

CUET UG Biology Sample Paper - 1

Duration: 1 Hour

Maximum Marks: 250

Instructions

- This paper contains a total of 50 Multiple Choice Questions.
- Each correct answer carries **+5 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. In flowering plants, double fertilization results in the formation of:

- (A) Zygote only
- (B) Endosperm only
- (C) Zygote and Endosperm
- (D) Embryo sac

Q2. The mature embryo sac in an angiosperm is characterized by:

- (A) 7 cells and 8 nuclei
- (B) 8 cells and 7 nuclei
- (C) 6 cells and 8 nuclei
- (D) 7 cells and 7 nuclei

Q3. Which type of pollination occurs in a flower with both male and female organs but prevents self-fertilization?

- (A) Autogamy
- (B) Geitonogamy
- (C) Xenogamy
- (D) Cleistogamy



Q4. In humans, oogenesis is arrested at which stage until ovulation?

- (A) Prophase I
- (B) Metaphase I
- (C) Metaphase II
- (D) Anaphase I

Q5. Blastocyst implantation in the uterine wall occurs at the:

- (A) Endometrium
- (B) Myometrium
- (C) Perimetrium
- (D) Cervix

Q6. Which contraceptive method acts by preventing ovulation?

- (A) Condoms
- (B) Oral contraceptive pills
- (C) Copper-T
- (D) Vasectomy

Q7. In IVF, the fertilized egg is transferred into the:

- (A) Ovary
- (B) Uterine tube
- (C) Uterus
- (D) Cervix

Q8. In a monohybrid cross of two heterozygotes ($Aa \times Aa$), the expected genotypic ratio is:



- (A) 1:1
- (B) 1:2:1
- (C) 3:1
- (D) 2:1

Q9. Down's syndrome occurs due to:

- (A) Trisomy 21
- (B) Trisomy 18
- (C) Monosomy X
- (D) Deletion of 22q

Q10. In a dihybrid cross, linked genes show:

- (A) Independent assortment
- (B) Recombination frequency $< 50\%$
- (C) Complete dominance
- (D) Incomplete dominance

Q11. DNA replication in prokaryotes begins at:

- (A) Origin of replication
- (B) Promoter region
- (C) Enhancer sequence
- (D) Terminator region

Q12. Lac operon is inducible in the presence of:

- (A) Lactose
- (B) Glucose
- (C) cAMP



(D) Repressor protein

Q13. Hardy-Weinberg equilibrium assumes all except:

- (A) No mutation
- (B) No migration
- (C) Random mating
- (D) Natural selection occurs

Q14. Which evolutionary event is an example of adaptive radiation?

- (A) Darwin's finches
- (B) Convergent evolution of wings in bats and birds
- (C) Homologous structures in vertebrates
- (D) Fossil formation

Q15. Plasmodium undergoes sexual reproduction in:

- (A) Human liver
- (B) Anopheles mosquito
- (C) Human blood
- (D) Red blood cells

Q16. Innate immunity includes all except:

- (A) Phagocytosis
- (B) Skin barrier
- (C) Antibody production
- (D) Mucus secretion

Q17. Which cancer is associated with human papillomavirus (HPV)?



- (A) Cervical cancer
- (B) Leukemia
- (C) Liver cancer
- (D) Lung cancer

Q18. Sewage treatment involves the following stages except:

- (A) Primary treatment
- (B) Secondary treatment
- (C) Tertiary treatment
- (D) Quaternary treatment

Q19. Restriction enzymes recognize sequences that are:

- (A) Palindromic
- (B) Random
- (C) Repetitive DNA
- (D) Exons only

Q20. PCR amplification requires all except:

- (A) DNA template
- (B) Primers
- (C) DNA polymerase
- (D) RNA polymerase

Q21. Bt cotton expresses a protein toxic to:

- (A) Lepidopteran insects
- (B) Nematodes
- (C) Fungi



(D) Bacteria

Q22. RNAi is used to:

- (A) Silence specific genes
- (B) Enhance transcription
- (C) Produce insulin
- (D) Cut DNA

Q23. A pyramid of energy is always:

- (A) Upright
- (B) Inverted
- (C) Hourglass
- (D) Irregular

Q24. $GPP - NPP$ equals:

- (A) Energy used in respiration
- (B) Energy stored in biomass
- (C) Energy lost in decomposition
- (D) Solar energy captured

Q25. Ex-situ conservation includes:

- (A) Biosphere reserves
- (B) Zoos and botanical gardens
- (C) National parks
- (D) Sacred groves

Q26. Spermatogenesis results in the formation of:



- (A) One sperm per spermatogonium
- (B) Two sperms per spermatogonium
- (C) Four sperms per spermatogonium
- (D) Eight sperms per spermatogonium

Q27. Which hormone triggers ovulation in humans?

- (A) FSH
- (B) LH
- (C) Progesterone
- (D) Estrogen

Q28. In double fertilization, the secondary nucleus fuses with:

- (A) Two polar nuclei
- (B) Egg cell
- (C) Synergids
- (D) Antipodal cells

Q29. GIFT and ZIFT are types of:

- (A) Assisted Reproductive Technology
- (B) Contraceptives
- (C) Gametogenesis processes
- (D) Plant pollination techniques

Q30. The menstrual cycle is primarily regulated by:

- (A) Thyroid hormones
- (B) Pituitary and ovarian hormones
- (C) Adrenal hormones



(D) Pancreatic hormones

Q31. A cross between two heterozygotes ($AaBb \times AaBb$) gives what phenotypic ratio in a dihybrid cross with independent assortment?

(A) 9:3:3:1

(B) 1:2:1

(C) 3:1

(D) 2:1:1

Q32. DNA fingerprinting is primarily used for:

(A) Cloning organisms

(B) Identifying genetic disorders and forensics

(C) Gene transcription

(D) Protein synthesis

Q33. Which enzyme unwinds the DNA helix during replication?

(A) DNA polymerase

(B) Helicase

(C) Ligase

(D) Primase

Q34. The genetic disorder Klinefelter's syndrome is caused by:

(A) 47, XXY

(B) 45, XO

(C) 47, XXX

(D) 46, XY



Q35. Translation occurs in the:

- (A) Nucleus
- (B) Ribosome
- (C) Golgi apparatus
- (D) Mitochondria

Q36. Which of the following is not a postulate of Hardy-Weinberg equilibrium?

- (A) No mutation
- (B) Large population size
- (C) Non-random mating
- (D) No migration

Q37. Homologous structures in different organisms indicate:

- (A) Convergent evolution
- (B) Divergent evolution
- (C) Parallel evolution
- (D) Random evolution

Q38. Which molecular tool is used to cut DNA at specific sequences?

