AIIMS Paramedical Biology Sample Paper – 11

Duration: 30 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of **AIIMS Paramedical** entrance.
- Each correct answer carries **+1 mark**. A penalty of $-\frac{1}{3}$ **mark** is deducted for each incorrect answer. Unattempted questions carry **0 marks** (no negative marking).
- Only **one** option is correct. Choose carefully.
- Syllabus level:**Class 11 & 12 NCERT Physics**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. A patient presents with chronic vitamin B12 deficiency. Upon investigation, a significant autoimmune destruction of specific cells in the gastric mucosa is noted. Which cells are primarily affected in this condition?

(A) Chief cells

(B) Peptic cells

(C) Oxyntic cells

(D) Goblet cells

Q2. If a segment of double-stranded DNA contains 28% cytosine bases, what will be the percentage of adenine bases present in this DNA fragment?

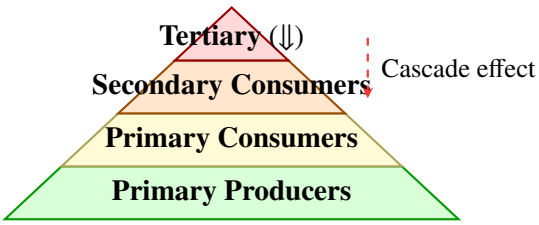
(A) 22%

(B) 28%

(C) 44%

(D) 56%

Q3. In an ecosystem, the population of a tertiary consumer decreases drastically due to a viral epidemic. What is the immediate expected effect on the secondary consumer and primary producer levels?



(A) Secondary consumers decrease; primary producers increase

(B) Secondary consumers increase; primary producers increase

(C) Secondary consumers increase; primary producers decrease

(D) Secondary consumers decrease; primary producers decrease

Q4. Consider a scenario where an endosperm cell of an angiosperm contains 36 chromosomes. What would be the expected chromosome number in the synergid cell and the microspore mother cell of the same plant species?

(A) 12 and 24

(B) 24 and 12

(C) 12 and 36

(D) 18 and 36

Q5. A student observes a plant specimen showing parallel venation and fibrous roots. Upon taking a cross-section of its stem, which anatomical feature is most likely to be observed under the microscope?

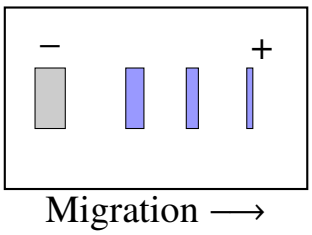
(A) Sclerenchymatous bundle sheath surrounding conjoint, closed vascular bundles

(B) Parenchymatous bundle sheath surrounding conjoint, open vascular bundles

(C) Vascular bundles arranged in a distinct ring with intrafascicular cambium

(D) Radial arrangement of xylem and phloem strands with exarch protoxylem

Q6. During the separation of DNA fragments using agarose gel electrophoresis, a student loaded the digested plasmid sample near the negative electrode. After running the gel, which fragments will be located closest to the anode?



(A) The largest linear fragments

(B) The smallest linear fragments

(C) Nicked circular plasmid DNA

(D) Fragments with the highest GC content

Q7. In an experimental setup, a plant is exposed to light containing only green wavelengths. What will be the direct effect on the rate of oxygen evolution compared to exposing the same plant to white light?

(A) It will double due to maximum absorption by carotenoids.

(B) It will drop close to zero because chlorophyll absorbs green light poorly.

(C) It will remain unchanged because accessory pigments absorb green light efficiently.

(D) It will shift towards cyclic photophosphorylation only, releasing more oxygen.

Q8. In a specific cross between individuals with genotypes AaBb and aabb, the offspring population shows a recombinant frequency of 16%. What is the precise distance between the two linked genes on the chromosome?

(A) 8 map units

(B) 16 map units

(C) 32 map units

(D) 84 map units

Q9. While examining a patient's blood report, a clinician notices an elevated level of a specific immunoglobulin responsible for mediating type-I hypersensitivity and allergic reactions. Which class of antibody is this?

(A) IgG

(B) IgM

(C) IgA

(D) IgE

Q10. Which statement regarding the chordate subphyla is entirely accurate regarding their structural characteristics?

(A) In Urochordata, the notochord persists throughout life from head to tail.

(B) In Cephalochordata, the notochord is present only in the larval tail.

(C) In Vertebrata, the embryonic notochord is replaced by a cartilaginous or bony vertebral column.

(D) All protochordates retain a bony vertebral column during adult stages.

Q11. A mutation alters the codon 5'-UAC-3' to 5'-UAA-3' in the middle of an mRNA sequence encoding a functional structural enzyme. What is the most likely consequence on the synthesized polypeptide?

(A) A different amino acid is inserted, changing protein conformation.

(B) Translation terminates prematurely, resulting in a shortened polypeptide.

(C) The translation speed increases significantly without changing the protein length.

(D) The ribosome skips the mutation site and continues normal elongation.

Q12. During a routine cardiac cycle assessment, the volume of blood pumped out by each ventricle per minute is calculated. If a person has a heart rate of 75 beats per minute and an end-diastolic volume of 120 mL with an end-systolic volume of 50 mL, what is their cardiac output?

(A) 3.75 L/min

(B) 5.25 L/min

(C) 6.00 L/min

(D) 9.00 L/min

Q13. In the context of wastewater treatment, the primary objective of secondary treatment in a sewage treatment plant is to drastically reduce which parameter?

(A) Dissolved heavy metal concentration

(B) Biochemical Oxygen Demand (BOD)

(C) Large floating debris and suspended grit

(D) Non-biodegradable synthetic polymers

Q14. An isolate from a hot spring is found to be a unicellular organism with a cell wall lacking peptidoglycan, containing branched-chain lipids in its membrane. To which taxonomic group does this organism belong?

