

IB BIOLOGY · D3.2

Inheritance

Notes to fill in alongside the guide. Each numbered block matches a chapter of the guide, and of the lesson slides. Write in the gaps, answer the cues, annotate the figures, and sum up each section in your own words.

BY THE END YOU CAN

- ☐ Explain how meiosis halves the chromosome number to make haploid gametes, and how fusion gives a diploid zygote D3.2.1
- ☐ Describe how a genetic cross is made in flowering plants, using the terms P generation, F1 generation, F2 generation and Punnett grid D3.2.2
- ☐ Define genotype, and use homozygous, heterozygous, gene and allele correctly D3.2.3
- ☐ Explain how phenotype comes from genotype and the environment, with examples of each D3.2.4
- ☐ Predict the effects of dominant and recessive alleles on phenotype D3.2.5
- ☐ Explain phenotypic plasticity as a change in gene expression, not in the genes themselves D3.2.6
- ☐ Explain phenylketonuria as a disease caused by a recessive allele D3.2.7
- ☐ Describe single-nucleotide polymorphisms and multiple alleles in a gene pool D3.2.8
- ☐ Use the ABO blood groups to show how multiple alleles are inherited D3.2.9
- ☐ Distinguish incomplete dominance from codominance D3.2.10
- ☐ Explain sex determination in humans and the inheritance of genes on the sex chromosomes D3.2.11
- ☐ Use haemophilia to explain a sex-linked genetic disorder D3.2.12
- ☐ Use pedigree charts to deduce patterns of inheritance of genetic disorders D3.2.13
- ☐ Explain continuous variation as the result of polygenic inheritance and the environment D3.2.14
- ☐ Draw and read box-and-whisker plots for a continuous variable such as student height D3.2.15
- ☐ Explain segregation and independent assortment of unlinked genes in meiosis D3.2.16
- ☐ Use Punnett grids to predict genotypic and phenotypic ratios in dihybrid crosses of unlinked autosomal genes D3.2.17
- ☐ Find the loci of human genes and their polypeptide products in a database D3.2.18
- ☐ Explain autosomal gene linkage D3.2.19
- ☐ Identify recombinants in crosses involving two linked or unlinked genes D3.2.20
- ☐ Use a chi-squared test on data from a dihybrid cross D3.2.21

01 Halve, then fuse

D3.2.1

CUES

Predict: A human body cell has 46 chromosomes. How many chromosomes are in a sperm, and how many in the zygote it helps to form?

What is meant by diploid?

NOTES

- 1** A cell like that is _____.
- 2** Most of them are _____, so a diploid cell has two copies of each autosomal gene: one on each chromosome of a pair.
- 3** Special cells divide by _____ to make _____, and each gamete gets one chromosome from every pair.

What is meant by autosomes?

What is meant by meiosis?

What is meant by gametes?

What is meant by haploid?

What is meant by zygote?

4 A cell with a single set is _____.

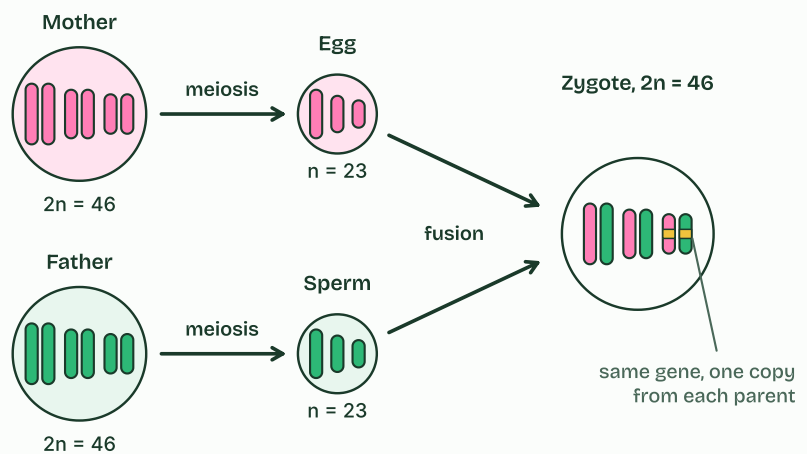
5 Their nuclei fuse to make a _____, which is diploid again, with one set from each parent.

