S5 Biology Practice Paper (Set 2): Mendelian Genetics and Inheritance Ratios, DNA Structure and Protein Synthesis, Cell Cycle and Meiosis, Photosynthesis and Transpiration, Respiration and Gas Exchange, Energy Flow in Ecosystems

S5 | Biology | Time: 60 minutes | Total: 100 marks | 24 questions

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Mendelian Genetics and Inheritance Ratios

Part A: Genetics and inheritance ratios (16 marks)

1. Two pea plants, both of genotype Tt (T = tall dominant, t = dwarf recessive), are crossed and give 400 offspring. Find the expected numbers of tall and dwarf plants. [4]

Answer: The cross Tt x Tt gives a genotypic ratio of 1 TT : 2 Tt : 1 tt and a phenotypic ratio of 3 : 1. Tall = 400 x 3/4 = 300 plants; dwarf = 400 x 1/4 = 100 plants.

2. Two plants of genotype AaBb are crossed (the two gene pairs are on different chromosomes) and give 320 offspring. Find the number showing both dominant traits and state the phenotypic ratio. [4]

Answer: AaBb x AaBb gives a phenotypic ratio of 9 : 3 : 3 : 1. Both dominant = 320 x 9/16 = 180 plants; the other classes are 60, 60 and 20 plants.

3. A tall pea plant (Tt) is test-crossed with a dwarf plant (tt) and gives 240 offspring. Find the expected numbers of each phenotype and the ratio. [4]

Answer: Tt x tt gives equal numbers of Tt and tt, a 1 : 1 ratio. Tall = 240 x 1/2 = 120 plants and dwarf is also 120 plants.

4. A person of blood group genotype I^A i marries a person of genotype I^B i and they have 400 children. Assuming both alleles are expressed, find the expected number of each blood group. [4]

Answer: I^A i x I^B i gives I^A I^B, I^A i, I^B i and ii in a 1 : 1 : 1 : 1 ratio, i.e. 100 children each of groups AB, A, B and O.

DNA Structure and Protein Synthesis

Part B: DNA and protein synthesis (16 marks)

5. In a double-stranded DNA sample adenine (A) makes up 30% of all bases. Find the percentages of thymine (T), guanine (G) and cytosine (C). [4]

Answer: A pairs with T, so T = 30%; the remaining 40% is shared equally by G and C, giving G = 20% and C = 20%.

6. A double-stranded DNA molecule has 600 base pairs, of which adenine is 20% of all bases. Find the number of A, T, G and C bases. [4]

Answer: Total bases = 600 x 2 = 1200; A = 1200 x 20% = 240 and T = 240; the other 720 bases are split equally between G and C, 360 each.

7. The coding region of a messenger RNA has 90 nucleotides, excluding the stop codon. Find the maximum number of amino acids it can specify and explain why. [4]

Answer: Three nucleotides form one codon, so 90 / 3 = 30 codons; each codon specifies one amino acid, giving a maximum of 30 amino acids.

8. One DNA molecule undergoes 3 rounds of semi-conservative replication. Find the total number of DNA molecules produced, how many still contain an original strand, and the number of newly made strands. [4]

Answer: Molecules = 2^3 = 8; the 2 original strands are conserved, so 2 molecules contain an old strand; there are 16 strands in total, of which 14 are newly made.

Cell Cycle and Meiosis

Part C: Cell cycle and meiosis (17 marks)

9. A cell has a cell cycle of 20 hours, of which interphase occupies 90%. Find the duration of interphase and of the mitotic (M) phase. [4]

Answer: Interphase = 20 x 90% = 18 hours; M phase = 20 - 18 = 2 hours. Interphase takes nine tenths of the cycle, matching DNA replication and preparation for division.

10. A human body cell has 2n = 46 chromosomes. Find (a) the chromosome number of a gamete and (b) the chromosome number of a zygote. [4]

Answer: (a) Meiosis halves the chromosome number: n = 46 / 2 = 23. (b) Two haploid gametes fuse, so the zygote has 2n = 46 chromosomes again.

11. One cell completes 5 successive mitotic divisions. Find the final number of cells and state whether the chromosome number of the daughter cells changes. [4]

Answer: Cell number = 2^5 = 32. Chromosomes replicate before mitosis and are divided equally, so each daughter has the same chromosome number (2n) as the parent cell.

12. A cell measures 40.0 mm across in a micrograph and its actual diameter is 0.05 mm. (a) Find the magnification of the micrograph. (b) At the same magnification, what is the image diameter of a cell whose actual diameter is 0.02 mm? [5]

Answer: (a) Magnification = image size / actual size = 40.0 mm / 0.05 mm = x800. (b) Image = 0.02 mm x 800 = 16.0 mm. Both measurements must be in the same unit.