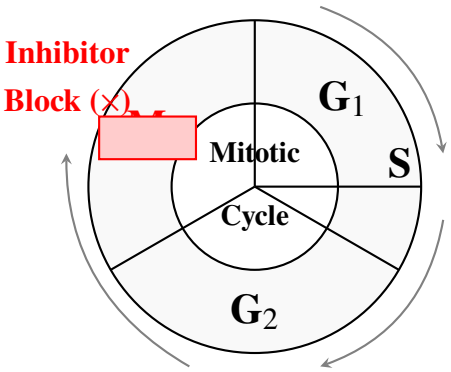
(A) Cyanobacteria

(B) Eubacteria

(C) Archaebacteria

(D) Dinoflagellates

Q15. A cell is treated with a metabolic inhibitor that specifically prevents the synthesis of the protein tubulin. During which specific phase of the mitotic cell cycle will this cell encounter an absolute arrest?



(A) G1 phase

(B) S phase

(C) G2 phase

(D) M phase

Q16. A hormonal imbalance in an adult patient causes a low metabolic rate, weight gain, a tendency to feel cold, and subcutaneous tissue swelling. Deficiency of which hormone is most likely responsible?

(A) Growth Hormone

(B) Cortisol

(C) Thyroxine

(D) Parathyroid Hormone

Q17. In a laboratory experiment, a restriction endonuclease creates staggered cuts leaving single-stranded sticky ends on a vector DNA molecule. What property allows these sticky ends to facilitate cloning?

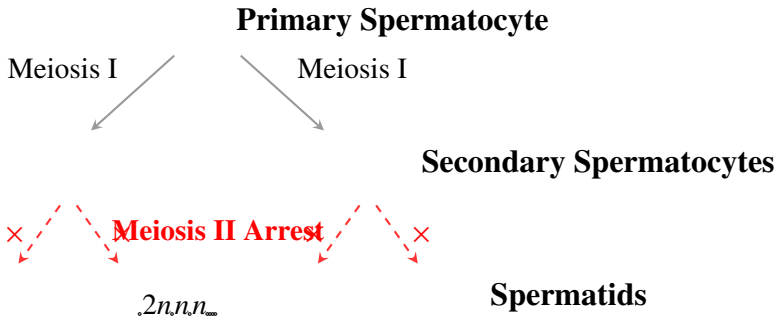
(A) They possess covalent phosphodiester bonds ready for exonuclease attack.

(B) They readily form hydrogen bonds with complementary single-stranded tails of the insert.

(C) They eliminate the necessity of using DNA ligase during the final sealing stage.

(D) They prevent the vector from undergoing any self-ligation reactions.

Q18. An individual experiences normal spermatogenesis up to the formation of secondary spermatocytes. However, these cells fail to undergo the second meiotic division. What will be the immediate direct outcome?



(A) Primary spermatocytes will accumulate exponentially.

(B) Spermatids will not be formed.

(C) Spermatozoa with double the normal chromosome number will develop.

(D) Leydig cells will stop secreting testosterone.

Q19. Under conditions of acute water stress, which endogenous plant growth regulator increases rapidly in leaves to trigger stomatal closure and minimize transpirational loss?

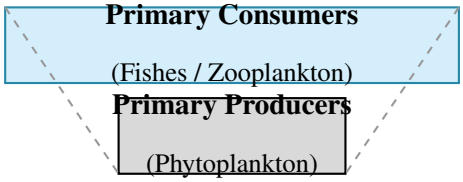
(A) Indole-3-acetic acid

(B) Abscisic acid

(C) Gibberellic acid

(D) Zeatin

Q20. An analysis of an ecosystem indicates that the biomass pyramid is inverted, where a small standing crop of primary producers supports a significantly larger biomass of primary consumers. Which ecosystem type does this represent?



(A) A dense tropical rainforest

(B) A temperate grassland

(C) A marine ecosystem

(D) A desert scrubland

Q21. A sample of fungi reveals septate hyphae and asexual reproduction through exogenously produced conidia. The sexual stage involves the endogenous formation of spores inside a sac-like structure. Which class does this belong to?

(A) Phycomycetes

(B) Ascomycetes

(C) Basidiomycetes

(D) Deuteromycetes

Q22. During replication, the lagging strand is synthesized discontinuously due to the inherent directional constraints of the replicating enzyme. Which statement correctly identifies the enzyme and direction of synthesis?

(A) DNA polymerase III synthesizes in the 3' to 5' direction.

(B) DNA polymerase III synthesizes in the 5' to 3' direction.

(C) DNA ligase synthesizes in the 3' to 5' direction.

(D) RNA primase synthesizes in the 3' to 5' direction.

Q23. A human female decides to use a copper-releasing intrauterine device (IUD) as a contraceptive method. What is the primary mechanism by which copper ions exert their contraceptive effect?

(A) Completely blocking the surge of luteinizing hormone to inhibit ovulation.

(B) Suppressing sperm motility and reducing the fertilizing capacity of sperms.

(C) Creating a permanent physical barrier across the external os of the cervix.

(D) Inducing immediate luteolysis of the corpus luteum within 24 hours.

Q24. A molecular biologist wants to amplify a specific gene sequence using Polymerase Chain Reaction (PCR). If they forget to add the step of denaturation, what will be the outcome of the reaction?

(A) The primers will bind non-specifically to double-stranded DNA.

(B) Taq polymerase will synthesize DNA at a reduced speed.

(C) No amplification will occur because the template strands cannot separate.

(D) The dNTPs will degrade due to the low temperature of the mixture.

Q25. While studying human nephron function, it is observed that a drug completely blocks the active transport of sodium ions in the thick ascending limb of the loop of Henle. What will be the direct effect on urine concentration?

(A) The urine will become highly concentrated (hypertonic).

(B) The medullary osmotic gradient will fail, resulting in dilute (hypotonic) urine.

(C) Large amounts of glucose and amino acids will appear in the urine.

(D) The glomerular filtration rate will increase five-fold immediately.

Q26. A standard mendelian dihybrid cross is performed between a plant with round yellow seeds (RRYY) and wrinkled green seeds (rryy). In the F2 generation, what proportion of the offspring is expected to display a completely heterozygous genotype for both traits?

(A) 1/16

(B) 2/16

(C) 4/16

(D) 9/16

Q27. A plant physiology experiment measures the rate of glycolysis in a tissue sample. If an inhibitor completely deactivates the enzyme phosphofructokinase, which intermediate product will fail to form?