Your own notes

ANNOTATE THE FIGURE

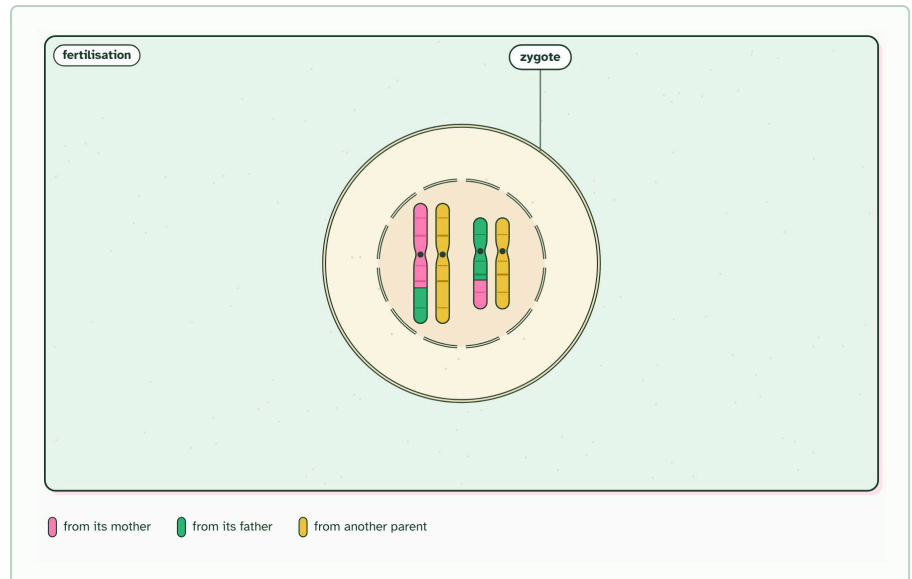
Number the 4 steps on the figure and note what happens at each: 1 diploid; 2 Meiosis, haploid; 3 Fusion; 4 same gene.

Halve, then fuse



ANNOTATE THE FIGURE

Annotate this still from the animation (Watch it happen: halving, then fusing): what is happening, and why?



SPOT THE MISTAKE

What do students often get wrong about halving and doubling? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 01 in two or three sentences of your own.

CUES

Predict: A student wants to cross a purple-flowered pea plant with a white-flowered one, but forgets to remove the anthers from the white plant. What is likely to happen?

What is meant by pollen?

What is meant by pollination?

What is meant by self-fertilisation?

What is meant by true-breeding?

What is meant by punnett grid?

NOTES

- 1 The male gametes are in _____, which forms in the anthers.
- 2 A pollen grain has to reach the stigma before it can fertilise an ovule, so a cross needs _____.
- 3 One flower makes both pollen and ovules, so it can pollinate itself: _____.
- 4 The two parents you choose are the _____.
- 5 Parents that are _____ give the _____ (F is for filial, meaning of a son or daughter).
- 6 Let the F1 plants pollinate each other, or themselves, and you get the _____.
- 7 A _____ predicts what the F2 should look like.

Your own notes

ANNOTATE THE FIGURE

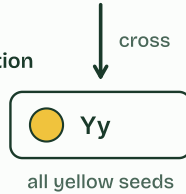
Number the 5 steps on the figure and note what happens at each: 1 Pollen, ovules; 2 pollinates itself; 3 cross; 4 P generation, F1 generation; 5 F2 generation, Punnett grid.

Making a cross in a pea plant

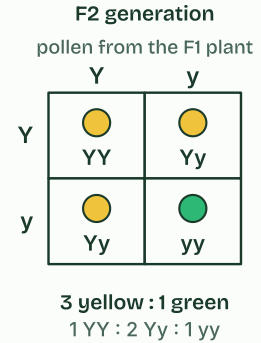
P generation



F1 generation



self-pollinate



REMEMBER IT

The generations of a cross

P Parents	F First	F Follows
P _____	F _____	F _____

SPOT THE MISTAKE

What do students often get wrong about genetic crosses in flowering plants? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 02 in two or three sentences of your own.

CUES

Predict: Two plants have the same genotype for every gene, but one grows much taller because it was given more water and fertiliser. What does this show?

