

Inheritance

IGCSE Biology

Chromosomes, genes and DNA

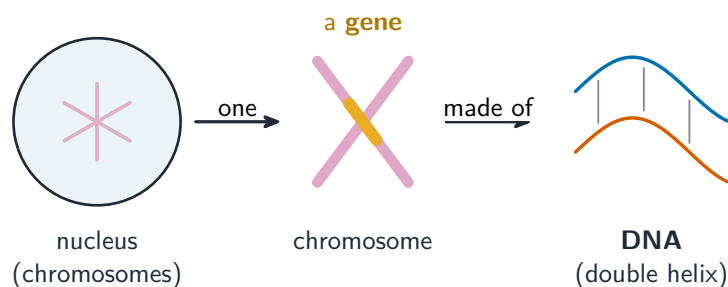


DNA carries inherited information in its double-helix structure.

Image: Flocci Nivis, CC BY 4.0 (commons.wikimedia.org)

Chromosomes 染色体 are made of **DNA**, which carries the genetic information in units called **genes** 基因.

- A **gene** is a length of DNA that **codes** 编码 for one **protein** 蛋白质.
- An **allele** 等位基因 is an alternative form of a gene. For example, a gene for eye colour may have a brown allele and a blue allele.



A chromosome is made of DNA and carries genes; a gene is a length of the DNA

Sex chromosomes

Sex is inherited through the **sex chromosomes** 性染色体. Females are **XX** and males are **XY**. An egg always carries an X; a sperm carries either an X or a Y, so the sperm decides the baby's sex. This gives a 1:1 **ratio** 比例 of girls to boys.

mother **XX** × father **XY**

		father		
		X	Y	
mother	X	XX	XY	1 : 1 girls (XX, purple) boys (XY, blue)
	X	XX	XY	

XX × XY gives a 1:1 ratio of girls to boys; the sperm decides the sex

How DNA controls the cell (Supplement)

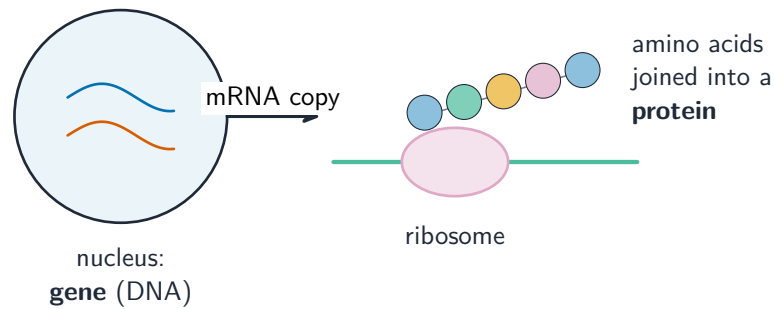
The **base sequence** 碱基序列 of a gene sets the order of **amino acids** 氨基酸 in a protein. A different order of amino acids folds the protein into a different shape, and the shape decides its job. So DNA controls the cell by controlling which proteins are made—including **enzymes** 酶, membrane carriers and **receptor proteins** 受体蛋白 for **neurotransmitters** 神经递质.

Most body cells hold the **same** genes, but each cell only **expresses** 表达 (switches on) the genes it needs, so it makes only the proteins for its own job.

Making a protein (Supplement)