Fructose-6-Phosphate

$\downarrow$ Phosphofructokinase ($\times$)

Fructose-1,6-Bisphosphate

(A) Glucose-6-phosphate

(B) Fructose-6-phosphate

(C) Fructose-1,6-bisphosphate

(D) Glyceraldehyde-3-phosphate

Q28. In a clinical case, a mother with blood group A (heterozygous) and a father with blood group B (heterozygous) have a child. What are all the possible blood groups that this child could potentially inherit?

(A) Only A and B

(B) Only AB and O

(C) Only A, B, and AB

(D) A, B, AB, and O

Q29. A botanist discovers a new plant species in an arid zone. The plant exhibits a specialized anatomical feature where bundle sheath cells contain large chloroplasts without grana, and mesophyll cells have normal grana. Which photosynthetic pathway does this plant utilize?

(A) C3 pathway

(B) C4 pathway

(C) CAM pathway

(D) C2 pathway (Photorespiration)

Q30. A team of conservationists measures a high rate of species loss in a small, fragmented forest habitat surrounded by intensive agricultural fields. This phenomenon of species loss due to habitat fragmentation is primarily categorized under which threat?

(A) Over-exploitation

(B) Alien species invasion

(C) Co-extinctions

(D) The Evil Quartet

Detailed Solutions

Q1.

Solution

Concept: The stomach wall contains gastric glands with highly specialized cells. Vitamin B12 absorption requires intrinsic factor, which is secreted by the same mucosal cells responsible for hydrochloric acid production. Autoimmune destruction of these specific cells stops both acid and intrinsic factor secretion, causing pernicious anemia.

Solution: Step 1: Analyze the physiological role of the cells mentioned. Chief cells and peptic cells are synonyms for the cells that secrete inactive pepsinogen, which is not directly involved in vitamin absorption.
Step 2: Goblet cells are specialized epithelial cells distributed throughout the gastrointestinal tract that secrete mucus to protect the mucosal lining from mechanical and chemical damage.
Step 3: Oxyntic cells, also universally known as parietal cells, possess a dual secretional role. They secrete hydrochloric acid (HCl) to activate pepsinogen and intrinsic factor (Castle's intrinsic factor).
Step 4: Intrinsic factor binds to dietary vitamin B12 in the small intestine, forming a complex essential for its absorption in the terminal ileum.
Step 5: When an autoimmune response targets and destroys oxyntic cells, intrinsic factor levels fall to zero. This leads to a severe malabsorption of vitamin B12, causing chronic deficiency.

Final Answer: Oxyntic cells

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: According to Chargaff's rules for double-stranded DNA molecules, base pairing is specific. Adenine always pairs with thymine via two hydrogen bonds, and guanine always pairs with cytosine via three hydrogen bonds. Consequently, the total percentage of purines equals the total percentage of pyrimidines.

Solution: Step 1: Identify the given base percentage. The problem states that the double-stranded DNA fragment contains 28% cytosine (C).
Step 2: Apply Chargaff's rule for guanine and cytosine. Because cytosine pairs exclusively with guanine, their quantities must be equal. Therefore, G = C = 28%.
Step 3: Calculate the combined percentage of the guanine-cytosine base pairs:

$$G + C = 28\% + 28\% = 56\%$$

Step 4: Determine the remaining portion of the DNA sequence, which must consist entirely of adenine (A) and thymine (T):

$$A + T = 100\% - 56\% = 44\%$$

Step 5: Apply Chargaff's rule for adenine and thymine, which states that A = T. Divide the remaining percentage equally between the two bases:

$$A = \frac{44\%}{2} = 22\%$$

Thus, the precise percentage of adenine bases in this double-stranded DNA fragment is 22%.

Final Answer: 22%

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: A trophic cascade occurs when a predator level in a food web is altered, leading to alternating reciprocal changes in the lower biomass levels. In an ecological pyramid, energy flows upwards, while population regulation often operates via top-down control systems.

Solution: Step 1: Establish the baseline structure of the four-tier ecological pyramid. The arrangement from base to apex is: Primary Producers → Primary Consumers → Secondary Consumers → Tertiary Consumers.
Step 2: Analyze the dynamic relationship between the top levels. Tertiary consumers feed directly upon secondary consumers. When a viral epidemic wipes out the tertiary consumers, the predatory pressure on secondary consumers is removed.
Step 3: Predict the immediate consequence on the secondary consumers. Due to the lack of predation, their survival rate increases dramatically, causing an immediate expansion in the secondary consumer population.
Step 4: Trace the impact from secondary consumers down to primary consumers. The surging secondary consumer population requires more food and consumes primary consumers at a much higher rate, causing primary consumers to decrease.
Step 5: Trace the final impact down to primary producers. A decline in primary consumers reduces the grazing pressure on primary producers. Therefore, the primary producer population will rise.

Final Answer: Secondary consumers increase; primary producers increase

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: Angiosperm structures follow precise ploidy rules during lifecycle development. The vegetative cells within the male and female gametophytes are haploid (n). The vegetative tissues and spore mother cells are diploid ($2n$). The endosperm tissue formed via triple fusion is triploid ($3n$).

Solution: Step 1: Utilize the given information to establish the base chromosome number (n). The endosperm cell is triploid ($3n$). We set up the algebraic equation:

$$3n = 36$$

Step 2: Calculate the value of a single haploid set by dividing the total endosperm count by three:

$$n = \frac{36}{3} = 12$$

Step 3: Determine the ploidy of a synergid cell. Synergid cells are structural components of the female gametophyte (embryo sac) formed by mitotic divisions of a functional megaspore, making them haploid (n):

$$\text{Synergid} = n = 12$$

Step 4: Determine the ploidy of a microspore mother cell. The microspore mother cell (pollen mother cell) is a specialized diploid microsporangial tissue destined to undergo meiosis to produce microspores:

$$\text{Microspore Mother Cell} = 2n = 2 \times 12 = 24$$

Step 5: Combine both values to form the required answer sequence, which yields 12 and 24.