What is meant by gene?

What is meant by alleles?

What is meant by genotype?

What is meant by homozygous?

What is meant by heterozygous?

What is meant by phenotype?

NOTES

- 1 A _____ is a length of DNA at one place on a chromosome.
- 2 Different versions of the same gene are _____.
- 3 The pair of alleles is your _____ for that gene.
- 4 If the two alleles are the same, you are _____ (YY or yy).
- 5 If they differ, you are _____ (Yy).
- 6 Your _____ is what can be observed: the colour of a seed, your blood group, your height, even your behaviour.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 gene, allele; 2 genotype, homozygous, heterozygous; 3 phenotype.

Genes, alleles and genotypes

ABO blood group



a scar from a cut



adult height



■ genotype ■ environment

Bar lengths show the idea, not measurements.

SPOT THE MISTAKE

What do students often get wrong about genotype and phenotype? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 03 in two or three sentences of your own.

CUES

Predict: Two yellow-seeded pea plants are crossed, and some of their offspring have green seeds. What must be true of both parents?

What is meant by dominant allele?

What is meant by recessive allele?

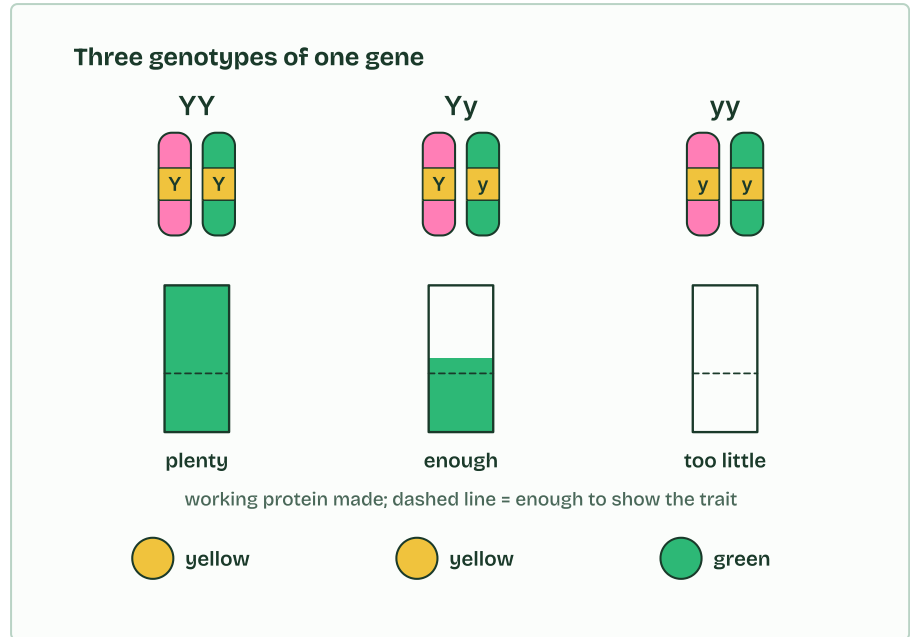
NOTES

- 1 A _____ shows its effect when it is present, in one copy or in two.
- 2 A _____ shows only when there is no dominant allele alongside it.
- 3 Three genotypes of the seed colour gene: two _____ and one _____.
- 4 Each gene makes a protein. A _____ allele makes a working one, and one working copy makes _____ to give the trait. With no working copy, the trait changes.
- 5 The phenotypes: _____ and _____ are both yellow, so the dominant allele shows in a heterozygote. Only _____ is green.
- 6 Each parent makes gametes by meiosis, one allele of each gene in each. The female parent's go down the side of the _____, the male parent's along the top.

