

Heredity

AP Biology ■ Unit 5

AP Biology

	B	b
B	BB	Bb
b	Bb	bb

What we will cover

- 1 Meiosis
- 2 Meiosis and genetic diversity
- 3 Mendelian genetics
- 4 Non-Mendelian patterns
- 5 Environment and phenotype

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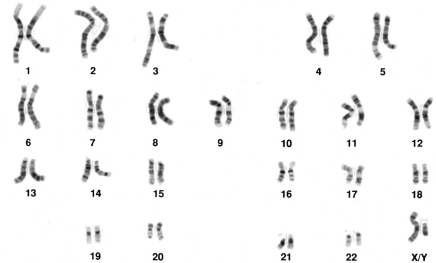


Meiosis

Meiosis turns one **diploid** cell into four **haploid gametes** – halving the chromosome number.

- **meiosis I** separates **homologous** pairs (halving)
- **meiosis II** separates the copies

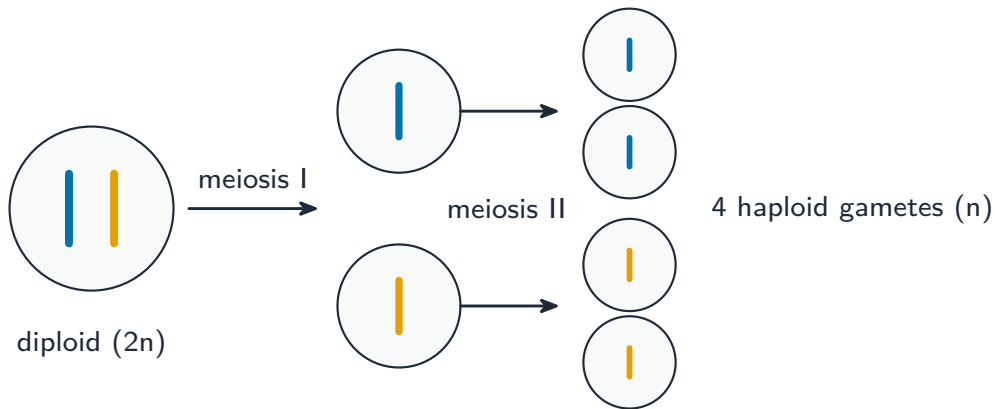
Two haploid gametes join at fertilization to restore the diploid number.



Normal Karyotype

Meiosis halves chromosome sets for gametes

Meiosis halves the chromosome number in two



Meiosis halves the chromosome number in two divisions



Meiosis and genetic diversity

Three shuffles make every gamete unique:

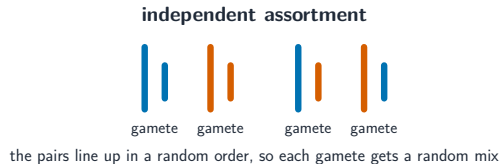
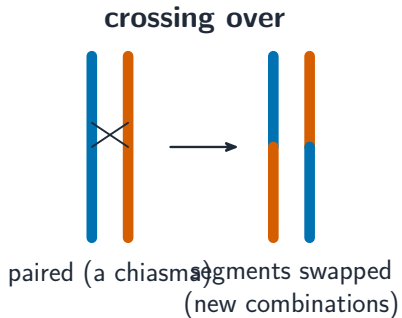
- **Crossing over** – homologs swap pieces
- **Independent assortment** – pairs line up at random
- **Random fertilization** – any sperm, any egg

Independent assortment alone gives 2^{23} human gamete types – **genetic diversity** is insurance.



Variation among offspring is not noise – it is insurance

Crossing over swaps segments between homologous



Independent assortment produces many gamete combinations

Crossing over swaps segments between homologous chromosomes

Where meiosis gets its variation

crossing over

homologous chromosomes swap segments in prophase I – new combinations *within* a chromosome

independent assortment

each homologous pair lines up independently at metaphase I – 2^{23} combinations in humans

random fertilisation

any sperm with any egg, multiplying the possibilities again

together

these create **enormous variation** – the raw material evolution acts on

homozygous / heterozygous

two identical alleles, or two different ones, at a locus

Mutation *creates* new alleles; meiosis *recombines* the existing ones. Both are needed, and they are not the same source.



Mendelian genetics

The **law of segregation** : alleles separate, so each gamete carries one. A **Punnett square** predicts the cross.