- (A) Ligase
- (B) Restriction endonuclease
- (C) DNA polymerase
- (D) RNA polymerase

Q39. Recombination frequency between two linked genes located far apart is approximately:



- (A) 0%
- (B) 25%
- (C) 50%
- (D) 75%

Q40. Adaptive radiation is best exemplified by:

- (A) Evolution of cacti in deserts
- (B) Darwin's finches
- (C) Convergent evolution of wings in bats and birds
- (D) Fossil horses

Q41. AIDS is caused by:

- (A) HIV
- (B) Hepatitis virus
- (C) Plasmodium
- (D) HPV

Q42. Active immunity can be acquired through:

- (A) Vaccination
- (B) Passive antibody transfer
- (C) Antibiotics
- (D) Antivirals

Q43. Biocontrol agents are used in agriculture to:

- (A) Enhance crop growth
- (B) Control pests
- (C) Improve soil fertility



(D) Store crops

Q44. The stage in sewage treatment where biological oxidation occurs is:

- (A) Primary treatment
- (B) Secondary treatment
- (C) Tertiary treatment
- (D) Quaternary treatment

Q45. Which microbe is commonly used as a biofertilizer for legumes?

- (A) Rhizobium
- (B) Bacillus thuringiensis
- (C) Saccharomyces
- (D) Pseudomonas

Q46. Humulin (synthetic insulin) is produced using:

- (A) E. coli recombinant DNA technology
- (B) Yeast fermentation only
- (C) Plant genetic engineering
- (D) Animal cloning

Q47. Bioreactors are used for:

- (A) Large-scale microbial culture and product formation
- (B) DNA replication
- (C) RNA transcription
- (D) Pollination in plants

Q48. Which RNA molecule brings amino acids to the ribosome during translation?



- (A) mRNA
- (B) tRNA
- (C) rRNA
- (D) snRNA

Q49. Mutualism is a type of species interaction where:

- (A) Both species benefit
- (B) One benefits, other unaffected
- (C) One benefits, other harmed
- (D) Both species harmed

Q50. A biodiversity hotspot is characterized by:

- (A) High species richness and high endemism
- (B) Low species richness
- (C) Absence of endemic species
- (D) Only plant diversity



Detailed Solutions**Q1.****Solution**

Concept: Double fertilization is the signature reproductive event of angiosperms, first discovered by S.G. Nawaschin. It ensures that the development of the nutrient-rich endosperm is synchronized with the formation of the embryo, preventing energy waste.

Solution: When a pollen grain germinates, it produces a pollen tube carrying two male gametes. Upon entering the embryo sac, the first male gamete (n) fuses with the egg cell (n) to form a diploid **Zygote** ($2n$). This process is called Syngamy. Simultaneously, the second male gamete (n) moves toward the center and fuses with the two polar nuclei (or the secondary nucleus, $2n$) to form a triploid ($3n$) Primary Endosperm Nucleus (PEN). This second event is called Triple Fusion. Because two distinct types of fusion occur, the process is termed "Double Fertilization." The zygote eventually develops into the embryo, while the triploid cell develops into the **Endosperm**, which serves as the food-storing tissue for the developing embryo.

Final Answer: Zygote and Endosperm

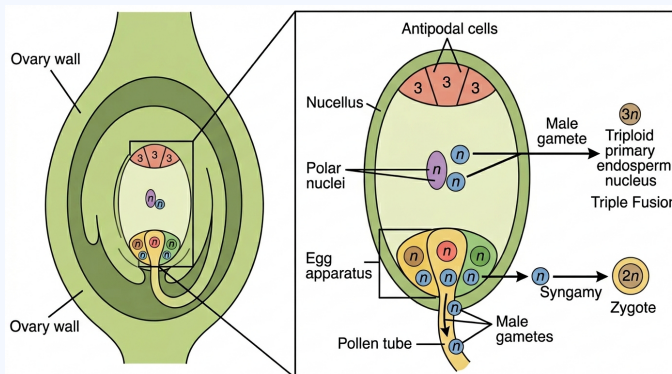
Answer: (C)



Q2.

Solution

Concept: The development of the female gametophyte, or embryo sac, involves megasporogenesis followed by megagametogenesis. In most flowering plants (Polygonum type), only one out of four megaspores survives to develop further.



Solution: The single functional megaspore undergoes three successive free-nuclear mitotic divisions. The first division produces 2 nuclei, the second produces 4, and the third results in 8 nuclei. These nuclei then migrate: three move to the micropylar end to form the egg apparatus (one egg cell and two synergids), and three move to the chalazal end to become antipodal cells. The remaining two nuclei, called polar nuclei, migrate to the center and remain within a single, massive central cell. Although there are **8 nuclei** in total, the central cell contains two of them, resulting in a mature structure that consists of exactly **7 cells**. This spatial organization is critical for the subsequent double fertilization event.

Final Answer: 7 cells and 8 nuclei

Answer: (A)

Q3.

Solution

Concept: Plants have evolved various "outbreeding devices" to discourage self-pollination (inbreeding depression) and encourage cross-pollination, which increases genetic variability and fitness.

Solution: Even in bisexual flowers, self-fertilization can be prevented through mechanisms like Dichogamy (anthers and stigma maturing at different times) or Self-incompatibility (a genetic mechanism preventing pollen germination from the same plant). **Xenogamy** is the biological term for cross-pollination, where pollen is transferred from the anther of one plant to the stigma of a genetically different plant of the same species. While Autogamy (selfing within the same flower) and Geitonogamy (selfing between different flowers of the same plant) keep the genetic makeup identical, Xenogamy is the only type that ensures the introduction of new genetic combinations, effectively bypassing the plant's own male/female organs to find a partner elsewhere.

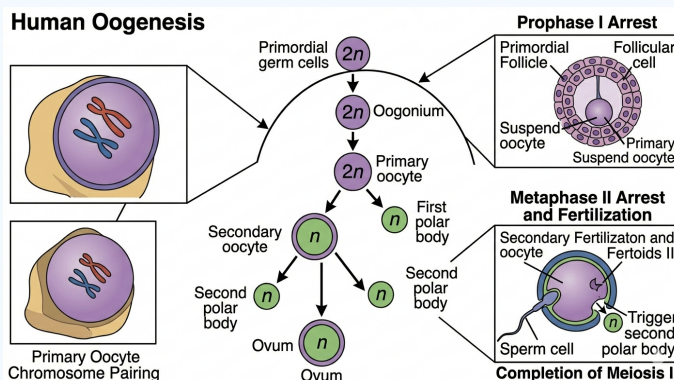
Final Answer: Xenogamy

Answer: (C)

Q4.

Solution

Concept: Oogenesis is a discontinuous process. Unlike males, who produce sperm continuously from puberty, a female is born with all the primary oocytes she will ever have, and these cells are "frozen" in time for years.



Solution: Oogenesis initiates during the embryonic developmental stage when a few million gamete mother cells (oogonia) are formed within each fetal ovary. These cells enter Meiosis I and proceed until the **Prophase I** stage (specifically the diplotene substage), where the process is suspended. This suspension is maintained by the follicular cells until the female reaches puberty. Every month thereafter, a surge of Luteinizing Hormone (LH) allows one primary oocyte to complete Meiosis I, producing a secondary oocyte and a tiny polar body. The secondary oocyte then enters Meiosis II but is arrested again at Metaphase II, only completing the division if fertilization by a sperm occurs.