Your own notes

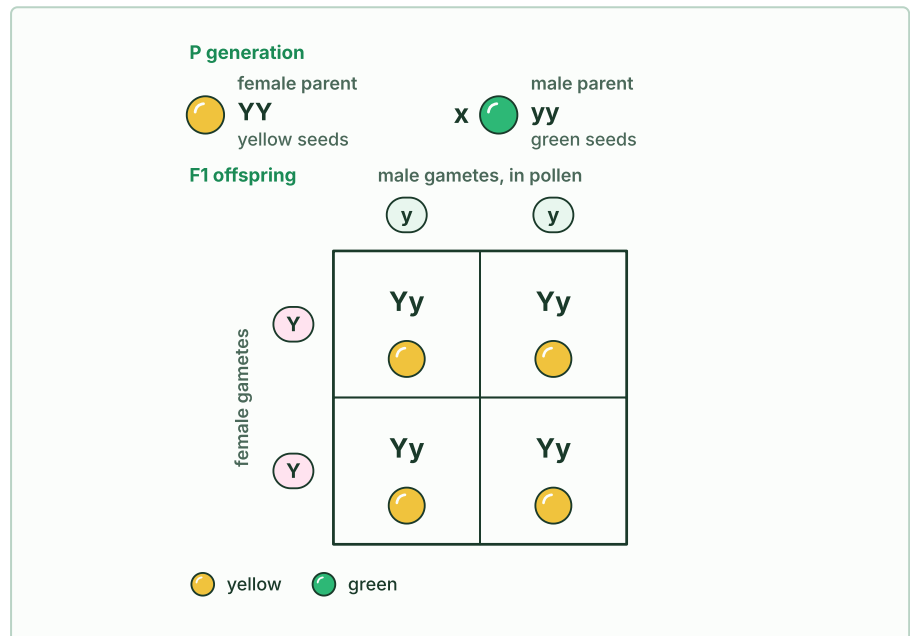
ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 homozygous, heterozygous; 2 Y, enough; 3 YY, Yy, yy.



ANNOTATE THE FIGURE

Number the 2 steps on the figure and note what happens at each.



SPOT THE MISTAKE

What do students often get wrong about dominant and recessive alleles?
Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 04 in two or three sentences of your own.

CUES

Predict: Two clones grow differently, one in sun and one in shade. What explains the difference?

What is meant by phenotypic plasticity?

What is meant by gene expression?

NOTES

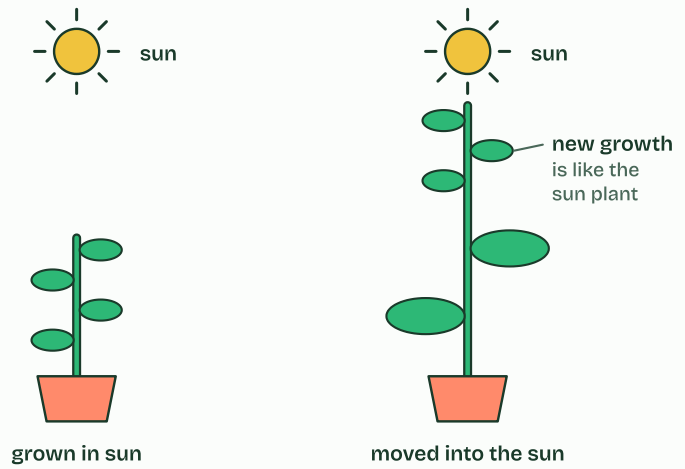
- 1 One individual, with one set of alleles, can develop different traits in different conditions, and the change often suits the conditions. That is _____.
- 2 The difference is in _____: which genes are switched on, where, and how strongly.
- 3 Because the alleles are the same, the change can be _____ during the life of the individual: move the shaded plant into the sun, and its new growth comes in short and sturdy, like the sun plant's.
- 4 Two _____ from it carry exactly the same alleles.
- 5 One cutting grows in _____ and one in _____. Same alleles, but different gene expression makes a short, sturdy plant and a tall one with broad leaves.
- 6 Move the shaded plant into the sun, and its _____ comes in like the sun plant's. The change is reversible, and the alleles never changed.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each.

Same alleles, different plants



SPOT THE MISTAKE

What do students often get wrong about phenotypic plasticity? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 05 in two or three sentences of your own.

CUES

Predict: Two parents do not have PKU, but their first child does. What is the chance that their second child has PKU?

What is meant by phenylketonuria?

What is meant by carrier?