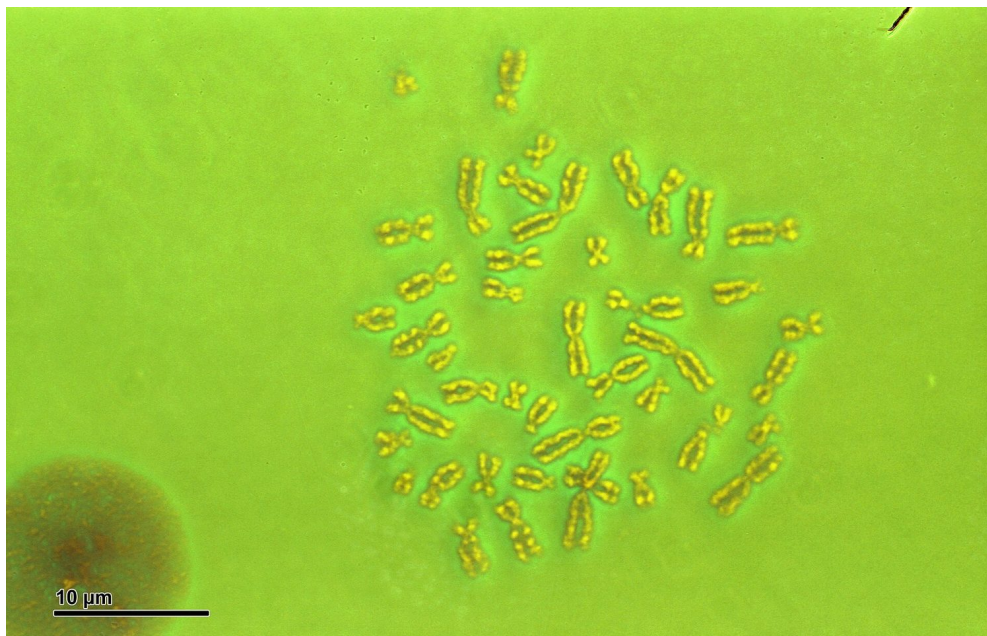
A gene stays in the **nucleus** 细胞核, but proteins are made in the **cytoplasm** 细胞质. The link between them is **messenger** 信使 RNA (mRNA):

1. mRNA is made in the nucleus as a copy of the gene.
2. the mRNA moves out into the cytoplasm and passes through a **ribosome** 核糖体.
3. the ribosome reads the mRNA's **bases** 碱基 and joins amino acids in the matching order to build the protein.



mRNA copies a gene, then a ribosome reads it to build a protein from amino acids

Cell division (Supplement)



A karyotype shows the full set of chromosomes in a human cell.

Image: Doc. RNDr. Josef Reischig, CSc, CC BY-SA 3.0 (commons.wikimedia.org)

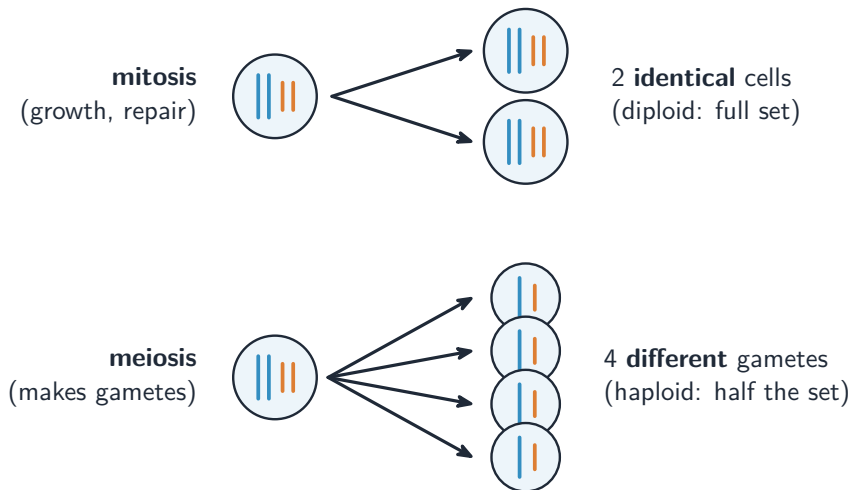
Body cells are **diploid** 二倍体 (two sets of chromosomes; humans have 23 pairs). Gametes are **haploid** 单倍体 (one set). Cells make new cells by nuclear **division** 分裂, of two kinds.

Mitosis 有丝分裂:

- makes two cells that are genetically **identical** to the parent cell.
- the chromosomes are copied exactly (**replication** 复制) before division, so each **daughter cell** 子细胞 keeps the full chromosome number.
- it is used for growth, repair of tissues, replacing old cells, and **asexual reproduction** 无性生殖.
- **stem cells** 干细胞 are unspecialised cells that divide by mitosis; their daughter cells can then become specialised.

Meiosis 减数分裂:

- makes **gametes** 配子.
- it is a **reduction division**: the chromosome number is halved, from diploid to haploid.
- the cells it makes are genetically **different** from one another.



