting the crop without needing heavy chemical pesticide spraying.

**Step 3:** Other useful traits.
Biotechnology has also been used to engineer resistance to plant nematodes (for example, using RNA interference against the root-knot nematode in tobacco), and to improve nutritional quality, as in golden rice, which is engineered to make beta-carotene, a source of vitamin A.

**Final Answer:**
In agriculture, biotechnology gives crops pest resistance (Bt cotton), nematode resistance (RNAi based), and better nutrition (golden rice), reducing losses and improving crop quality.

**Quick Tip:** Think of three kinds of benefit: fighting insects, fighting

nematodes, and improving nutrition.

**6(d).** Describe the different types of ecological pyramids in brief.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:
An ecological pyramid is a graphic way to show how some quantity changes from the producer level, through successive consumer levels, to the top of a food chain. There are three standard types, based on what is being measured.

**Step 2:** Pyramid of numbers.
This plots the number of individual organisms at each trophic level. It is usually upright (many producers, fewer top consumers), but it can be inverted, for example one large tree (one producer) supporting many insects feeding on it.

**Step 3:** Pyramid of biomass.
This plots the total dry mass of organisms at each trophic level. On land it is usually upright, since plant biomass is large, but in some aquatic ecosystems it can be inverted, since small, fast-reproducing phytoplankton support a heavier standing mass of animals.

**Step 4:** Pyramid of energy.
This plots the rate of energy flow through each trophic level. Because energy is always lost as heat at every transfer (following the second law of thermodynamics), this pyramid is always upright and is never inverted, in any ecosystem.

**Final Answer:**
The three types are the pyramid of numbers, the pyramid of biomass (both of which can sometimes be inverted), and the pyramid of energy, which is always upright.

**Quick Tip:** Two of the three pyramids can sometimes flip upside down; one of them, tied to thermodynamics, never can.

**7.** Define oogenesis. Describe the process of oogenesis with a diagram.

**Correct Answer:** —

**Solution:**

**Step 1:** Define oogenesis.
Oogenesis is the process by which a diploid oogonium (egg mother cell) in the ovary develops into a mature haploid female gamete, the ovum (egg), through a specific sequence of growth and meiotic division.

**Step 2:** Formation of primary oocytes, before birth.
In the foetal ovary, oogonia multiply by mitosis, then some enter meiosis I but stop partway through, arresting at the prophase I stage. Each arrested cell, now called a primary oocyte, gets surrounded by a layer of granulosa cells, forming a primary follicle. Millions of these primary follicles are already present at birth.

**Step 3:** Growth and completion of meiosis I, at puberty.
From puberty onward, in each menstrual cycle a batch of primary

follicles starts growing further under hormonal control, and usually one dominant follicle matures fully into a Graafian follicle. Just before ovulation, the primary oocyte inside it completes meiosis I, producing two unequal-sized cells, a large secondary oocyte and a tiny first polar body.

**Step 4:** Ovulation and completion of meiosis II.
The secondary oocyte is released at ovulation and starts meiosis II, but again stops partway, this time at metaphase II. It only completes this second division, forming the mature ovum and a second polar body, if a sperm actually fertilises it.

**Step 5:** Diagram description.
A simple flow diagram would show: oogonium (mitosis) -> primary oocyte (arrested in meiosis I, inside a primary follicle) -> [puberty, growth] -> secondary oocyte + first polar body (meiosis I complete) -> [after fertilisation] -> ovum + second polar body (meiosis II complete).

**Final Answer:**
Oogenesis converts a diploid oogonium into a haploid ovum through two meiotic divisions that pause at prophase I (until puberty) and at metaphase II (until fertilisation), each division producing one large cell and one small polar body.

**Quick Tip:** Track the two pause points in meiosis: one lasts until puberty, the other lasts until fertilisation.

*OR*

Write explanatory notes on the following: (i) Sterilization (ii) Infertility.

**Correct Answer:** –

**Solution:**

**Step 1:** Sterilization, what it is.

Sterilization refers to surgical birth control methods that permanently block the passage of gametes, so fertilisation cannot happen. It is meant for couples who do not want any more children, since it is usually not easily reversible.

**Step 2:** Sterilization, the two procedures.

In males, the procedure is vasectomy, a small cut is made in the scrotum and each vas deferens (the tube carrying sperm) is cut and tied, so sperm can no longer reach the semen. In females, the procedure is tubectomy, where each fallopian tube is cut and tied, so the egg can no longer meet sperm or reach the uterus.

**Step 3:** Infertility, what it is.

Infertility is the inability of a couple to conceive a child even after one year of regular, unprotected intercourse. The cause can lie with either partner and includes physical, hormonal, functional, psychological, or congenital reasons.

**Step 4:** Infertility, how it is addressed.

Once the specific cause is diagnosed, treatment can range from correcting the underlying problem to using Assisted Reproductive Technology (ART), such as in vitro fertilisation (IVF), where fertilisation is done outside the body and the resulting embryo is transferred into the uterus.

**Final Answer:**

Sterilization (vasectomy in males, tubectomy in females) permanently blocks gamete transport for birth control, while infertility is the inability to conceive after a year of trying, treatable with methods including ART like IVF.

**Quick Tip:** One is a deliberate, permanent contraceptive choice; the other is an unwanted medical condition with a range of causes.

**8.** Describe the technique and application of DNA fingerprinting.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:

DNA fingerprinting is a technique that identifies differences in specific, repetitive regions of DNA, called VNTRs (variable number tandem repeats), which vary a lot between individuals even though most of the rest of the genome is very similar between people. This variability gives each person (other than identical twins) a unique DNA 'fingerprint' pattern.