Final Answer: 12 and 24

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: The combination of parallel leaf venation and fibrous root systems identifies a plant specimen as a monocotyledon. Monocot stems possess distinct tissue arrangements that differentiate them from dicot stems, notably regarding vascular bundles and the absence of cambial layers.

Solution: Step 1: Identify the taxonomic group of the plant based on its morphology. Parallel venation and a fibrous root system are diagnostic structural features confined to monocotyledonous plants.
Step 2: Evaluate the general vascular architecture of a monocotyledonous stem. Monocot stems possess numerous vascular bundles scattered throughout the ground tissue rather than arranged in a coordinated concentric ring.
Step 3: Analyze the internal components of these individual vascular bundles. Each bundle is conjoint, collateral, and closed, meaning it lacks intrafascicular cambium and cannot undergo secondary growth.
Step 4: Examine the structural support surrounding each bundle. To withstand physical bending forces, each scattered vascular bundle is enclosed by a rigid, protective sheath composed of thick-walled sclerenchyma cells.
Step 5: Contrast with options B, C, and D. Open vascular bundles, distinct ring arrangements, and radial arrangements with exarch xylem are characteristics belonging to dicot stems and root systems.

Final Answer: Sclerenchymatous bundle sheath surrounding conjoint, closed vascular bundles

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: Agarose gel electrophoresis separates DNA molecules strictly on the basis of their structural length and molecular weight. Because the sugar-phosphate backbone gives DNA an inherent net negative charge, fragments migrate through the gel matrix towards the positive anode when subjected to an electric field.

Solution: Step 1: Understand the driving force behind migration. DNA molecules are highly polyanionic due to their phosphate groups. When placed in an electric field, they experience an electrostatic force directing them toward the positive electrode (anode).
Step 2: Analyze the filtering mechanism of the agarose gel. The gel behaves as a microscopic molecular sieve. Smaller DNA fragments move easily through the pores, encountering minimal friction.
Step 3: Analyze how larger DNA structures travel. Long, bulky fragments become entangled within the structural polymer network, slowing their migration rate.
Step 4: Determine the relative final positions on the gel. Because small fragments migrate at the highest velocity, they travel the furthest distance away from the loading wells (negative cathode) and settle closest to the anode.
Step 5: Conclude that the smallest linear fragments will be positioned closest to the anode at the end of the run. GC content does not alter migration distance in standard agarose matrices.

Final Answer: The smallest linear fragments

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Photosynthetic activity depends heavily on the absorption profiles of primary and accessory photosynthetic pigments. Chlorophyll α and chlorophyll β absorb photons primarily in the blue and red regions of the visible light spectrum while reflecting or transmitting green light.

Solution: Step 1: Understand the physiological source of oxygen evolution. Oxygen is produced during the light-dependent reactions of photosynthesis via the photolysis of water molecules at the oxygen-evolving complex of photosystem II.
Step 2: Relate photon absorption to photolysis. Photolysis requires chlorophyll molecules to absorb light energy and transition to an excited state.
Step 3: Examine the absorption spectrum of chlorophyll pigments. Chlorophylls exhibit maximum absorption peaks in the blue (430–470 nm) and red (640–670 nm) bands. They possess an extremely low absorption coefficient for green light (500–550 nm).
Step 4: Evaluate the experimental condition. When a plant is illuminated exclusively with green light, the pigments cannot absorb enough light energy to drive photolysis.
Step 5: Conclude that the light reactions will cease, causing the overall rate of oxygen evolution to drop close to zero.

Final Answer: It will drop close to zero because chlorophyll absorbs green light poorly.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: In genetics, mapping gene loci on a linear chromosome relies on crossing over frequencies. The recombination frequency between two linked genes is directly proportional to the physical distance separating them. One percent recombination equates to one map unit (or centimorgan).

Solution: Step 1: Identify the nature of the genetic cross. The cross between a dihybrid individual (AaBb) and a homozygous recessive individual (aabb) constitutes a classic dihybrid test cross used to evaluate genetic linkage.
Step 2: Interpret the recombination data. The problem states that the resulting offspring population displays a combined recombinant frequency of 16%.
Step 3: Apply the fundamental postulate established by Alfred Sturtevant. The recombination frequency percentage can be converted directly into relative genetic map distances on a chromosome.
Step 4: Define the standard unit conversion:

$$1\% \text{ Recombination Frequency} = 1 \text{ Map Unit (mu) or Centimorgan (cM)}$$

Step 5: Substitute the given value into the scale equation:

$$\text{Distance} = 16\% = 16 \text{ map units}$$

Hence, the precise distance separating the two linked genes along the chromosome string is exactly 16 map units.

Final Answer: 16 map units

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: Immunoglobulins fulfill distinct defensive roles based on their structural constant regions. Allergic reactions and immediate type-I hypersensitivity involve a specific class of antibody that binds with high affinity to receptors on the surface of mast cells and basophils.

Solution: Step 1: Review the functional assignments of the main immunoglobulin classes. IgG is the most abundant blood antibody and crosses the placenta. IgM is secreted first during a primary immune response. IgA provides mucosal immunity in secretions.
Step 2: Identify the antibody responsible for allergies. Immunoglobulin E (IgE) is synthesized by plasma cells in response to environmental allergens.
Step 3: Analyze the mechanism of action of IgE. The Fc region of IgE binds tightly to specific FcϵRI receptors found on the membranes of tissue mast cells and circulating basophils.
Step 4: Examine what happens during re-exposure. When the allergen cross-links the bound IgE molecules, it triggers immediate degranulation. This releases pharmacological mediators like histamine, causing anaphylactic and allergic symptoms.
Step 5: Conclude that an elevated level of IgE in a patient's blood report indicates type-I hypersensitivity activity.

Final Answer: IgE

Answer: (D)

Go Back to Question 9

Q10.

Solution

Concept: Phylum Chordata is defined by key features like a dorsal notochord, a hollow nerve cord, and pharyngeal gill slits. The phylum is split into three subphyla: Urochordata, Cephalochordata, and Vertebrata, which are distinguished by how long the notochord persists and where it is located.