Photosynthesis and Transpiration

Part D: Photosynthesis and transpiration (17 marks)

13. The overall equation for photosynthesis is 6CO2 + 6H2O -> C6H12O6 + 6O2. If a leaf absorbs 264 g of carbon dioxide (Mr 44), all used in photosynthesis, find the mass of glucose (Mr 180) formed and the mass of oxygen released. [4]

Answer: 6 mol of CO2 (264 g) give 1 mol of glucose: glucose = 264 / 44 x 180 = 180 g; oxygen = 264 / 44 x 6 x 32 = 192 g.

14. A potometer is used to measure water uptake: the air bubble moves 12 mm in 5 minutes. Find (a) the distance moved per minute and (b) the total distance moved in 30 minutes at the same rate. [4]

Answer: (a) Rate = 12 mm / 5 min = 2.4 mm per minute. (b) Total = 2.4 x 30 = 72 mm. Bubble movement measures water uptake, not transpiration directly.

15. The lower epidermis of a dicot leaf has on average 200 stomata per square millimetre, and the leaf area is 5 square centimetres. Find the total number of stomata on the lower epidermis. [4]

Answer: Leaf area = 5 cm2 x 100 = 500 mm2; stomata = 200 x 500 = 100000. Note 1 cm2 = 100 mm2.

16. A plant loses 24 g of water by transpiration in 8 hours while absorbing 200 g in total. (a) Find the mean transpiration rate. (b) Find the percentage of absorbed water lost by transpiration. (c) Explain the use of the remaining water. [5]

Answer: (a) Rate = 24 g / 8 h = 3 g per hour. (b) Percentage = 24 / 200 x 100% = 12%. (c) The remaining 88% supports photosynthesis, cell turgidity and acts as a solvent for metabolic reactions.

Respiration and Gas Exchange

Part E: Respiration and gas exchange (17 marks)

17. Complete aerobic oxidation of one glucose molecule yields 38 ATP. Find the ATP yield from 2 glucose molecules. [4]

Answer: ATP = 2 x 38 = 76. Aerobic respiration occurs in the cytoplasm and mitochondria, with oxygen as the final electron acceptor.

18. In the absence of oxygen muscle carries out lactic acid fermentation, yielding only 2 ATP per glucose. Find the ATP from 5 glucose molecules and compare with complete oxidation of the same amount (as a multiple). [4]

Answer: Fermentation = 5 x 2 = 10 ATP; complete oxidation = 5 x 38 = 190 ATP; the ratio is 190 / 10 = 19 times. Fermentation relies on glycolysis only, so energy remains in the lactate.

19. An organism consumes 250 cm3 of oxygen with a respiratory quotient (RQ) of 0.8. Find the volume of carbon dioxide released and state which class of respiratory substrate is mainly used. [4]

Answer: RQ = CO2 released / O2 consumed, so CO2 = 0.8 x 250 = 200 cm3. An RQ near 0.7 to 0.8 indicates lipid as the main substrate (carbohydrate gives about 1.0).

20. At rest a person breathes 15 times per minute with a tidal volume of 500 cm3; during exercise the rate rises to 30 per minute with a tidal volume of 900 cm3. (a) Find the minute ventilation at rest and during exercise. (b) Find how many times greater the exercise value is. [5]

Answer: (a) Rest = 15 x 500 = 7500 cm3 per minute; exercise = 30 x 900 = 27000 cm3 per minute. (b) Ratio = 27000 / 7500 = 3.6 times. Higher oxygen demand during exercise is met by faster and deeper breathing.

Energy Flow in Ecosystems

Part F: Energy flow in ecosystems (17 marks)

21. Producers in an ecosystem fix 50000 kJ of energy, and only 10% passes to the next trophic level. Find the energy available to primary, secondary and tertiary consumers. [4]

Answer: Primary consumers = 50000 x 10% = 5000 kJ; secondary = 500 kJ; tertiary = 50 kJ. The rest is lost as heat from respiration, in excretory waste and in uneaten parts.

22. From the same ecosystem, how many kJ and what percentage of the energy fixed by producers fails to reach primary consumers? State the main form of loss. [4]

Answer: Loss = 50000 - 5000 = 45000 kJ; percentage = 45000 / 50000 x 100% = 90%. The main loss is heat from respiration, plus excretory waste and uneaten parts.

23. An ecosystem has a gross primary production (GPP) of 8000 kJ/m2/year and producer respiration of 3000 kJ/m2/year. Find net primary production (NPP) and explain its meaning. [4]

Answer: NPP = GPP - respiration = 8000 - 3000 = 5000 kJ/m2/year. NPP is the energy available for producer growth and for consumers and decomposers, the real energy base of the food chain.

24. Researchers capture 40 snails in a woodland, mark them all and release them. Later they capture 200 snails, of which 8 are marked. (a) Estimate the population size. (b) State two assumptions of this method. [5]

Answer: (a) Population = (marked first x second sample) / marked in second sample = (40 x 200) / 8 = 1000. (b) Assumptions: marking does not affect survival or catchability, the population is well mixed, and there is no immigration, emigration or heavy mortality between samples.