- **genotype** (Bb) vs **phenotype** (trait)
- **dominant** (capital) hides **recessive**

$Bb \times Bb \Rightarrow$ phenotype ratio **3:1**. Test the fit with $\chi^2 = \sum \frac{(O - E)^2}{E}$.

	B	b
B	BB	Bb
b	Bb	bb



Non-Mendelian patterns

Many traits break Mendel's simple dominant/recessive rule:

Incomplete dominance :
red+white $\rightarrow$ pink

Codominance : AB blood (both show)

Multiple alleles : I^A, I^B, i

Sex-linked : colour blindness

Polygenic & epistasis : a smooth range

Non-Mendelian patterns, continued

father:		X^B	Y
mother	X^B	$X^B X^B$	$X^B Y$
	X^b	$X^B X^b$	$X^b Y$
		carrier daughter	color-blind son

- **Incomplete dominance** : heterozygotes are a blend (red $\times$ white $\rightarrow$ pink).
- **Codominance** : both alleles show fully (AB blood type).
- **Multiple alleles, polygenic** traits (many genes, like height), **pleiotropy** (one gene, many effects), and **sex-linked** genes (on the X chromosome) all give more complex ratios.

Worked example – the chi-square test

A monohybrid cross predicts 3 : 1. Of 80 offspring, 55 show the dominant trait and 25 the recessive. Do the data fit?

- expected: 60 and 20
- $\chi^2 = \sum \frac{(o - e)^2}{e} = \frac{25}{60} + \frac{25}{20} = 0.42 + 1.25 = 1.67$
- $df = 2 - 1 = 1$; the critical value at $p = 0.05$ is 3.84
- $1.67 < 3.84$, so **do not reject** the null hypothesis – the data fit

The null hypothesis is that any difference is **chance alone**. Failing to reject it is not proof the ratio is right, only that the deviation is unremarkable.

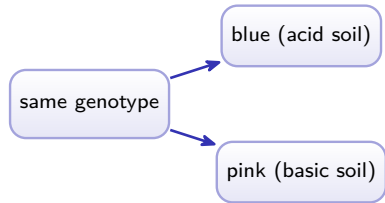


Environment and phenotype

Genes are not the whole story – the **environment** shapes the phenotype too.

- temperature (dark fur on cool paws)
- nutrition, light

Phenotypic plasticity : one genotype, a **range** of phenotypes – nature sets the options, the environment chooses.



Hydrangea: the soil decides the colour.

Phenotype is not set by genes alone

the claim

the **environment** also shapes how a genotype is expressed

temperature

Siamese cat coat colour, and temperature-dependent sex determination in some reptiles

nutrition

height and mass in almost every organism

density and crowding

can change growth form in plants and behaviour in animals

the general point

a genotype specifies a **range** of possible phenotypes, not one outcome

Identical twins are the standard evidence: the same genome, and measurably different phenotypes. That is what the term *norm of reaction* names.

Mendelian Genetics, continued

parents: $Tt \times Tt$

	T	t
T	TT	Tt
t	Tt	tt

green = tall (has a T)

orange = short (tt)

ratio 3 tall : 1 short

A monohybrid Punnett square giving a 3:1 ratio

Exam tips

- Contrast mitosis (2 identical, full chromosome number) with **meiosis** (4 non-identical gametes, half the number).
- Explain variation from **crossing over, independent assortment, and random fertilisation**.
- Use the multiplication rule for dihybrid crosses (each gene's 3:1 multiplied), and a **chi-square** test ($\chi^2 = \sum \frac{(o-e)^2}{e}$) to judge observed vs expected ratios.
- Keep **genotype** (the alleles) separate from **phenotype** (what you see) – AA and Aa can look the same.
- Recognise non-Mendelian patterns: incomplete dominance, codominance, and sex linkage.



Unit 5 – key takeaways

1

Meiosis

diploid $\rightarrow$ four haploid gametes;
halves chromosomes

2

Diversity

crossing over, independent assortment,
random fertilization

3

Mendel

$Bb \times Bb \Rightarrow 3:1$; test fit with χ^2

4

Beyond Mendel

incomplete dominance, codominance,
plasticity

Check yourself

- 1 How many cells, and what ploidy, does meiosis produce?
- 2 What phenotype ratio comes from $Bb \times Bb$?
- 3 Red + white flowers give pink – which inheritance pattern?
- 4 Two identical clones differ in colour – what is this called?

BB	Bb
Bb	bb

Answers 1. four haploid cells 2. 3:1 3. incomplete dominance 4. phenotypic plasticity