

17.1 Chromosomes, genes and proteins

Name: _____ Class: _____ Date: _____

Total: 29 marks

KEY WORDS proteins 蛋白质 • codes 编码 • ribosome 核糖体 • gene 基因 • amino acids 氨基酸

Objective

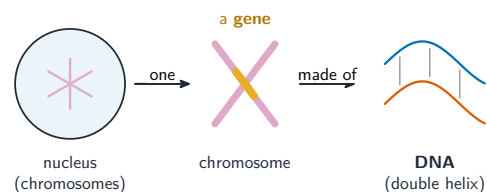
Build the skills to answer exam questions on **chromosomes, genes and proteins** 染色体、基因与蛋白质 — the terms, sex chromosomes, and how DNA controls a cell.

You must be able to:

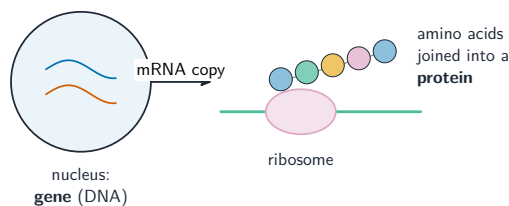
- define chromosome, gene and allele
- explain sex determination (XX/XY)
- describe how a gene's base sequence codes for a protein

1 Worked examples

■ Genes and protein synthesis



A gene is a length of DNA that codes for one protein; an allele is one form of a gene



The base sequence sets the order of amino acids → the protein's shape → its job

- **sex:** XX female, XY male; sperm (X or Y) decides the sex → 1:1 ratio.

■ The words, in the order they nest

A **chromosome** 染色体 is a thread of DNA carrying many genes. A **gene** 基因 is a length of DNA that codes for one protein. An **allele** 等位基因 is one of the alternative forms of a gene — for example the allele for a round seed and the allele for a wrinkled seed sit at the same place on the chromosome.

Genotype and phenotype. The **genotype** 基因型 is the alleles an organism carries (TT, Tt or tt); the **phenotype** 表现型 is the observable feature (tall or short). Two alleles the same is **homozygous** 纯合的; two different is **heterozygous** 杂合的. A **dominant** 显性 allele shows in the phenotype whenever it is present; a **recessive** 隐性 allele only shows when both alleles are recessive.

Sex determination. A human has 23 pairs of chromosomes, one pair of which is the sex chromosomes: a female is **XX** and a male is **XY**. Every egg carries an X. A sperm carries either an X or a Y, and it is the sperm that decides: X sperm + X egg gives a girl, Y sperm + X egg gives a boy. Because the two kinds of sperm are made in equal numbers, the chance of each is $\frac{1}{2}$, or 50%.

Worked example (a monohybrid cross). Two plants heterozygous for height (Tt) are crossed. Give the phenotype ratio.

1. Parents: Tt × Tt.
2. Gametes: T and t from each.
3. Offspring genotypes: TT, Tt, Tt, tt.
4. T is dominant, so TT, Tt and Tt are all tall and tt is short.
5. Phenotype ratio **3 tall : 1 short**; genotype ratio 1 : 2 : 1.

Every layer of that working carries a mark, so write all five lines even when you can see the answer.

2 Practice

2.1 Define a gene. [1]

2.2 State the sex chromosomes of a human female. [1]

2.3 State the difference between a genotype and a phenotype. [2]

2.4 State what is meant by homozygous recessive, and give an example using the symbols T and t. [2]

2.5 Give the probability that a child is male, and explain your answer. [2]

3 Exam-style questions

3.1 An allele is: [1]

- A a whole chromosome
- B an alternative form of a gene
- C a protein
- D a ribosome

3.2 The sex of a baby is determined at fertilisation.

(a) Explain why the sperm, not the egg, determines the sex. [2]

(b) State the ratio of males to females this produces. [1]

3.3 Explain how the base sequence of a gene determines the protein made. [2]

3.4 In a species of mouse, black fur (B) is dominant to brown fur (b).

(a) State the genotypes of a homozygous black mouse and of a brown mouse. [2]

(b) A homozygous black mouse is crossed with a brown mouse. Draw the genetic diagram and give the genotypes and phenotypes of the offspring. [4]

(c) Two of the offspring from part (b) are crossed with each other. Give the expected phenotype ratio, showing your working. [4]

(d) A black mouse is crossed with a brown mouse and produces some brown offspring. Deduce the genotype of the black parent, and explain your reasoning. [3]

(e) Explain why the sperm, and not the egg, determines the sex of a human baby. [2]

Solutions

2.1 a length of DNA that codes for one protein.

2.2 XX.

2.3 The genotype is the alleles an organism carries; the phenotype is the observable characteristic those alleles produce.

2.4 Both alleles are the recessive form; for example tt, which would give a short plant.

2.5 $\frac{1}{2}$ or 50%; a sperm carries either an X or a Y chromosome and the two kinds are made in equal numbers, so either is equally likely to fertilise the egg.

3.1 B. An allele is an alternative form of a gene.

3.2 (a) the egg always carries an X; the sperm carries either an X or a Y; so whether it is XX or XY depends on the sperm.

(b) 1:1.

3.3 the base sequence sets the order of amino acids in the protein; this gives the protein its shape, which decides its job.

3.4 (a) Homozygous black: BB; brown: bb.

(b) Parents BB $\times$ bb; gametes all B from one parent and all b from the other; all offspring are Bb; all are black, because B is dominant.

(c) Parents Bb $\times$ Bb; gametes B and b from each; offspring BB, Bb, Bb, bb; phenotype ratio 3 black : 1 brown.

(d) The black parent must be Bb, heterozygous; a brown offspring is bb and must have received a b allele from each parent; so the black parent carries a b allele as well as the B that makes it black.

(e) Every egg carries an X chromosome, so the egg cannot vary; a sperm carries either an X or a Y, and which one fertilises the egg decides whether the child is XX or XY.