Final Answer: Prophase I

Answer: (A)

Q5.

Solution

Concept: Implantation represents the physical and physiological connection between the mother and the embryo, occurring roughly 6 to 9 days after fertilization.

Solution: After fertilization in the fallopian tube, the zygote undergoes rapid mitotic divisions (cleavage) as it moves toward the uterus. By the time it reaches the uterine cavity, it has become a hollow sphere of cells called a blastocyst. The outer layer, the trophoblast, secretes enzymes that allow it to penetrate the **Endometrium** (the innermost glandular lining of the uterus). As the trophoblast invades, the endometrial cells grow rapidly and cover the blastocyst, completely embedding it within the uterine wall. This successful "nesting" in the endometrium is essential because it allows for the formation of the placenta, which will provide oxygen and nutrients to the growing fetus throughout gestation.

Final Answer: Endometrium

Answer: (A)

Q6.

Solution

Concept: Hormonal contraceptives mimic the state of pregnancy to trick the female body's endocrine system into "resting" the ovaries.

Solution: ****Oral contraceptive pills**** typically contain synthetic versions of the hormones Progesterone and Estrogen. In a normal cycle, a drop in these hormones triggers the release of FSH (which matures follicles) and an LH surge (which triggers ovulation). By taking a daily pill, these hormone levels are kept consistently high. This high level provides negative feedback to the hypothalamus and the anterior pituitary gland, suppressing the secretion of GnRH, FSH, and LH. Without the LH surge, the Graafian follicle does not rupture, and the egg is never released from the ovary. Thus, ****ovulation is prevented****, making fertilization impossible. Additionally, these pills thicken cervical mucus to block sperm and alter the endometrium to prevent implantation.

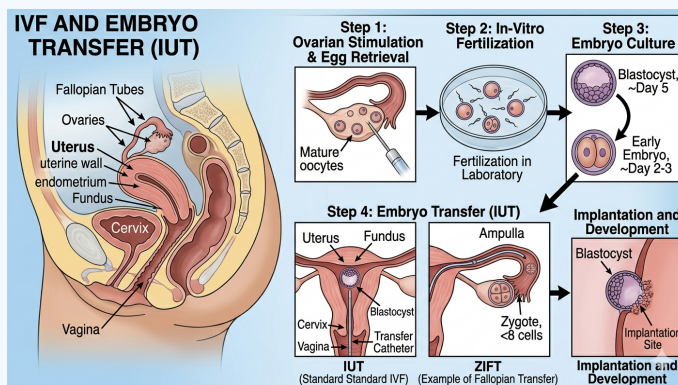
Final Answer: Oral contraceptive pills

Answer: (B)

Q7.

Solution

Concept: In-Vitro Fertilization (IVF) is the process of fertilizing an egg with sperm outside the body ("in glass"). The subsequent transfer of the embryo is the most delicate stage of the procedure.



Solution: Following fertilization in a laboratory dish, the resulting zygote is monitored as it begins to divide. The transfer protocol depends strictly on the developmental stage of the embryo. If the embryo is transferred very early (at the 1 to 8 blastomere stage), it is placed into the fallopian tube (Zygote Intra-Fallopian Transfer or ZIFT). However, the standard IVF protocol often involves culturing the embryo further. If the embryo has reached more than 8 blastomeres or the blastocyst stage, it is transferred directly into the ****Uterus****. This is known as Intrauterine Transfer (IUT). The uterus provides the natural environment for the embryo to implant and develop into a fetus.

Final Answer: Uterus

Answer: (C)

Q8.

Solution

Concept: Mendel's Law of Segregation states that the two alleles for a trait separate during gamete formation, and each gamete receives only one allele.

Solution: In a monohybrid cross between two heterozygotes ($Aa \times Aa$), both parents produce two types of gametes: 50% carry the dominant allele (A) and 50% carry the recessive allele (a). Using a Punnett square to map the potential fertilizations, we find: 1. $A \times A = AA$ (Homozygous Dominant) 2. $A \times a = Aa$ (Heterozygous) 3. $a \times A = Aa$ (Heterozygous) 4. $a \times a = aa$ (Homozygous Recessive) Counting these results, we get **1 AA **, **2 Aa **, and **1 aa **. Therefore, the **genotypic ratio is 1:2:1**. Note that the phenotypic ratio would be 3:1 (dominant to recessive), but the question specifically asks for the genetic makeup distribution.

Final Answer: 1:2:1

Answer: (B)

Q9.

Solution

Concept: Down's Syndrome is a classic example of "aneuploidy," a condition where the total number of chromosomes is not an exact multiple of the haploid set.

Solution: This disorder is caused by a chromosomal error called "non-disjunction." During the formation of gametes (usually the egg), the two copies of chromosome 21 fail to separate properly. This results in an egg that carries two copies of chromosome 21 instead of one. When this egg is fertilized by a normal sperm, the resulting zygote has three copies of chromosome 21, totaling 47 chromosomes instead of the usual 46. This specific condition is known as **Trisomy 21**. Named after Langdon Down who first described it in 1866, the syndrome leads to distinct physical characteristics and varying degrees of cognitive impairment due to the gene dosage imbalance caused by the extra chromosome.

Final Answer: Trisomy 21

Answer: (A)



Q10.

Solution

Concept: Linkage is the exception to Mendel's Law of Independent Assortment. It was extensively studied by T.H. Morgan using fruit flies (*Drosophila melanogaster*).

Solution: Genes located on the same chromosome are physically "linked" together. During meiosis, these genes tend to be inherited as a single unit unless a crossover event occurs between them. If two genes are very close together (tightly linked), crossing over is rare, and the offspring will mostly show parental phenotypes. If they are further apart, crossing over occurs more frequently, creating "recombinants." However, regardless of the distance, linked genes will always show a ****recombination frequency of less than 50%****. A frequency of 50% is the hallmark of unlinked genes (independent assortment). Therefore, any value below 50% indicates that the genes are located on the same chromosome and do not assort independently.

Final Answer: Recombination frequency < 50%

Answer: (B)

Q11.

Solution

Concept: DNA replication is not a random process; it is a highly coordinated enzymatic event that begins at a genetically predetermined site to ensure the entire genome is copied accurately.

Solution: In prokaryotic organisms like *E. coli*, the circular DNA contains a single, specific sequence called the ****Origin of Replication**** (often abbreviated as *oriC*). This region is typically rich in Adenine and Thymine (A-T) base pairs, which are easier to separate because they share only two hydrogen bonds.

The replication machinery, including DnaA proteins and helicase, identifies this site to begin unwinding the double helix. Without this specific "starting line," the DNA polymerase enzyme cannot initiate the synthesis of new strands. In biotechnology, an *ori* sequence is a mandatory component of any vector (like a plasmid) to ensure it can replicate inside a host cell.