NOTES

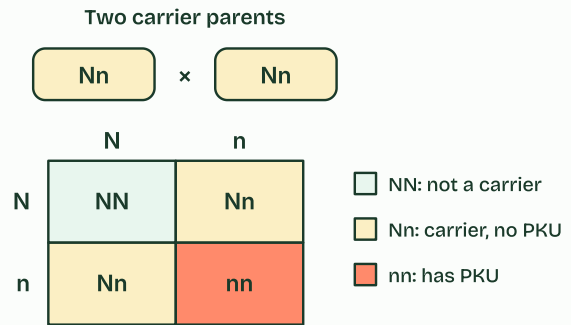
- 1 _____ (PKU) is a human disease caused by a recessive allele of an autosomal gene.
- 2 Because the allele is recessive, a person with one working and one faulty allele has no symptoms. That person is a _____.
- 3 In a person with a working allele, the _____ converts phenylalanine to tyrosine, which has one extra OH group.
- 4 In a person with two faulty alleles the enzyme does not work. Little tyrosine is made and _____.
- 5 A _____ gives the body less to build up. The genotype is the same, and the phenotype changes.
- 6 Two _____ parents (Nn): each child has a 1 in 4 chance of nn, so of PKU.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each: 1 enzyme; 2 phenylalanine builds up; 3 diet low in phenylalanine; 4 carrier.

One step in the pathway fails



Each child has a 1 in 4 chance of PKU.

SPOT THE MISTAKE

What do students often get wrong about phenylketonuria: a recessive disease? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 06 in two or three sentences of your own.

07 Many alleles, not just two

D3.2.8 D3.2.9

CUES

Predict: A man with blood group AB (IAIB) and a woman with group O (ii) have children. Which groups are possible?

What is meant by single-nucleotide polymorphism?

What is meant by gene pool?

What is meant by ABO blood group?

NOTES

- 1 A place in the genome where people differ by a single base, and where each version is common enough to count (often taken as more than 1 in 100), is a _____, or SNP ("snip").
- 2 All the alleles of all the genes in a population make up its _____.
- 3 The _____ is the textbook example.
- 4 DNA from four people at one place. They differ at a single base: a _____.
- 5 Across a whole population a gene can have many _____. The _____ holds them all.
- 6 Each person inherits just _____ of them.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each.

SNPs, alleles and the gene pool

genotype	blood group
IAIA	group A
IAi	group A
IBIB	group B
IBi	group B
IAIB	group AB
ii	group O

Three alleles in the pool, so six genotypes and four groups.

REMEMBER IT

The four blood groups

A Apple	B Banana	B Both	O Orange
A _____	B _____	B _____	O _____

SPOT THE MISTAKE

What do students often get wrong about SNPs, multiple alleles and ABO blood groups? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 07 in two or three sentences of your own.

08 Neither wins, or both do

D3.2.10

CUES

Predict: A red four o'clock plant is crossed with a white one.
What colour are the F1 flowers?

What is meant by incomplete dominance?

What is meant by codominance?

NOTES

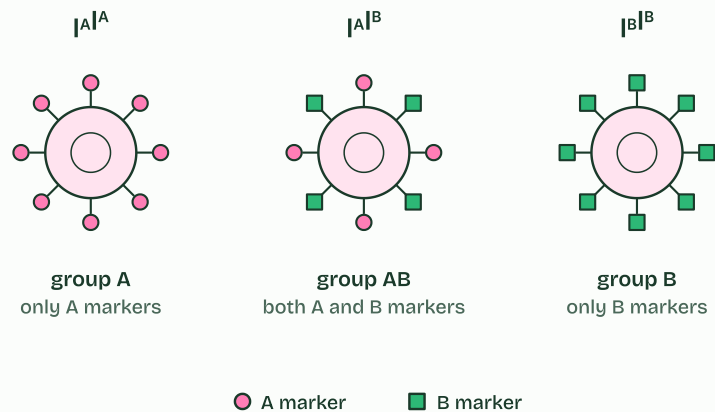
- 1 In _____ the heterozygote has an _____ phenotype.
- 2 In _____ both alleles are expressed fully, and the heterozygote has a _____ phenotype.
- 3 _____: the heterozygote is in between.
- 4 _____: the heterozygote shows both at once.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 Incomplete dominance; 2 1 red : 2 pink : 1 white; 3 Codominance.

When neither allele wins outright



SPOT THE MISTAKE

What do students often get wrong about incomplete dominance and codominance? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 08 in two or three sentences of your own.