Solution: Step 1: Evaluate subphylum Urochordata (tunicates). In urochordates, the structural notochord is not persistent throughout life; it is present only during the motile larval stage and is confined strictly to the tail region. Thus, option A is false.
Step 2: Evaluate subphylum Cephalochordata (lancelets). In cephalochordates, the notochord extends from the tip of the head to the tail and persists throughout their entire life cycle. Thus, option B is false.
Step 3: Evaluate subphylum Vertebrata. Vertebrates possess a temporary notochord during early embryonic development. As development proceeds, this flexible rod is replaced by a segmented, supportive cartilaginous or bony vertebral column.
Step 4: Analyze option D. Protochordates (comprising Urochordata and Cephalochordata) are primitive chordates that never develop a true bony vertebral column at any stage.
Step 5: Conclude that statement C is the only entirely accurate structural description.

Final Answer: In Vertebrata, the embryonic notochord is replaced by a cartilaginous or bony vertebral column.

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: Translation depends on standard triplet codons reading from the 5′ to 3′ direction on an mRNA transcript. Point mutations that convert an amino-acid-specifying codon into a stop codon are classified as nonsense mutations, which alter translation termination.

Solution: Step 1: Analyze the initial molecular state. The codon 5′-UAC-3’ codes for the amino acid tyrosine, allowing the ribosome to continue elongating the polypeptide chain.
Step 2: Examine the single-nucleotide substitution mutation. The third base, cytosine, undergoes a point mutation and is substituted with an adenine base, changing the codon sequence to 5′-UAA-3’.
Step 3: Identify the function of the mutated codon. In the universal genetic code, 5′-UAA-3’, 5′-UAG-3’, and 5′-UGA-3’ are stop codons (nonsense codons) that do not recruit an aminoacyl-tRNA.
Step 4: Determine the effect on the translation machinery. When the translating ribosome encounters 5′-UAA-3’ in the middle of the open reading frame, release factors bind to the site, triggering the immediate release of the nascent peptide.
Step 5: Conclude that translation terminates prematurely, resulting in an incomplete, truncated, and usually non-functional polypeptide.

Final Answer: Translation terminates prematurely, resulting in a shortened polypeptide.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Cardiac output is the total volume of blood pumped out by a single ventricle into the systemic circulation each minute. It is calculated by multiplying the stroke volume—the net volume ejected per single contraction—by the heart rate.

Solution: Step 1: State the equation for determining stroke volume (SV). Stroke volume is the difference between the volume of blood in the ventricle at the end of filling (End-Diastolic Volume, EDV) and the volume remaining after contraction (End-Systolic Volume, ESV):

$$\text{SV} = \text{EDV} - \text{ESV}$$

Step 2: Substitute the given volumetric measurements into the formula:

$$\text{SV} = 120 \text{ mL} - 50 \text{ mL} = 70 \text{ mL per beat}$$

Step 3: State the equation for total Cardiac Output (CO):

$$\text{CO} = \text{Stroke Volume (SV)} \times \text{Heart Rate (HR)}$$

Step 4: Substitute the calculated stroke volume and the given heart rate (75 beats/min) into the equation:

$$\text{CO} = 70 \text{ mL/beat} \times 75 \text{ beats/min} = 5250 \text{ mL/min}$$

Step 5: Convert the final volumetric value from milliliters into liters per minute:

$$\text{CO} = \frac{5250}{1000} = 5.25 \text{ L/min}$$

The individual's net cardiac output is 5.25 L/min.

Final Answer: 5.25 L/min

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Sewage treatment operates in sequential stages. Primary treatment utilizes physical separation methods to remove grit and large floating debris. Secondary treatment is a biological process that uses aerobic microorganisms to metabolize organic matter dissolved within the effluent.

Solution: Step 1: Characterize the composition of primary effluent. After physical screening, the water contains high amounts of dissolved organic matter, which exerts a massive oxygen demand on receiving water bodies.
Step 2: Define Biochemical Oxygen Demand (BOD). BOD measures the mass of dissolved oxygen consumed by aerobic microbes to completely decompose the organic material present in a specific volume of water.
Step 3: Analyze the mechanics of biological secondary treatment. The primary effluent is continuously pumped into large aeration tanks containing active flocs of aerobic bacteria and fungi.
Step 4: Observe the resulting metabolic effect. These microbes consume the organic matter, converting it into cellular mass and carbon dioxide, which reduces the BOD of the sewage water.
Step 5: Conclude that the primary objective of secondary treatment is to lower the BOD before discharging the water into natural ecosystems.

Final Answer: Biochemical Oxygen Demand (BOD)

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Kingdom Monera includes diverse prokaryotic organisms split into distinct evolutionary branches. Archaebacteria possess unique biochemical adaptations that allow them to thrive in extreme environments like hydrothermal vents, hyper-saline lakes, and highly acidic hot springs.

Solution: Step 1: Analyze the structural data provided. The specimen is a unicellular prokaryotic organism isolated from an extreme thermal habitat (a hot spring).
Step 2: Examine the composition of its cell wall. Unlike typical eubacteria and cyanobacteria, which possess a rigid peptidoglycan matrix, this organism's cell wall lacks peptidoglycan entirely.
Step 3: Analyze its plasma membrane chemistry. Standard organisms possess straight-chain fatty acids linked via ester bonds to glycerol. In contrast, this organism has branched-chain lipids linked via ether bonds.
Step 4: Relate membrane structure to environmental tolerance. The branched-chain structure reduces membrane fluidity and increases thermal stability, preventing the bilayer from melting at high temperatures.
Step 5: Match these specific biochemical and ecological traits to the correct group: Archaebacteria (specifically thermoacidophiles).

Final Answer: Archaebacteria

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept: Mitosis requires the assembly and disassembly of a bipolar spindle apparatus to accurately segregate sister chromatids. Spindle fibers are composed of microtubules, which are structural polymers assembled from heterodimers of α-tubulin and β-tubulin proteins.