Final Answer: Origin of replication

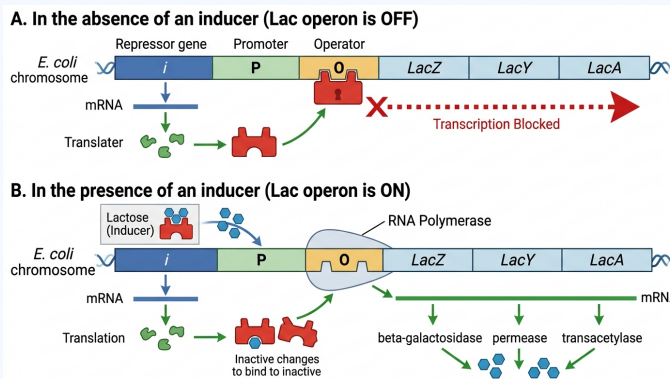
Answer: (A)



Q12.

Solution

Concept: The Lac Operon, proposed by Jacob and Monod, is a polycistronic system that allows bacteria to save energy by only producing certain enzymes when their substrate is available.



Solution: The operon consists of a promoter, an operator, and three structural genes (*z*, *y*, *a*). In the absence of an inducer, a repressor protein produced by the *i* gene binds to the operator, physically blocking RNA polymerase.

When **Lactose** is present in the medium, a small amount enters the cell and is converted into allolactose. Allolactose acts as the **inducer** by binding to the repressor protein and changing its conformation. This prevents the repressor from binding to the operator, "switching on" the operon and allowing the transcription of enzymes like Beta-galactosidase to break down the sugar.

Final Answer: Lactose

Answer: (A)

Q13.

Solution

Concept: The Hardy-Weinberg Principle is a null hypothesis in evolutionary genetics. It states that under specific "ideal" conditions, the gene pool of a population will not change over time.

Solution: The equilibrium relies on five rigid assumptions: 1. No mutation, 2. No gene flow (migration), 3. A very large population size (to prevent genetic drift), 4. Random mating, and 5. No natural selection.

If **Natural selection occurs**, individuals with certain advantageous traits will survive and reproduce more successfully than others. This disproportionate reproductive success changes the frequency of alleles in the next generation, thereby causing evolution. Since Hardy-Weinberg describes a state where evolution is *not* happening, the presence of natural selection is a direct violation of its core assumptions.

Final Answer: Natural selection occurs

Answer: (D)

Q14.

Solution

Concept: Adaptive radiation is a specific pattern of macroevolution where a single lineage quickly branches into many specialized species to fill different ecological "niches."

Solution: The most famous example is **Darwin's finches** found on the Galápagos Islands. Millions of years ago, a single species of finch arrived from mainland South America. Because the islands offered diverse habitats with different food sources—such as hard seeds, insects, and cactus nectar—the birds evolved different beak shapes specialized for these specific diets.

This radiation is driven by the lack of competition in new environments, allowing a single ancestor to "radiate" into various forms. Other examples include Australian marsupials and the cichlid fishes in East African lakes.

Final Answer: Darwin's finches

Answer: (A)

Q15.

Solution

Concept: The life cycle of *Plasmodium* involves a complex alternation of generations, switching between asexual reproduction in a vertebrate and sexual reproduction in an invertebrate.

Solution: When a female **Anopheles mosquito** bites a human, it injects sporozoites. These undergo asexual reproduction (schizogony) first in the human liver and then in the red blood cells. Some parasites eventually differentiate into male and female gametocytes.

However, these gametocytes cannot fuse in the warm, acidic environment of the human body. When another mosquito sucks these up, the cooler environment of the mosquito's gut triggers **sexual reproduction**. The gametes fuse to form a zygote, which matures into an ookinete and eventually produces new sporozoites, completing the cycle in the insect host.

Final Answer: Anopheles mosquito

Answer: (B)



Q16.

Solution

Concept: The immune system is divided into two main branches: Innate (general, fast-acting) and Acquired (specific, slow-acting but with memory).

Solution: Innate immunity consists of physical barriers (skin), physiological barriers (tears, stomach acid), and cellular barriers (phagocytes like neutrophils). These are present at birth and treat all invaders the same way.

In contrast, **Antibody production** is the hallmark of **Acquired (Adaptive) Immunity**. This process involves B-lymphocytes recognizing a specific antigen and differentiating into plasma cells that secrete highly specific antibodies. Because this response requires previous exposure to a pathogen and creates "memory" for future defense, it is not considered part of the innate system.

Final Answer: Antibody production

Answer: (C)

Q17.

Solution

Concept: Oncogenic viruses contribute to cancer by inserting their own DNA into the host cell's genome, often overriding the "checkpoints" that normally prevent uncontrolled cell division.

Solution: The **Human Papillomavirus (HPV)** is a group of more than 200 related viruses. While many are harmless, "high-risk" types like HPV-16 and HPV-18 produce proteins (E6 and E7) that deactivate the host's tumor suppressor proteins, such as p53 and pRb.

The persistent infection of the epithelial lining of the cervix leads to the gradual development of abnormal cells, eventually resulting in **Cervical cancer**. This discovery led to the development of the HPV vaccine, which is highly effective in preventing this specific malignancy.

Final Answer: Cervical cancer

Answer: (A)

Q18.

Solution

Concept: Sewage treatment is a standardized multi-step engineering process designed to purify urban wastewater before it is returned to natural water bodies.

Solution: 1. **Primary treatment** involves physical filtration and sedimentation of floating debris and grit. 2. **Secondary treatment** is biological, using aerobic microbes to digest organic matter (measured by BOD reduction). 3. **Tertiary treatment** is a chemical process (using chlorine, UV, or ozone) to remove remaining pathogens and nutrients like nitrogen or phosphorus. While some advanced facilities use specialized filtration for micro-pollutants, there is no universally recognized biological or ecological curriculum stage known as **Quaternary treatment**. The standard three-stage process is sufficient to make water safe for discharge.

Final Answer: Quaternary treatment

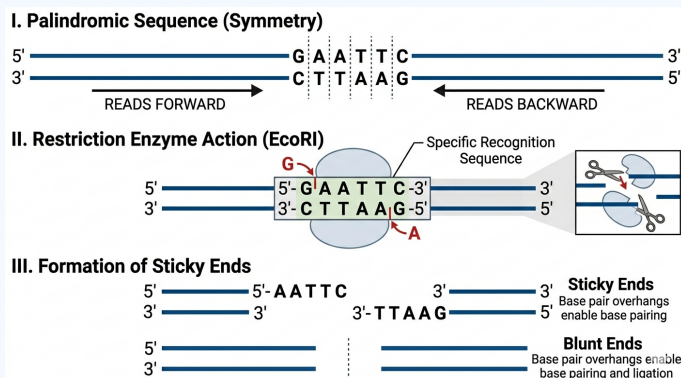
Answer: (D)



Q19.