CUES

Predict: A man with haemophilia (X^hY) and a woman who is not a carrier (X^HX^H) have children. What are the children like?

What is meant by sex-linked?

What is meant by haemophilia?

NOTES

- 1 A _____ gene is one that sits on a sex chromosome, and in practice nearly all of them are on the X.
- 2 _____ is the standard example.
- 3 The _____ is big and carries many genes. The _____ is small and carries far fewer. Two Xs develop female, an X and a Y develop male.
- 4 Every egg carries an X. A sperm carries X or Y, so the _____ the sex: half girls, half boys.
- 5 _____: a carrier mother (X^HX^h) and an unaffected father (X^HY). Half the sons have haemophilia and half the daughters are carriers. No daughter is affected.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 X, Y; 2 sperm decides; 3 Haemophilia.

X, Y and sex

carrier mother × unaffected father

	X^H	Y
X^H	X^HX^H girl, not affected	X^HY boy, not affected
X^h	X^HX^h girl, carrier	X^hY boy, has haemophilia

Mother: row of eggs. Father: column of sperm.

SPOT THE MISTAKE

What do students often get wrong about sex determination and sex linkage?
Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 09 in two or three sentences of your own.

CUES

Predict: In a pedigree, two unaffected parents have an affected daughter. Which statement is correct?

What is meant by pedigree chart?

What is meant by inductive reasoning?

What is meant by deductive reasoning?

NOTES

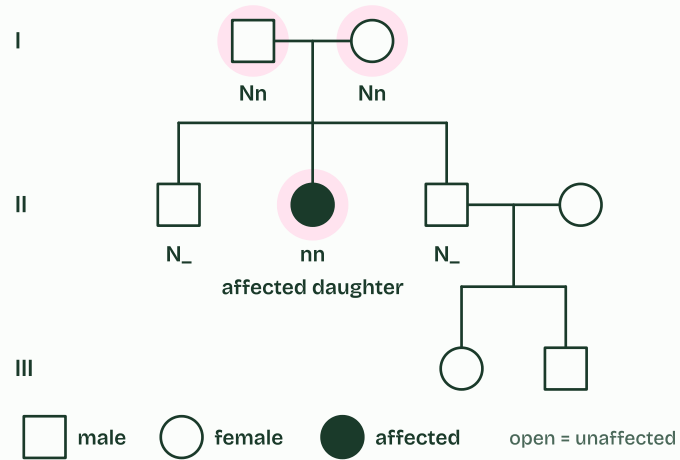
- 1 A _____ follows a trait through a family.
- 2 Looking over the family and deciding "this pattern fits a recessive trait" is _____.: you generalise from the cases you can see.
- 3 Once you have the pattern, you use _____ to find the genotype of a particular person: if the trait is recessive, an affected woman must be nn, and her unaffected parents must both be Nn.
- 4 The key: _____ are males, _____ are females, filled symbols are affected. A line across joins a couple, and lines down lead to their children.
- 5 Two unaffected parents (generation I) have an affected daughter (generation II). The condition was _____ in both parents.
- 6 _____ the genotypes: a recessive condition needs _____ in the daughter and one _____ from each parent, so both parents are _____.

Your own notes

ANNOTATE THE FIGURE

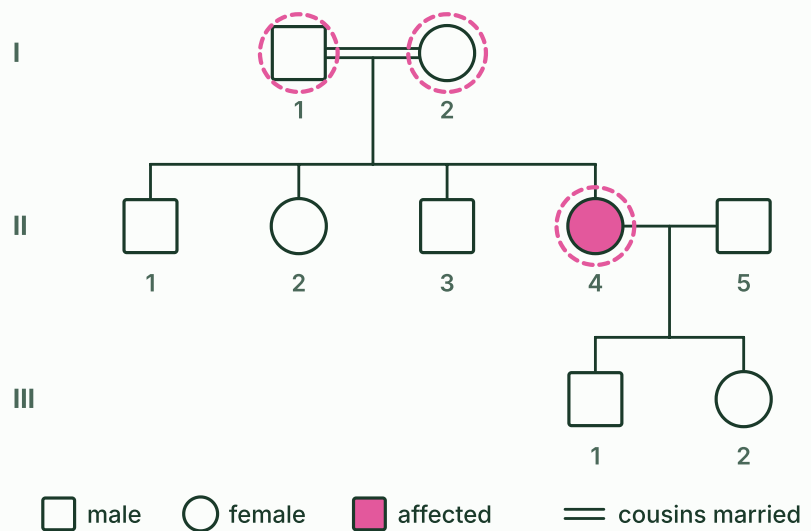
Number the 3 steps on the figure and note what happens at each: 1 squares, circles; 2 hidden; 3 Deducing, nn, n, Nn.