Solution: Step 1: Understand the biochemical effect of the drug. The metabolic inhibitor halts the synthesis of tubulin proteins, meaning no new microtubule subunits are available inside the cytoplasm.
Step 2: Evaluate the cellular requirements of the interphase stages. G1, S, and G2 phases focus on metabolic growth, DNA replication, and organelle duplication, which do not rely on a spindle apparatus.
Step 3: Analyze the structural requirements of the mitotic phase (M phase). During prophase and metaphase, the cell must rapidly polymerize tubulin subunits into dynamic spindle fibers.
Step 4: Determine the impact of a tubulin deficit on M phase. Without tubulin, the cell cannot form spindle fibers or attach them to the kinetochores of aligned chromosomes.
Step 5: Conclude that the cell cycle will arrest during M phase (specifically at the spindle assembly checkpoint) because it cannot complete chromosome segregation.

Final Answer: M phase

Answer: (D)

Go Back to Question 15

Q16.

Solution

Concept: The endocrine system regulates basal metabolic rate via hormones secreted by the thyroid gland. In adults, a severe deficiency in these iodinated amine hormones slows metabolic processes and causes distinct physical symptoms.

Solution: Step 1: Analyze the clinical presentation. The patient exhibits a low basal metabolic rate, unexplained weight gain, cold intolerance, and subcutaneous tissue swelling due to water retention.
Step 2: Identify the classic pathology described. This constellation of symptoms in an adult patient is diagnostic of severe hypothyroidism, clinically known as myxedema.
Step 3: Evaluate the physiological role of the thyroid hormones. Thyroxine (T_4) and triiodothyronine (T_3) act on almost all tissues to stimulate oxygen consumption, heat production, and nutrient metabolism.
Step 4: Correlate deficiency with the symptoms. When thyroxine levels fall, cellular respiration slows, reducing heat production (causing cold intolerance) and shifting energy storage toward fat accumulation.
Step 5: Rule out the other options. Growth hormone deficiency causes dwarfism in children. Cortisol deficiency causes Addison's disease. Parathyroid hormone deficiency causes tetany. Thus, thyroxine deficiency is responsible.

Final Answer: Thyroxine

Answer: (C)

Go Back to Question 16

Q17.

Solution

Concept: Recombinant DNA technology relies on restriction endonucleases to cut DNA backbones at specific palindromic sequences. Enzymes that make staggered cuts leave short, single-stranded overhangs known as sticky ends, which facilitate molecular cloning.

Solution: Step 1: Analyze the physical nature of sticky ends. Staggered cuts leave un-paired nucleotides extending from the double-stranded DNA molecule.
Step 2: Examine how sticky ends interact. These single-stranded overhangs can form spontaneous base pairs with any complementary single-stranded sequence cut by the same restriction enzyme.
Step 3: Identify the chemical bonds involved in initial annealing. The complementary bases pair via non-covalent hydrogen bonding, which stabilizes the vector and insert interaction.
Step 4: Evaluate the role of DNA ligase. Hydrogen bonding holds the fragments together temporarily, but DNA ligase is still required to catalyze the formation of covalent phosphodiester bonds to seal the backbone.
Step 5: Select the correct statement. The utility of sticky ends lies in their ability to easily form hydrogen bonds with complementary single-stranded tails on the insert DNA fragment.

Final Answer: They readily form hydrogen bonds with complementary single-stranded tails of the insert.

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: Spermatogenesis is a highly coordinated differentiation process where diploid germ cells undergo meiotic divisions to produce haploid gametes. Each stage of division produces a structurally distinct cell type along the pathway.

Solution: Step 1: Outline the standard sequence of spermatogenesis. Spermatogonia ($2n$) undergo mitotic differentiation to form primary spermatocytes ($2n$).
Step 2: Track the first meiotic division. Primary spermatocytes undergo meiosis I to yield two haploid secondary spermatocytes (n).
Step 3: Track the second meiotic division. Under normal conditions, each secondary spermatocyte undergoes meiosis II to produce two haploid spermatids (n). Therefore, a total of four spermatids are formed.
Step 4: Evaluate the experimental block. If the secondary spermatocytes fail to complete meiosis II, the transition from secondary spermatocyte to spermatid is blocked.
Step 5: Conclude the immediate direct outcome. Because meiosis II cannot proceed, spermatids will not be formed. Consequently, mature spermatozoa cannot develop.

Final Answer: Spermatids will not be formed.

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Plants utilize phytohormones to coordinate physiological adaptations to environmental stressors. When a plant faces a severe water deficit, it produces a specific signaling molecule to conserve water by inducing stomatal closure.

Solution: Step 1: Define the physiological challenge. Under acute water stress, transpirational water loss through open stomata can lead to wilting and cellular dehydration.
Step 2: Identify the hormone triggered by stress. Abscisic acid (ABA) is synthesized rapidly in response to drought, salinity, and cold temperatures, earning it the designation "the stress hormone."
Step 3: Analyze the mechanism of action of ABA in leaves. ABA binds to receptors on guard cell plasma membranes, triggering an influx of calcium ions and an efflux of potassium ions (K^+) and anions.
Step 4: Relate ion movement to stomatal closure. The loss of ions lowers the osmotic pressure inside the guard cells, causing water to leave via exosmosis. The guard cells lose turgor and collapse, closing the stomatal pore.
Step 5: Conclude that abscisic acid is the hormone responsible for triggering rapid stomatal closure during water stress.

Final Answer: Abscisic acid

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: Ecological pyramids depict the structural relationships between trophic levels in terms of individual numbers, energy, or biomass. While energy pyramids are always upright, biomass pyramids can invert in aquatic environments due to differences in the turnover rates of organisms.

Solution: Step 1: Define a biomass pyramid. It measures the dry weight of organic matter present at each trophic level at a specific point in time.
Step 2: Examine terrestrial biomass distributions. In ecosystems like tropical rainforests or grasslands, the primary producers (trees and grasses) possess a massive standing biomass that far outweighs the consumers, yielding an upright pyramid.
Step 3: Analyze open ocean aquatic environments. The primary producers are microscopic phytoplankton. Though they have a high reproductive rate, they are heavily grazed by zooplankton and small fish, leaving them with a very low standing crop biomass at any single moment.
Step 4: Contrast producer biomass with consumer biomass. The consumers (zooplankton and long-lived predatory fish) accumulate biomass over time, resulting in a larger total standing biomass than the phytoplankton.
Step 5: Conclude that this dynamic produces an inverted biomass pyramid, which is a key characteristic of marine ecosystems.