Solution

Concept: Restriction enzymes are part of a bacterium's natural defense against viral infections. They cut foreign DNA at specific, symmetrical sites.



Solution: A **Palindromic** sequence in DNA is a location where the base sequence on one strand reads the same as the complementary strand when both are read in the 5' to 3' direction. For example, the sequence 5'-GAATTC-3' has a complement of 3'-CTTAAG-5'. Restriction enzymes like EcoRI "scan" the DNA and bind only when they find this specific symmetry. They then cut the sugar-phosphate backbone, often leaving "sticky ends" (overhanging single strands) that are incredibly useful in genetic engineering for "pasting" different DNA fragments together.

Final Answer: Palindromic

Answer: (A)

Q20.

Solution

Concept: PCR (Polymerase Chain Reaction) is an *in vitro* method of DNA replication that allows scientists to turn a single DNA molecule into billions of copies within hours.

Solution: The reaction requires: 1. A DNA template, 2. Primers (small RNA or DNA sequences that provide a starting 3'-OH group), 3. Deoxynucleotides (dNTPs), and 4. A heat-stable DNA polymerase (Taq polymerase).

RNA polymerase is the enzyme responsible for synthesizing RNA from a DNA template during transcription in living cells. Since PCR is specifically designed to replicate **DNA**, and uses pre-synthesized primers to avoid the need for *de novo* initiation, RNA polymerase is not involved in the process.

Final Answer: RNA polymerase

Answer: (D)



Q21.

Solution

Concept: Bt cotton is a transgenic crop engineered to provide built-in resistance against specific pests, significantly reducing the environmental impact of chemical pesticides.

Solution: The "Bt" refers to *Bacillus thuringiensis*, a soil bacterium that produces cry proteins (crystalline toxins). The *cryIAC* and *cryIIAb* genes are inserted into the cotton genome.

These toxins are specifically lethal to **Lepidopteran insects**, such as the bollworm and tobacco budworm. The toxin remains inactive (pro-toxin) until it enters the alkaline environment of the insect's midgut. There, it is solubilized and activated, eventually binding to the gut lining and creating pores that cause the insect to starve to death. This specificity ensures that beneficial insects, humans, and animals remain unaffected by the protein.

Final Answer: Lepidopteran insects

Answer: (A)

Q22.

Solution

Concept: RNA interference (RNAi) is a revolutionary gene-silencing technology that mimics a natural defense mechanism found in all eukaryotic organisms to combat viral infections.

Solution: The core mechanism involves the introduction of double-stranded RNA (dsRNA) that is complementary to a target mRNA. An enzyme called Dicer cuts this dsRNA into small interfering RNAs (siRNAs). These fragments guide a protein complex (RISC) to the target mRNA, where it is cleaved and degraded.

In biotechnology, this is used to **silence specific genes** that are essential for a parasite's survival. For instance, it has been used to develop tobacco plants resistant to the nematode *Meloidogyne incognita*. When the nematode feeds on the plant, it ingests the dsRNA, which shuts down its own vital genes, leading to the death of the parasite without harming the host plant.

Final Answer: Silence specific genes

Answer: (A)



Q23.

Solution

Concept: Ecological pyramids represent the relationship between different trophic levels. While pyramids of numbers or biomass can be inverted, the pyramid of energy is bound by the laws of thermodynamics.

Solution: According to the **Second Law of Thermodynamics**, energy transfer is never 100% efficient. As energy flows from producers to primary, secondary, and tertiary consumers, a vast majority (roughly 90%) is lost to the environment as metabolic heat.

Only about 10% of the energy is stored as biomass and passed to the next level (Lindeman's 10% Law). Because the amount of energy available at the base (producers) is always the maximum, and it diminishes at every subsequent step, a pyramid of energy is **always upright**. It is physically impossible to have more energy at a consumer level than was available at the producer level.

Final Answer: Upright

Answer: (A)

Q24.

Solution

Concept: Understanding ecosystem efficiency requires distinguishing between total energy capture and the energy actually available for growth and consumption.

Solution: Gross Primary Productivity (GPP) is the total rate at which organic matter is synthesized by producers via photosynthesis. However, plants are living organisms that require energy for their own maintenance, growth, and cellular activities.

The energy consumed during these metabolic processes is termed **Respiration (R)**. The energy that remains after this "tax" is paid is known as Net Primary Productivity (NPP). Therefore, the equation **GPP – R = NPP** yields the value of energy lost or **used in respiration**. This NPP is the actual biomass available for the heterotrophs (herbivores and decomposers) in the food chain.

Final Answer: Energy used in respiration

Answer: (A)



Q25.

Solution

Concept: Biodiversity conservation strategies are divided into "In-situ" (protecting species in their wild home) and "Ex-situ" (protecting species by moving them to safety).

Solution: Ex-situ conservation is often the last line of defense for species that are critically endangered or extinct in the wild. It involves the removal of the organism from its natural threatened habitat to a controlled, human-made environment.

****Zoos and botanical gardens**** are primary examples, as they provide specialized care, breeding programs, and protection from predators or poachers. Other advanced ex-situ methods include seed banks and cryopreservation of gametes. Conversely, National Parks and Biosphere Reserves are in-situ methods because they focus on protecting the entire ecosystem where the species naturally resides.

Final Answer: Zoos and botanical gardens

Answer: (B)

Q26.

Solution

Concept: Spermatogenesis is the complex process of male gamete formation that occurs in the seminiferous tubules of the testes, characterized by a series of mitotic and meiotic divisions.

Solution: A single diploid spermatogonium (stem cell) differentiates into a primary spermatocyte. This cell undergoes Meiosis I to produce two haploid secondary spermatocytes. These two cells then immediately enter Meiosis II, which results in the production of ****four haploid spermatids****. Through a subsequent process called spermiogenesis, these four non-motile spermatids undergo structural transformations—including the development of a flagellum and an acrosome—to become four functional, motile spermatozoa. Thus, the division of one primary spermatocyte leads to the generation of exactly four sperm cells, ensuring a high quantity of gametes for reproduction.

Final Answer: Four sperms per spermatogonium

Answer: (C)



Q27.

Solution

Concept: The mid-cycle hormonal surge is a critical regulatory checkpoint in the human menstrual cycle that dictates the timing of fertility.

Solution: During the follicular phase, developing follicles secrete increasing amounts of estrogen. Once estrogen levels cross a certain threshold, they switch from negative to positive feedback on the pituitary gland. This triggers a sudden, massive release of **LH (Luteinizing Hormone)**, known as the "LH surge."

The surge causes the dominant Graafian follicle to rupture and release the secondary oocyte into the fallopian tube—a process called ovulation. While FSH is also present, it is the peak in LH that is directly responsible for the mechanical rupture of the follicle and the subsequent transformation of the empty follicle into the corpus luteum.

Final Answer: LH

Answer: (B)

Q28.