A family tree for one condition



ANNOTATE THE FIGURE

Number the 2 steps on the figure and note what happens at each: 1 affected; 2 ruled out.



REMEMBER IT

Four clues for reading a pedigree

Q Quiet	L Loud	D Dad	B Boys
Q _____	L _____	D _____	B _____

SPOT THE MISTAKE

What do students often get wrong about pedigree charts? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 10 in two or three sentences of your own.

CUES

Predict: Which of these shows discrete variation?

What is meant by discrete variation?

What is meant by continuous variation?

What is meant by polygenic?

NOTES

- 1 ABO blood group is A, B, AB or O, and nobody is halfway. That is _____, and it usually comes from one gene with a few alleles.
- 2 Other traits, such as height, skin colour or the mass of a seed, form a smooth range with every value in between. That is _____.
- 3 A trait can be _____: controlled by several genes whose small effects add up.
- 4 And the _____ blurs the steps further, because it nudges every genotype a little up or down.
- 5 The _____ is the sum divided by the number of values.
- 6 The _____ is the middle value when they are in order.
- 7 The _____ is the most frequent value.

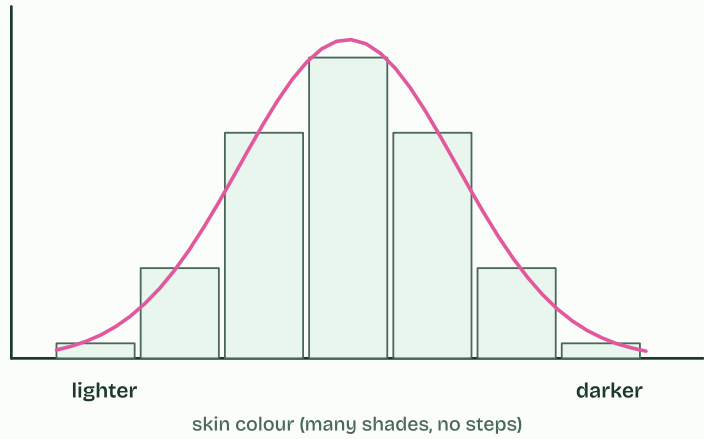
Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 Discrete; 2 polygenic; 3 environment, continuous.

Discrete or continuous?

Add sun, diet and other environmental effects



SPOT THE MISTAKE

What do students often get wrong about continuous variation? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 11 in two or three sentences of your own.

12 Showing a spread with a box plot

D3.2.15

CUES

Predict: In a box plot, what fraction of the data lie inside the box?

What is meant by box-and-whisker plot?

What is meant by quartiles?

What is meant by interquartile range?

What is meant by outlier?

NOTES

- 1 A _____ does it with six aspects of the data: the minimum, the first quartile, the median, the third quartile, the maximum and any outliers.
- 2 The _____ split each half again: a quarter of the values are below Q_1 and a quarter are above Q_3 .
- 3 The length of the box, $Q_3 - Q_1$, is the _____ (IQR).
- 4 A value is an _____ if it is more than $1.5 \times \text{IQR}$ above Q_3 or below Q_1 .