**Step 2:** Steps of the technique.

DNA is extracted from a sample (blood, hair root, or any tissue), then cut into fragments using restriction endonucleases. These fragments are separated by size using gel electrophoresis, then transferred onto a nylon membrane (Southern blotting). A labelled probe that binds the VNTR regions is then used to reveal the pattern of bands, the DNA fingerprint.

**Step 3:** Applications.
It is used in forensic science, to match DNA from a crime scene (blood, hair, semen) to a suspect. It is used in paternity and family relationship testing, since children share fingerprint bands with their biological parents. It is also used in population and wildlife genetic studies, and evolutionary studies of genetic diversity.

**Final Answer:**
DNA fingerprinting detects an individual's unique VNTR band pattern using restriction digestion, gel electrophoresis, and probe hybridisation, and is widely applied in forensics, paternity testing, and population studies.

**Quick Tip:** Focus on the repeat sequences that vary between people, and the steps that turn them into a visible band pattern.

*OR*

Write notes on the following: (i) Chromosomal aberrations (ii) Pedigree analysis.

**Correct Answer:** —

**Solution:**

**Step 1:** Chromosomal aberrations, what they are.
Chromosomal aberrations are changes in the normal structure or number of chromosomes, different from a simple gene mutation, which only changes one small DNA sequence.

**Step 2:** Chromosomal aberrations, types.
Structural aberrations include deletion (part of a chromosome is lost),

duplication (a segment is repeated), inversion (a segment is reversed), and translocation (a segment moves to a different chromosome). Numerical aberrations, called aneuploidy, involve gain or loss of individual chromosomes, as seen in Down's syndrome, where an extra copy of chromosome 21 is present (trisomy 21).

**Step 3:** Pedigree analysis, what it is.
Pedigree analysis is the study of a family's history of a particular trait or disorder across several generations, recorded using a standard chart of symbols, to work out how that trait is being inherited.

**Step 4:** Pedigree analysis, its use.
By tracing which family members show a trait, geneticists can tell whether the trait is dominant or recessive, and whether the gene is autosomal or sex linked, which is valuable for genetic counselling of families.

**Final Answer:**
Chromosomal aberrations are structural or numerical changes to chromosomes (like trisomy 21 in Down's syndrome); pedigree analysis traces a trait through a family tree to work out its pattern of inheritance.

**Quick Tip:** One note is about changes to chromosome structure or number; the other is about reading inheritance patterns from a family tree.

**9.** Describe the different population interactions with suitable examples.

**Correct Answer:** —

**Solution:**

**Step 1:** Understanding the Concept:

Population interactions describe how two different species living together in the same habitat affect each other's survival, growth, or reproduction. These interactions can help, harm, or have no effect on each species.

**Step 2:** Mutualism and commensalism.

In mutualism, both species benefit, for example lichens, where a fungus and an alga live together, the fungus giving protection and minerals while the alga provides food through photosynthesis. In commensalism, one species benefits while the other is unaffected, for example an orchid growing as an epiphyte on a large tree branch, gaining support without harming the tree.

**Step 3:** Predation and parasitism.

In predation, one organism (the predator) kills and eats another (the prey), for example a tiger hunting a deer. In parasitism, one organism (the parasite) lives in or on another (the host) and feeds off it, harming the host without immediately killing it, for example a tapeworm living in the human intestine.

**Step 4:** Competition and amensalism.

In competition, both species are harmed as they struggle over the same limited resource, for example two species of flour beetle competing for the same grain. In amensalism, one species is harmed while the other is unaffected, for example a large tree shading out and stunting small plants growing beneath it, without gaining anything itself from doing so.

**Final Answer:**
Population interactions include mutualism (both gain, as in lichens), commensalism (one gains, other unaffected, as with epiphytic orchids), predation and parasitism (one gains, other harmed), competition (both harmed), and amensalism (one harmed, other unaffected).

**Quick Tip:** Score each interaction as plus, minus, or zero for each of the two species involved; that gives you all six named interactions.

*OR*

Comment upon the following: (i) Biodiversity hotspots (ii) Productivity.

**Correct Answer:** —

**Solution:**

**Step 1:** Biodiversity hotspots, what they are.
A biodiversity hotspot is a region of the world that has an exceptionally large number of species found nowhere else (high endemism), but which is also under serious threat from habitat loss, making it a priority for conservation.

**Step 2:** Biodiversity hotspots, examples and importance.
The Western Ghats and Sri Lanka, along with the Indo-Burma region, are recognised biodiversity hotspots within India's neighbourhood. Because such a large fraction of unique species is packed into a small area, protecting hotspots is a highly efficient way to save global biodiversity with limited conservation resources.

**Step 3:** Productivity, what it is.

Productivity in ecology is the rate at which biomass (organic matter) is produced by organisms in an ecosystem, per unit area, over a period of time, and it forms the base of the energy that supports the whole food chain.

**Step 4:** Productivity, its two main types.
Gross primary productivity (GPP) is the total rate of production of organic matter by producers through photosynthesis. Net primary productivity (NPP) is what is left after subtracting the amount the producers themselves use up in respiration (NPP = GPP minus respiration), and it is this NPP that is actually available to the herbivores that eat the producers.

**Final Answer:**
Biodiversity hotspots are species rich but threatened regions (like the Western Ghats) that are conservation priorities, while productivity is the rate of biomass production in an ecosystem, split into gross and net primary productivity.

**Quick Tip:** A hotspot needs both high uniqueness and high threat; productivity splits into what is made (gross) and what is left over after the plant's own use (net).