Final Answer: A marine ecosystem

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept: Kingdom Fungi is categorized into classes based on the morphology of the mycelium, the mode of spore formation, and the structure of the fruiting bodies. Each class displays a unique combination of asexual and sexual reproductive features.

Solution: Step 1: Analyze the mycelial anatomy. The fungal isolate possesses septate (cross-walled) and branched hyphae, ruling out Phycomycetes, which typically feature coenocytic, aseptic hyphae.
Step 2: Examine the mode of asexual reproduction. The fungus produces asexual spores called conidia exogenously at the tips of specialized hyphae known as conidiophores.
Step 3: Examine the mode of sexual reproduction. Sexual reproduction produces sexual spores endogenously inside a specialized, sac-like microscopic structure called an ascus.
Step 4: Cross-reference these characteristics with the fungal taxonomical classes. Fungi that form septate hyphae, reproduce asexually via conidia, and produce sexual spores endogenously within a sac are classified as Ascomycetes (sac fungi).
Step 5: Rule out Basidiomycetes (which form exogenous sexual spores) and Deuteromycetes (which lack a known sexual stage).

Final Answer: Ascomycetes

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: DNA replication requires high-fidelity enzymatic polymerases to synthesize complementary strands. The principal replicating enzyme can only add incoming deoxyribonucleotide triphosphates to a free 3′-OH group, which imposes a strict directional constraint on synthesis.

Solution: Step 1: State the directional constraint of DNA polymerase III. The enzyme can only catalyze the polymerization of nucleotides in the 5′ to 3′ direction.
Step 2: Analyze the replication fork structure. DNA is an antiparallel double helix. At the replication fork, one template strand runs 3′ to 5′ and the other runs 5′ to 3′.
Step 3: Describe leading strand synthesis. The template strand running 3′ to 5′ allows DNA polymerase III to synthesize a complementary strand continuously in the 5′ to 3′ direction, moving toward the unwinding fork.
Step 4: Describe lagging strand synthesis. The opposite template strand runs 5′ to 3′. To synthesize a complementary strand in the mandatory 5′ to 3′ direction, the enzyme must work in short bursts away from the fork, creating Okazaki fragments.
Step 5: Conclude that DNA polymerase III synthesizes both continuous and discontinuous strands strictly in the 5′ to 3′ direction.

Final Answer: DNA polymerase III synthesizes in the 5’ to 3’ direction.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: Intrauterine devices (IUDs) are highly effective contraceptives placed within the uterine cavity. They are categorized as non-medicated, copper-releasing, or hormone-releasing, and each category employs a distinct physiological mechanism to prevent pregnancy.

Solution: Step 1: Identify the specific device. The user selects a copper-releasing intrauterine device (such as the CuT or Cu7).
Step 2: Analyze the cellular effect of copper ions (Cu^{2+}). Once deployed, the device continuously releases copper ions into the local uterine and cervical fluids.
Step 3: Examine the impact of copper on sperm physiology. Cu^{2+} ions act as a local cytotoxin to spermatozoa, suppressing their motility and reducing their ability to swim through the cervical mucus.
Step 4: Analyze the impact on fertilization. By impairing motility, the ions degrade the sperm's fertilizing capacity, preventing it from reaching and penetrating the ovum in the fallopian tube.
Step 5: Rule out alternative mechanisms. Copper IUDs do not block the luteinizing hormone surge, act as a mechanical barrier across the external cervix, or induce luteolysis of the corpus luteum.

Final Answer: Suppressing sperm motility and reducing the fertilizing capacity of sperms.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: The Polymerase Chain Reaction (PCR) amplifies specific DNA sequences across repeated thermal cycles. Each cycle consists of three sequential, temperature-dependent steps: denaturation, annealing, and extension.

Solution: Step 1: Analyze the structural state of the starting material. The target DNA template is a stable, double-stranded helix held together by complementary hydrogen bonds.
Step 2: Examine the role of the denaturation step. Heating the reaction mixture to 94–96°C breaks these hydrogen bonds, separating the double-stranded DNA into two single-stranded templates.
Step 3: Analyze the subsequent annealing step. Once the strands are separated, the temperature is lowered to allow forward and reverse primers to bind to their target sites on the single-stranded templates.
Step 4: Determine the consequence of omitting denaturation. If the denaturation step is skipped, the reaction mixture never reaches the temperature required to separate the strands, leaving the template double-stranded.
Step 5: Conclude the final outcome. Because the strands remain locked in a double helix, the primers cannot bind, preventing Taq polymerase from synthesizing new strands. As a result, no amplification occurs.

Final Answer: No amplification will occur because the template strands cannot separate.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept: The kidneys concentrate urine using a countercurrent multiplier system, which relies on a high osmotic gradient within the medullary interstitium. This osmotic gradient is generated by transport mechanisms operating in the loop of Henle.

Solution: Step 1: Analyze the transport mechanisms of the loop of Henle. The thin descending limb is permeable to water but impermeable to solutes, while the thick ascending limb actively pumps sodium (Na^+), potassium (K^+), and chloride (Cl^-) ions out of the tubular fluid into the medullary interstitium.
Step 2: Examine the permeability of the ascending limb. The ascending limb is completely impermeable to water molecules.
Step 3: Analyze the effect of blocking active transport. If a drug inhibits the active transport of sodium ions in the thick ascending limb, salt cannot accumulate in the surrounding tissue.
Step 4: Determine the impact on the medullary osmotic gradient. Without salt accumulation, the hypertonic gradient of the renal medulla collapses, preventing the collecting duct from reabsorbing water via osmosis.
Step 5: Conclude that the kidney will lose its ability to concentrate urine, resulting in the excretion of a large volume of dilute, hypotonic urine.

Final Answer: The medullary osmotic gradient will fail, resulting in dilute (hypotonic) urine.

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: A Mendelian dihybrid cross tracks the inheritance patterns of two unlinked genes. Crossing two homozygous dominant and recessive parents (RRYY $\times$ rryy) produces a completely heterozygous F1 generation (RrYy), which is then selfed to yield the F2 generation.