Solution

Concept: In angiosperms, the fusion of nuclei within the central cell is a prerequisite for the formation of the endosperm, which provides nutrition to the embryo.

Solution: The embryo sac of a flowering plant contains a large central cell that houses two haploid **polar nuclei**. Just before or during the fertilization process, these two nuclei often fuse to form a single diploid **secondary nucleus** (also called the definitive nucleus).

During double fertilization, one of the two male gametes discharged by the pollen tube moves to the center and fuses with this secondary nucleus. This fusion of three haploid nuclei (one male gamete + two polar nuclei) is termed "triple fusion," resulting in a triploid ($3n$) Primary Endosperm Nucleus. This triploid nature is unique to angiosperms and allows for a vigorous nutrient-storage tissue.

Final Answer: Two polar nuclei

Answer: (A)



Q29.

Solution

Concept: Assisted Reproductive Technologies (ART) represent a group of clinical procedures used to address infertility by manipulating gametes or embryos outside the body.

Solution: ****GIFT**** (Gamete Intra-Fallopian Transfer) and ****ZIFT**** (Zygote Intra-Fallopian Transfer) are specialized forms of ART. In GIFT, both eggs and sperm are collected and immediately placed into the fallopian tube, allowing fertilization to occur naturally inside the mother's body. In ZIFT, the egg is fertilized in a laboratory (in-vitro), and the resulting zygote is then transferred into the fallopian tube. Both methods require functional fallopian tubes, unlike standard IVF-ET where the embryo is placed directly into the uterus. These techniques are designed to bypass specific reproductive barriers such as low sperm count or ovulation issues.

Final Answer: Assisted Reproductive Technology

Answer: (A)

Q30.

Solution

Concept: The human menstrual cycle is a highly synchronized physiological event governed by an axis of communication between the brain and the reproductive organs.

Solution: The cycle is orchestrated by the ****Hypothalamic-Pituitary-Ovarian (HPO) axis****. The anterior ****pituitary gland**** secretes gonadotropins: FSH (Follicle Stimulating Hormone) and LH (Luteinizing Hormone), which stimulate the growth of ovarian follicles and trigger ovulation. In response, the ****ovaries**** produce steroid hormones: Estrogen and Progesterone. These ovarian hormones regulate the thickening of the uterine lining (endometrium) and provide feedback to the brain to modulate the release of FSH and LH. This constant chemical "conversation" between the pituitary and the ovaries ensures that the uterus is perfectly prepared for a potential pregnancy each month.

Final Answer: Pituitary and ovarian hormones

Answer: (B)



Q31.

Solution

Concept: Mendel's Law of Independent Assortment states that alleles of different genes distribute into gametes independently of one another during meiosis, provided they are on different chromosomes.

Solution: In a dihybrid cross between two individuals heterozygous for both traits ($AaBb \times AaBb$), each parent produces four types of gametes: AB , Ab , aB , and ab in equal frequencies (25% each). When these gametes combine in a 16-square Punnett grid, the resulting offspring exhibit four distinct phenotypes. Under the condition of complete dominance, the frequencies appear in a constant **9:3:3:1** ratio. This represents 9 individuals dominant for both traits, 3 dominant for the first and recessive for the second, 3 recessive for the first and dominant for the second, and 1 individual recessive for both. This ratio serves as the mathematical proof that the inheritance of one trait (e.g., seed color) does not influence the inheritance of another (e.g., seed shape).

Final Answer: 9:3:3:1

Answer: (A)

Q32.

Solution

Concept: DNA Fingerprinting, developed by Alec Jeffreys, relies on the high degree of polymorphism in certain non-coding sequences of human DNA known as Variable Number of Tandem Repeats (VNTRs).

Solution: Every individual (except monozygotic twins) possesses a unique pattern of these repetitive sequences. In forensic science, DNA is extracted from biological evidence—such as blood, hair, or skin cells—and amplified. The resulting "barcode" of DNA bands is compared against suspects or relatives.

This technique is the gold standard for **identifying genetic disorders** through linkage analysis and for **forensic investigations** to determine the presence of an individual at a crime scene. It is also the most accurate method for settling paternity and maternity disputes, as a child's VNTR pattern is a direct combination of the parents' patterns.

Final Answer: Identifying genetic disorders and forensics

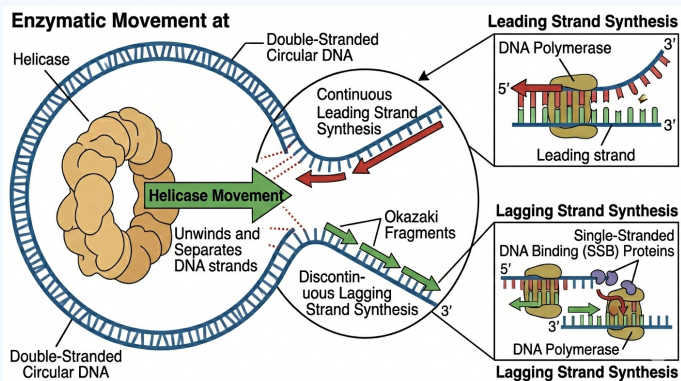
Answer: (B)



Q33.

Solution

Concept: DNA replication is a semi-conservative process that requires the physical separation of the double-stranded template to allow access for the replication machinery.



Solution: The enzyme **Helicase** is often referred to as the "unzipper" of the DNA molecule. It utilizes energy derived from ATP hydrolysis to travel along the DNA backbone and break the hydrogen bonds between complementary nitrogenous bases ($A = T$ and $C \equiv G$).

This action creates the "replication fork," a Y-shaped region where the two single strands are exposed. Once unwound, Single-Strand Binding Proteins (SSBs) stabilize the strands to prevent them from re-annealing, and Topoisomerase relieves the torsional strain ahead of the fork. This allows DNA Polymerase to bind and begin synthesizing the new complementary strands.

Final Answer: Helicase

Answer: (B)

Q34.

Solution

Concept: Klinefelter's syndrome is a type of sex-chromosomal aneuploidy caused by the presence of an extra X chromosome in a male, resulting from non-disjunction during meiosis.

Solution: A normal human male possesses 46 chromosomes, including one X and one Y (46, XY). In individuals with Klinefelter's syndrome, an error in chromosomal separation (usually during maternal oogenesis) results in a zygote with **47 chromosomes**, specifically **47, XXY**.

The presence of the Y chromosome ensures male sexual differentiation, but the extra X chromosome leads to "feminized" physical features. Symptoms often include taller stature, reduced muscle mass, enlarged breast tissue (gynecomastia), and underdeveloped testes leading to infertility. Because it is a chromosomal disorder, it cannot be cured, but symptoms are often managed with testosterone therapy.

Final Answer: 47, XXY

Answer: (A)



Q35.

Solution

Concept: Translation is the process of protein synthesis where the genetic information transcribed into mRNA is converted into a specific sequence of amino acids.

