IB BIOLOGY | D3.2 | SL AND HL

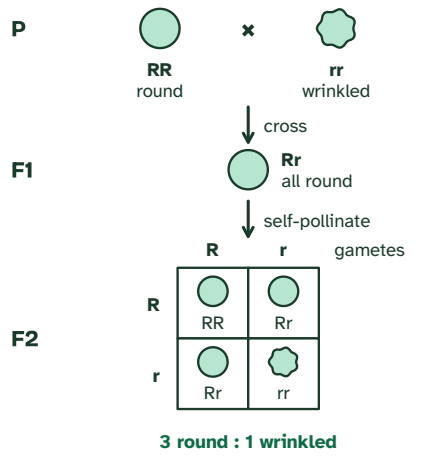
REVISION ON TWO PAGES

How genes are *inherited*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Each gamete carries one allele of every gene. Dominance, the environment and the chromosome a gene sits on decide what shows.



Draw it like this. Gametes on the edges of the Punnett grid. It gives chances, not exact counts.

D3.2.1, D3.2.2 START HERE

Halve, fuse, then *cross*

- Meiosis makes **haploid gametes**, one chromosome from each pair. Fertilisation fuses two into a **diploid zygote**, with **two copies of each autosomal gene**.
- This loop is shared by **all eukaryotes with a sexual life cycle**. In humans n = 23 and 2n = 46.
- **In flowering plants:** male gametes are in **pollen**, female gametes in ovules in the ovary, so a cross needs **pollination**.
- A pea flower makes both, so it can **self-fertilise**. For a cross, remove its anthers early and carry pollen from the other parent to its stigma.
- Breeders use crosses to make **new crop and ornamental varieties**.

THE GENERATIONS OF A CROSS

Parents, First, Follows

P **P generation** the parents you choose

F1 **F1 generation** their offspring

F2 **F2 generation** offspring of two F1 plants

D3.2.3, D3.2.4

Genotype and *phenotype*

- A **gene** is one place on a chromosome; an **allele** is one version of it (Y or y).
- Genotype: the alleles you inherit. The same two: **homozygous** (YY, yy). Two different: **heterozygous** (Yy).
- Phenotype: the observable traits, from **genotype and environment**.
- **In humans:** ABO group is genotype only; a scar is environment only; height and skin colour are both.

D3.2.5

Dominant and *recessive*

- A **dominant** allele shows in one copy or two. A **recessive** allele shows only with no dominant allele.
- So **YY and Yy look the same**; only yy differs.
- **Why:** often the recessive allele makes no working protein, and **one working copy makes enough**.

YY yellow | **Yy** yellow | **yy** green

D3.2.6

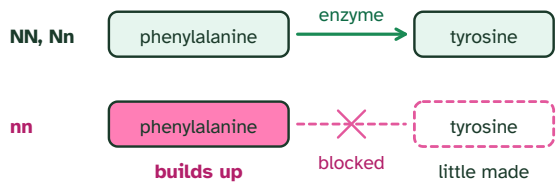
Phenotypic *plasticity*

- One genotype develops different traits in different conditions, by **varying gene expression**.
- **The genotype does not change**, and the change can be **reversible** in a lifetime.
- **Shade:** a cutting grows taller with broader leaves than one from the same plant in sun.
- **Also:** skin tans and fades; an Arctic hare is white in winter.

D3.2.7

PKU: one faulty *enzyme*

- An **autosomal recessive** disease. The gene codes for **phenylalanine hydroxylase**, which converts phenylalanine to tyrosine.
- **nn:** no working enzyme, so **phenylalanine builds up** and can damage the developing brain.
- **Nn carriers** have no symptoms. Two carriers: a **1 in 4 chance** of PKU for each child.
- Newborn screening and a **low-phenylalanine diet** change the phenotype, not the genotype.



D3.2.8 to 10

Many alleles; *codominance*

- **SNP**: a place in the genome where people differ by **a single base**.
- A gene pool can hold **any number of alleles** of a gene; a diploid individual inherits **only two**.

ABO	GROUP A	GROUP B	GROUP AB	GROUP O
Genotype	I^AI^A or I^Ai	I^BI^B or I^Bi	I^AI^B	ii
Marker	A	B	A and B	neither

Three alleles, four groups.

Apple, Banana, Both, Orange

Codominance dual phenotype
I^AI^B: red cells carry both the A and the B marker.

Incomplete dominance intermediate phenotype
Four o'clock, *Mirabilis jalapa*: C^RC^R red, C^WC^W white, C^RC^W pink. Pink × pink: 1 red : 2 pink : 1 white.