Mitosis makes two identical diploid cells; meiosis makes four different haploid gametes

Inheritance: key words

Inheritance 遗传 is the passing of genetic information from one generation to the next.
Learn these words:

BB	→	brown eyes	B (brown) is dominant b (blue) is recessive
Bb	→	brown eyes	
bb	→	blue eyes	

A dominant allele shows with one copy; a recessive needs two

Word	Meaning
genotype 基因型	the alleles an organism has (its genetic make-up)
phenotype 表现型	the features you can observe
dominant 显性 allele	shown in the phenotype even if only one copy is present (written as a capital letter, e.g. B)
recessive 隐性 allele	shown only when no dominant allele is present (small letter, e.g. b)
homozygous 纯合子	two identical alleles (BB or bb); these breed true, or pure-breeding 纯种
heterozygous 杂合子	two different alleles (Bb); not pure-breeding

Monohybrid crosses

To predict the offspring of a **cross** 杂交 involving one gene, use a genetic diagram or a **Punnett square** 庞纳特方格:

- write each parent's genotype, then the gametes (each gamete carries one allele).
- combine them in a grid to find the possible offspring genotypes and phenotypes.

Two heterozygous parents ($Bb \times Bb$) give a **3:1** ratio of dominant to recessive. A heterozygous crossed with a homozygous recessive ($Bb \times bb$) gives a **1:1** ratio. You can also read a **pedigree diagram** 系谱图 (a family tree) to follow a feature and work out genotypes.

$Bb \times Bb$ (both parents)

gametes		B	b	
B		BB	Bb	3 : 1 3 dominant (blue) 1 recessive (orange)
b		Bb	bb	

A Punnett square for $Bb \times Bb$ gives a 3:1 ratio of dominant to recessive

(Supplement) A **test cross** 测交 finds an unknown genotype: cross the unknown with a homozygous recessive. If any offspring show the recessive feature, the unknown must have been heterozygous.

Worked example. Brown eyes (B) are dominant to blue (b). Two brown-eyed parents have a blue-eyed child. Give the parents' genotypes, and the chance that their next child has blue eyes. Start from the child: blue is recessive, so the child must be **bb**, and it got one b from each parent. So each parent carries a b. But both parents show brown eyes, so each must also carry a B: both parents are **Bb**. The Punnett square for $Bb \times Bb$ gives BB, Bb, Bb and bb, so the chance of a blue-eyed child is **1 in 4 (25%)**. Always work backwards from the recessive individual - a recessive phenotype pins a genotype exactly, and the rest follows. The 25% applies to **each** child on its own: three brown-eyed children do not make the fourth blue.

Codominance and blood groups (Supplement)

In **codominance** 共显性, **both** alleles in a heterozygous organism show in the phenotype.

The ABO **blood groups** 血型 are an example. The alleles are I^A , I^B and I^o . The alleles I^A and I^B are codominant, while I^o is recessive:

- $I^A I^A$ or $I^A I^o \rightarrow$ group A
- $I^B I^B$ or $I^B I^o \rightarrow$ group B
- $I^A I^B \rightarrow$ group AB (both alleles shown)

- $I^o I^o \rightarrow$ group O

Sex linkage (Supplement)

A **sex-linked** 伴性遗传 characteristic is controlled by a gene on a sex chromosome (usually the X). Because males have only one X chromosome, a recessive allele on it always shows in males, so the feature is more common in males than in females.

Red-green colour blindness 色盲 is an example: the recessive allele is on the X chromosome, so it is much more common in boys than in girls.

Exam tips

- Gene = a length of DNA coding for a protein. Allele = one form of a gene.
- Genotype = the alleles present; phenotype = what you see. Homozygous = two same; heterozygous = two different.
- Dominant shows with one copy; recessive needs two copies.
- Learn to draw a Punnett square. $Bb \times Bb \rightarrow 3:1$; $Bb \times bb \rightarrow 1:1$.
- (Supplement) Codominance: both alleles show (blood group AB). Sex linkage: a gene on the X, more common in boys (colour blindness).