2.2 Meiosis, gametes and fertilisation

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

KEY WORDS meiosis I • independent assortment • crossing over • acrosome • cortical reaction • double fertilisation

Objective

Practise statements 3.9-3.13: meiosis and its two sources of variation, gamete specialisation, and fertilisation in mammals and flowering plants.

1 Key knowledge and worked examples

■ Two divisions, four cells, two sources of variation

DNA replicates once; the cell divides twice. **Meiosis I** separates the homologous pairs; **meiosis II** separates the chromatids. Variation comes from **independent assortment** (which member of each pair ends in which gamete – 2^n combinations for n pairs) and **crossing over** (homologous chromatids exchanging sections in prophase I).

■ Gametes and fertilisation

Sperm: **acrosome** of enzymes, midpiece of mitochondria, flagellum. Egg: supplies the cytoplasm, its **zona pellucida** hardens after the **cortical reaction** so only one sperm enters. In flowering plants the pollen tube delivers two nuclei: one fertilises the egg cell, the other joins the polar nuclei – **double fertilisation** forming embryo and endosperm.

■ Worked example: counting chromosome combinations

An organism has 3 pairs of chromosomes. Independent assortment alone gives $2^3 = 8$ gamete types; two parents each with 8 types give $8 \times 8 = 64$ zygote combinations – before any crossing over. With 23 pairs the count is $2^{23} \times 2^{23}$, over 70 trillion: the reason no two people (except identical twins) are genetically the same.

2 Practice

2.1 State two differences between mitosis and meiosis in the cells produced. [2]

2.2 Name the two processes in meiosis that produce genetic variation. [2]

2.3 Give two adaptations of a sperm cell and state how each helps fertilisation. [2]

3 Exam-style questions

3.1 A cell has 4 chromosomes (2 pairs), and its DNA is labelled before meiosis. Explain how independent assortment alone produces genetically different gametes in this cell, state how many different combinations of chromosomes the gametes could receive, and explain what crossing over would add to this variety. [5]

3.2 Describe the events of fertilisation in a mammal from the sperm reaching the egg to the fusion of nuclei, including how further sperm are prevented from entering. [5]

3.3 In a flowering plant, the pollen tube carries two male nuclei to the embryo sac. Describe what each nucleus fuses with and what each product becomes, and explain why this is called double fertilisation. [4]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Meiosis gives four haploid, genetically different cells; mitosis gives two diploid, genetically identical cells.

2.2 Independent assortment and crossing over.

2.3 Acrosome contains digestive enzymes to penetrate the egg's coatings; mitochondria-packed midpiece supplies ATP for the flagellum's swimming; (accept flagellum for propulsion).

3.1 In meiosis I each homologous pair separates, and which member of a pair goes to which pole is random; with 2 pairs the combinations are $2^2 = 4$. Crossing over in prophase I swaps chromosome sections between homologous chromatids, creating new allele combinations on the same chromosome that assortment alone cannot make.

3.2 The sperm's acrosome releases enzymes that digest a path through the zona pellucida and follicle cells; the sperm's membrane fuses with the egg's membrane and the nucleus enters; the fusion triggers the cortical reaction – cortical granules release contents that harden the zona pellucida; the sperm and egg nuclei fuse, restoring diploidy.

3.3 One male nucleus fuses with the egg cell nucleus to form the diploid zygote that becomes the embryo; the other fuses with the two polar nuclei to form the triploid endosperm that nourishes the seed; two fusion events occur, hence double fertilisation.