Sex, families, spreads and *two genes* at once

D3.2.11, D3.2.12

Sex and *haemophilia*

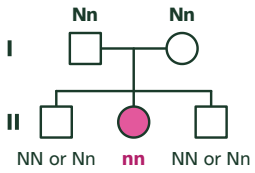
- XX female, XY male: the **sperm decides** male-typical or female-typical traits. The X has **far more genes** than the Y.
- **Haemophilia:** a recessive allele on the X, so a clotting protein is faulty. Write **X^H and X^h**; the Y gets no letter.
- A male has one X, so **one recessive allele shows**. Below, a carrier mother.

SPERM	EGG, NORMAL X	EGG, FAULTY X
X^H	X^HX^H girl	X^HX^h carrier girl
Y	X^HY boy	**X^hY haemophilia**

D3.2.13

Reading a *pedigree*

- **Nature of science:** find the pattern by **inductive reasoning**, then a person's genotype by **deductive reasoning**.
- Relatives' children are more often **homozygous for a harmful recessive**: the reason close-relative marriage is banned.

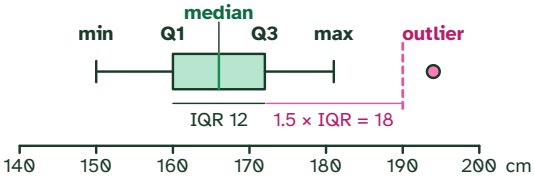


- Square male, circle female, **filled affected**.
- **Unaffected parents, affected child:** recessive.
- **Affected girl, unaffected father:** not X-linked recessive.

D3.2.14, D3.2.15

Continuous variation and *box plots*

- **Discrete:** a few types (ABO). **Continuous:** any value in a range, from **polygenic inheritance**, environment or both (skin colour).
- **Mean** sum ÷ number; **median** the middle value; **mode** the most frequent.
- **Box plot:** six aspects. An **outlier** is over **1.5 × IQR** beyond Q1 or Q3.



D3.2.16, D3.2.17 HIGHER LEVEL

Dihybrid crosses

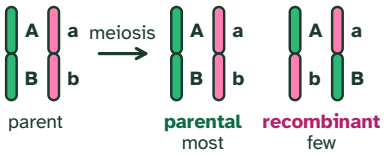
- **Segregation**: homologues part in meiosis I, one allele per gamete.
- **Independent assortment**: pairs line up either way; YyRr gives YR, Yr, yR, yr.
- YyRr × YyRr: **9 : 3 : 3 : 1**. YyRr × yyrr: **1 : 1 : 1 : 1**.
- **Nature of science:** Mendel's second law fails for linked genes.

9 : 3 : 3 : 1 is (3 : 1) × (3 : 1).

D3.2.18 to 20 HIGHER LEVEL

Linkage and *recombinants*

- A database gives a gene's **locus** and polypeptide: HBB and HBA1 are on different chromosomes; HBD is by HBB.
- **Linked genes** share a chromosome, so **fail to assort independently**. A crossover makes **recombinants**, seen in gametes, genotypes and phenotypes.



D3.2.21 HIGHER LEVEL

The *chi-squared* test

- **Null:** no real difference between O and E. **Alternative:** a real one.
- $\chi^2 = \Sigma (O - E)^2 \div E$; degrees of freedom (df) = classes − 1.
- Over the critical value at **p = 0.05**: **reject the null**.
- The F2 is a **sample** of the population.

3.84	7.81
critical, 1 df	critical, 3 df

WATCH OUT

Six mistakes that *cost marks*

- ✕ **A gene is not an allele.** Alleles are its versions.
- ✕ **Dominant does not mean common.** It only says what shows in a heterozygote.
- ✕ **Plasticity is not mutation.** The genotype stays.
- ✕ **Codominance is not intermediate.** AB cells carry both markers; a pink four o'clock is in between.
- ✕ **Sons never get X alleles from fathers.** They get his Y.
- ✕ **Not significant does not prove the null.** The data are just not enough to reject it.

COVER THE SHEET

Can you *answer these?*

1. Describe how to cross two pea plants.
2. Explain why YY and Yy have the same phenotype.
3. Outline phenotypic plasticity, and how PKU is treated.
4. Deduce the blood groups of children of $I^Ai \times I^Bi$.
5. Explain why haemophilia is commoner in males.
6. Distinguish inductive from deductive reasoning.
7. State the six aspects a box plot shows.
8. Explain why linked genes do not give 9 : 3 : 3 : 1. HL
9. State when a χ^2 test rejects the null hypothesis. HL

IN THE EXAM

Show every cross in order: parents' genotypes, gametes, Punnett grid, then the ratio in words. For sex linkage, put alleles on the X (X^hY).

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.