Solution: In eukaryotic cells, while transcription occurs in the nucleus, the actual assembly of proteins takes place in the cytoplasm. The **Ribosome** serves as the cellular "factory" or workbench for this process. It consists of a small subunit that binds to the mRNA and a large subunit that facilitates the formation of peptide bonds between amino acids.

The ribosome has three specialized sites (A, P, and E) that coordinate the movement of tRNA molecules. Ribosomes may be found free-floating in the cytosol, producing proteins for internal use, or attached to the Rough Endoplasmic Reticulum, producing proteins intended for secretion or membrane insertion.

Final Answer: Ribosome

Answer: (B)

Q36.

Solution

Concept: The Hardy-Weinberg equilibrium is a mathematical principle that provides a baseline for a non-evolving population. It describes the conditions under which allele frequencies remain static.

Solution: For a population to remain in genetic equilibrium, five specific criteria must be met: 1. A very large population size (to minimize genetic drift), 2. No gene flow (no migration in or out), 3. No mutations (to prevent new alleles from forming), 4. No natural selection (equal survival for all), and 5. **Random mating**.

If mating is **non-random** (such as sexual selection or inbreeding), certain genotypes will pair more frequently than predicted by chance. This changes the distribution of genotypes in the next generation, pushing the population away from the $p^2 + 2pq + q^2 = 1$ equilibrium. Therefore, non-random mating is a factor that causes evolution, rather than a postulate of the equilibrium state itself.

Final Answer: Non-random mating

Answer: (C)



Q37.

Solution

Concept: Evolutionary patterns are identified by comparing the anatomy of different species to determine their ancestral relationships.

Solution: ****Homologous structures**** are organs or skeletal elements that, by virtue of their similarity, suggest a connection to a common ancestor. For example, the pattern of bones in the forelimbs of humans, cheetahs, whales, and bats is remarkably similar, consisting of the humerus, radius, ulna, carpals, metacarpals, and phalanges.

Despite this shared structural origin, these limbs have been modified to perform vastly different functions—grasping, running, swimming, and flying. This process of a common ancestral trait evolving in different directions to meet different environmental challenges is known as ****Divergent evolution****. It stands in contrast to convergent evolution, where unrelated species develop similar traits (analogous structures) for similar functions.

Final Answer: Divergent evolution

Answer: (B)

Q38.

Solution

Concept: Recombinant DNA technology requires precise tools to manipulate DNA strands. Restriction endonucleases serve as the primary "surgical" tools for this purpose.

Solution: ****Restriction endonucleases**** are enzymes produced naturally by bacteria to degrade viral DNA. They are highly specific, scanning long DNA molecules to find a particular "recognition sequence," which is usually a 4 to 8 base-pair long palindrome.

Once the sequence is found, the enzyme binds and cuts the sugar-phosphate backbone at a specific point within the sequence. Depending on the enzyme, it may leave "blunt ends" or "sticky ends" (single-stranded overhangs). These sticky ends are crucial because they can easily base-pair with complementary sequences from another DNA source, allowing researchers to splice genes together into vectors.

Final Answer: Restriction endonuclease

Answer: (B)



Q39.

Solution

Concept: Recombination frequency (RF) is a measure of the distance between two genes on a chromosome, used to construct genetic maps.

Solution: Crossover events occur randomly along the length of a chromosome during prophase I of meiosis. The further apart two genes are, the more likely a crossover will occur between them. However, even if genes are at opposite ends of a very long chromosome, the measured ****recombination frequency cannot exceed 50%****.

At 50% RF, the genes behave as if they are on entirely different chromosomes, obeying Mendel's Law of Independent Assortment. This occurs because multiple crossovers and the random assortment of chromatids "mask" the linkage. Therefore, any RF value significantly below 50% confirms that the genes are linked, while 50% represents the theoretical limit where linkage becomes indistinguishable from independent assortment.

Final Answer: 50%

Answer: (C)

Q40.

Solution

Concept: Adaptive radiation is a powerful evolutionary process where a single ancestral species diversifies rapidly into many new species with specialized adaptations.

Solution: This phenomenon typically occurs when a species reaches a new environment with many unoccupied ecological niches and little competition. ****Darwin's finches**** on the Galápagos Islands are the textbook example. A small population of seed-eating finches arrived from the mainland and encountered islands with varied food sources.

Through natural selection, different groups evolved specialized beaks: some for cracking large seeds, some for eating cactus pulp, and others for catching insects. This radiation allowed the finches to exploit all available resources on the islands. Other examples include the Australian marsupials, which radiated from a single ancestor into forms resembling wolves, moles, and anteaters.

Final Answer: Darwin's finches

Answer: (B)



Q41.

Solution

Concept: Acquired Immunodeficiency Syndrome (AIDS) is a chronic, potentially life-threatening condition caused by the Human Immunodeficiency Virus (HIV).

Solution: **HIV** is a retrovirus that contains RNA as its genetic material and uses the enzyme reverse transcriptase to convert it into DNA within the host cell. The virus specifically targets and infects helper T-lymphocytes (T_H cells), which are the "commanders" of the immune system.

As the virus replicates, it destroys these cells, leading to a progressive decline in the body's ability to fight infections. When the T_H cell count drops below a critical level (typically 200 cells/mm³), the individual is diagnosed with AIDS. This leaves the patient vulnerable to "opportunistic infections" like *Mycobacterium*, *Toxoplasma*, and various fungal infections that would not normally affect a healthy person.

Final Answer: HIV

Answer: (A)

Q42.

Solution

Concept: Immunity can be classified based on how it is acquired. Active immunity involves the body's own direct response to a pathogen or its components.

Solution: **Active immunity** is characterized by the production of antibodies by the host's own B-cells and the creation of memory cells. This is best achieved through **vaccination**, where a weakened (attenuated), killed, or recombinant part of a pathogen is introduced into the body.

The immune system recognizes these antigens and mounts a primary immune response. If the actual pathogen later enters the body, the pre-existing memory cells trigger a rapid and massive secondary response, neutralizing the threat before symptoms occur. This differs from passive immunity, where pre-formed antibodies (like those in colostrum or anti-venom) are provided, which gives immediate but temporary protection without creating immunological memory.

Final Answer: Vaccination

Answer: (A)



Q43.

Solution

Concept: Biological control is a sustainable component of Integrated Pest Management (IPM) that uses natural enemies to manage pest populations.

Solution: In conventional agriculture, chemical pesticides are used to eradicate pests, but they often kill beneficial insects and cause environmental toxicity. **Biocontrol agents** function on the principle of predation or parasitism rather than total eradication.

Common examples include using Ladybirds to control aphids and Dragonflies to control mosquitoes. Another highly effective method involves the bacterium *Bacillus thuringiensis* (Bt), whose spores are sprayed on crops; when caterpillars eat them, the toxin released in their gut kills them. This approach is ecologically sound because it targets only the **pests**, maintains the local food web, and prevents the development of chemical resistance in insect populations.

Final Answer: Control pests

Answer: (B)

Q44.