Solution: Step 1: Write out the F1 parental cross that produces the F2 generation:

$$\text{RrYy} \times \text{RrYy}$$

Step 2: Construct a 4×4 Punnett square, which yields a total of 16 possible genotypic combinations.
Step 3: Identify the specific target genotype. The question asks for the proportion of offspring that are completely heterozygous for both genetic traits, which corresponds to the genotype RrYy.
Step 4: Count the occurrences of RrYy within the Punnett square matrix. This genotype appears along the main diagonal of the square at four positions:

$$\text{Row 1, Col 4(RrYy), Row 2, Col 3(RrYy), Row 3, Col 2(RrYy), Row 4, Col 1(RrYy)}$$

Step 5: Calculate the final probability fraction by dividing the target count by the total number of boxes:

$$\text{Proportion} = \frac{4}{16}$$

Thus, exactly $4/16$ of the F2 generation will be fully heterozygous.

Final Answer: 4/16

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: Glycolysis is a universal metabolic pathway that breaks down glucose into pyruvate via a sequence of ten enzyme-catalyzed reactions. Phosphofructokinase (PFK) is a key regulatory enzyme that catalyzes a critical, irreversible step in the preparatory phase of the pathway.

Solution: Step 1: Review the initial steps of glycolysis. Glucose is first phosphorylated by hexokinase to form glucose-6-phosphate.
Step 2: Track the next conversion. Glucose-6-phosphate is isomerized by phosphoglucose isomerase into fructose-6-phosphate. Both intermediates form normally upstream of the inhibitor block.
Step 3: Analyze the step catalyzed by phosphofructokinase. PFK transfers a phosphate group from an ATP molecule to the first carbon of fructose-6-phosphate:

$$\text{Fructose-6-phosphate} + \text{ATP} \xrightarrow{\text{PFK}} \text{Fructose-1,6-bisphosphate} + \text{ADP}$$

Step 4: Apply the effect of the enzyme inhibitor. If an inhibitor completely deactivates phosphofructokinase, the reaction is blocked, and fructose-6-phosphate cannot be converted.
Step 5: Conclude which intermediate product will fail to form. Because the enzyme is blocked, the downstream product, fructose-1,6-bisphosphate, cannot be synthesized.

Final Answer: Fructose-1,6-bisphosphate

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: The ABO blood group system in humans is determined by the I gene, which features three alleles (I^A, I^B, and i) and exhibits codominance and multiple allelism. An individual's blood phenotype depends on the specific pair of alleles they inherit from their parents.

Solution: Step 1: Determine the genotypes of both parents from the problem description. The mother has blood group A and is heterozygous, meaning her genotype is I^Ai. The father has blood group B and is heterozygous, meaning his genotype is I^Bi.
Step 2: Cross the parental genotypes ($I^Ai \times I^Bi$) and determine the possible allelic combinations for the offspring:

$$\text{Gametes from Mother: } I^A, i \quad \text{Gametes from Father: } I^B, i$$

Step 3: List all four potential genotypic outcomes for the child:

$$I^AI^B, \quad I^Ai, \quad I^Bi, \quad ii$$

Step 4: Map each genotype to its corresponding blood group phenotype:

$$I^AI^B \rightarrow \text{Blood Group AB}$$

$$I^Ai \rightarrow \text{Blood Group A}$$

$$I^Bi \rightarrow \text{Blood Group B}$$

$$ii \rightarrow \text{Blood Group O}$$

Step 5: Conclude that the child can potentially inherit any of the four major blood groups: A, B, AB, or O.

Final Answer: A, B, AB, and O

Answer: (D)

Go Back to Question 28

Q29.

Solution

Concept: Plants adapt to hot, arid environments by modifying their internal leaf anatomy to minimize photorespiration. This specialized spatial separation of carbon fixation steps is accompanied by a distinct anatomical arrangement known as Kranz anatomy.

Solution: Step 1: Analyze the leaf anatomy of the specimen. The plant features bundle sheath cells arranged in a ring around the vascular bundles, containing large chloroplasts that lack grana (agranal chloroplasts).
Step 2: Analyze the mesophyll cells. The mesophyll cells contain smaller, standard chloroplasts with well-developed thylakoid stacks (granal chloroplasts).
Step 3: Identify this anatomical pattern. This dimorphic chloroplast arrangement divided between tissue layers is the definition of Kranz leaf anatomy.
Step 4: Relate Kranz anatomy to its metabolic pathway. Kranz anatomy is a physical adaptation exclusive to C_4 plants (such as maize and sugarcane).
Step 5: Outline how this structure functions. Initial carbon fixation occurs in the mesophyll cells via PEP carboxylase, and the resulting four-carbon acid is transported to the bundle sheath cells, where rubisco fixes CO_2 away from atmospheric oxygen. This identifies it as a C_4 pathway plant.

Final Answer: C4 pathway

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Biodiversity depletion is driven by primary environmental pressures collectively known in ecology as "The Evil Quartet." This group includes habitat loss and fragmentation, over-exploitation, alien species invasions, and co-extinctions.

Solution: Step 1: Identify the ecological scenario. A small forest habitat has been broken up and surrounded by agricultural fields, leading to a high rate of local species extinction.
Step 2: Define habitat fragmentation. It occurs when a large, continuous habitat is broken into smaller, isolated patches, often due to human activities like agriculture or urban development.
Step 3: Analyze the biological consequences of fragmentation. Small patches isolate populations, increase edge effects, disrupt migration patterns, and reduce genetic diversity, which accelerates species loss.
Step 4: Match this phenomenon to its overarching category. Habitat loss and fragmentation is the most critical driver of biodiversity loss within the classification scheme known as "The Evil Quartet."
Step 5: Select the correct option. The overall threat profile that encompasses this phenomenon is categorized under "The Evil Quartet."

Final Answer: The Evil Quartet

Answer: (D)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	A	3	B	4	A	5	A
6	B	7	B	8	B	9	D	10	C
11	B	12	B	13	B	14	C	15	D
16	C	17	B	18	B	19	B	20	C
21	B	22	B	23	B	24	C	25	B
26	C	27	C	28	D	29	B	30	D