Solution

Concept: Sewage treatment involves the systematic reduction of the organic load in wastewater through physical, biological, and chemical processes.

Solution: After the physical removal of solids in primary treatment, the liquid effluent undergoes **Secondary treatment**, which is the biological phase. The effluent is pumped into large aeration tanks and constantly agitated. This encourages the growth of aerobic bacteria and fungi, which form masses called "flocs."

These microbes perform **biological oxidation** by consuming the organic matter dissolved in the sewage. This process continues until the Biochemical Oxygen Demand (BOD)—a measure of the organic pollution—is significantly reduced. The more the BOD is lowered, the less polluting the water becomes. Following this, the microbial flocs are allowed to settle, and the treated water is prepared for tertiary treatment or discharge.

Final Answer: Secondary treatment

Answer: (B)



Q45.

Solution

Concept: Biofertilizers are living organisms that increase the availability of primary nutrients to the host plant, particularly nitrogen, which is often a limiting factor for growth.

Solution: The most prominent example of a symbiotic biofertilizer is the bacterium **Rhizobium**. These bacteria form a specialized relationship with **leguminous plants** (such as peas, clover, and soy). They infect the plant's roots, leading to the formation of "root nodules."

Inside these nodules, the bacteria possess the enzyme nitrogenase, which allows them to "fix" atmospheric nitrogen (N_2) into ammonia (NH_3), a form the plant can easily assimilate into amino acids and proteins. In exchange, the plant provides the bacteria with carbohydrates produced through photosynthesis. This natural fertilization process enriches the soil and reduces the farmer's dependence on synthetic, energy-intensive nitrogen fertilizers.

Final Answer: Rhizobium

Answer: (A)

Q46.

Solution

Concept: The production of Humulin (human insulin) marked a major milestone in biotechnology, being the first therapeutic product derived from recombinant DNA technology.

Solution: Prior to 1983, insulin was extracted from the pancreases of slaughtered cows and pigs, which often caused allergic reactions in patients. To solve this, the American company Eli Lilly used ***E. coli* recombinant DNA technology**.

The human insulin molecule consists of two short polypeptide chains: Chain A and Chain B, linked by disulfide bridges. Scientists synthesized two DNA sequences corresponding to these chains and inserted them into plasmids of *E. coli*. The bacteria then produced the chains separately. These chains were subsequently extracted, purified, and combined by creating disulfide bonds in a controlled laboratory environment to produce functional human insulin, identical to that produced by the human pancreas.

Final Answer: *E. coli* recombinant DNA technology

Answer: (A)



Q47.

Solution

Concept: Bioreactors are specialized engineering vessels designed to provide a strictly controlled environment for the optimized growth of microorganisms or mammalian cells.

Solution: Laboratory flasks are insufficient for producing industrial quantities of biological products. **Bioreactors** (usually 100 to 1000 liters in volume) solve this by providing the "optimal" conditions required for **large-scale microbial culture**.

They are equipped with agitation systems for even mixing, oxygen delivery systems (aeration), and sophisticated sensors to monitor and adjust temperature, pH, and substrate concentration in real-time. This allows for the mass production of vitamins, enzymes, antibiotics, and therapeutic proteins. The most commonly used type is the stirred-tank bioreactor, which ensures that oxygen is available throughout the vessel to maximize the metabolic output of the culture.

Final Answer: Large-scale microbial culture and product formation

Answer: (A)

Q48.

Solution

Concept: The "Adapter Hypothesis," proposed by Francis Crick, suggested that a specific molecule must bridge the gap between the language of nucleic acids and the language of proteins.

Solution: **tRNA (transfer RNA)** serves as this essential adapter. It has a distinctive "clover-leaf" secondary structure (or an inverted "L" tertiary structure). At one end, it possesses an "anticodon loop" that recognizes and base-pairs with the complementary codon on the mRNA strand.

At the opposite end (the 3' end), it has an amino acid acceptor arm that carries the specific amino acid corresponding to that codon. During translation, the tRNA molecules **bring amino acids to the ribosome**, ensuring they are added to the growing polypeptide chain in the precise sequence dictated by the mRNA. This ensures the high fidelity of protein synthesis.

Final Answer: tRNA

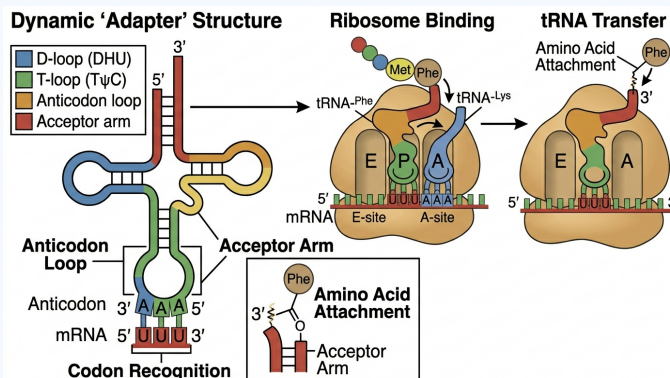
Answer: (B)



Q49.

Solution

Concept: Mutualism is a type of positive interspecific interaction that is fundamental to the survival of many species and the stability of ecosystems.



Solution: **Mutualism** is a symbiotic relationship in which **both interacting species benefit** (+/+). These interactions are often so specialized that the species become co-evolved and may even be unable to survive without each other (obligate mutualism).

Common examples include Lichens (a partnership between a fungus and a photosynthesizing alga or cyanobacterium) and Mycorrhizae (fungi and the roots of higher plants). In the animal kingdom, the classic example is the relationship between pollinators and plants: the plant receives the service of pollen dispersal for reproduction, while the animal receives high-energy food in the form of nectar or pollen.

Final Answer: Both species benefit

Answer: (A)

Q50.

Solution

Concept: The concept of Biodiversity Hotspots was developed by Norman Myers to identify and prioritize the most significant areas for global conservation.

Solution: A region must meet two strict criteria to be declared a biodiversity hotspot: 1. It must contain a very **high species richness** (at least 1,500 species of vascular plants found nowhere else), and 2. It must show **high endemism**, meaning many of its species are native only to that specific geographic area.

Additionally, these regions are characterized by a high degree of threat; a hotspot must have lost at least 70% of its original habitat. By focusing conservation efforts on these relatively small areas (which cover less than 2.3% of the Earth's land surface), scientists can protect a disproportionately large percentage of the world's plant and animal species from extinction.

Final Answer: High species richness and high endemism

Answer: (A)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	A	3	C	4	A	5	A
6	B	7	C	8	B	9	A	10	B
11	A	12	A	13	D	14	A	15	B
16	C	17	A	18	D	19	A	20	D
21	A	22	A	23	A	24	A	25	B
26	C	27	B	28	A	29	A	30	B
31	A	32	B	33	B	34	A	35	B
36	C	37	B	38	B	39	C	40	B
41	A	42	A	43	B	44	B	45	A
46	A	47	A	48	B	49	A	50	A