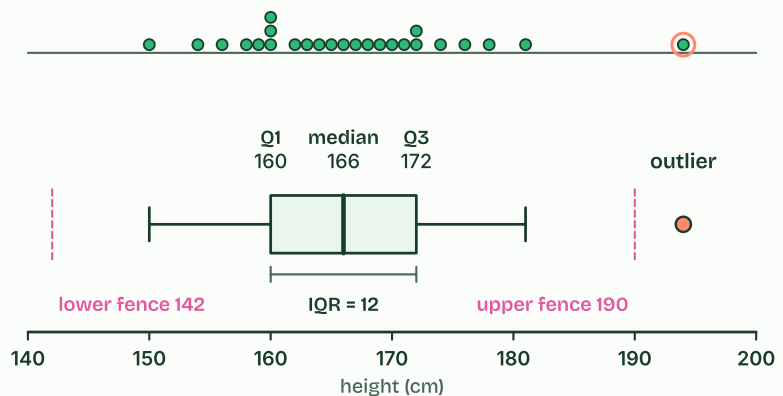
Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each.

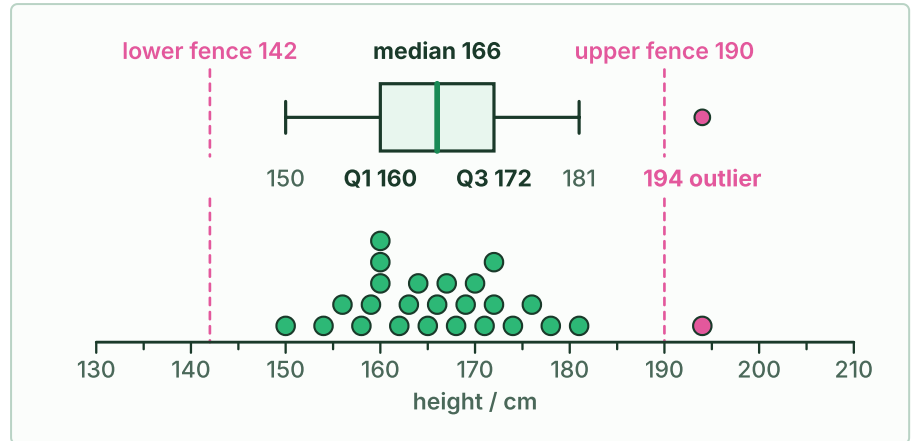
25 student heights (made-up data)

each dot is one student



ANNOTATE THE FIGURE

Number the 2 steps on the figure and note what happens at each: 1 continuously; 2 box, median, outlier.



SUMMARY

Sum up section 12 in two or three sentences of your own.

13 Two genes at once

D3.2.16 HL D3.2.17 HL

CUES

Predict: A plant YyRr is crossed with a plant yyrr. What proportion of the offspring are yellow and round?

What is meant by dihybrid cross?

What is meant by segregation?

What is meant by independent assortment?

NOTES

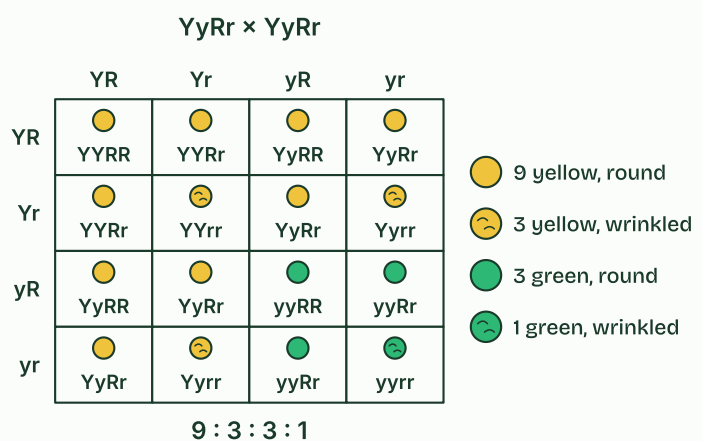
- 1 A _____ follows two genes.
- 2 In meiosis I the two chromosomes of a homologous pair go to opposite poles, so the two alleles of a gene end up in different gametes: each gamete gets one. That is _____.
- 3 Both are equally likely, so it makes four kinds of gamete, YR, Yr, yR and yr, in equal numbers. This is _____.
- 4 Count the phenotypes: 9 yellow round, 3 yellow wrinkled, 3 green round and 1 green wrinkled. That is _____.
- 5 Cross a double heterozygote YyRr with a double recessive yyrr and the recessive parent adds only yr, so the offspring show the heterozygote's four gametes: _____.

Your own notes

ANNOTATE THE FIGURE

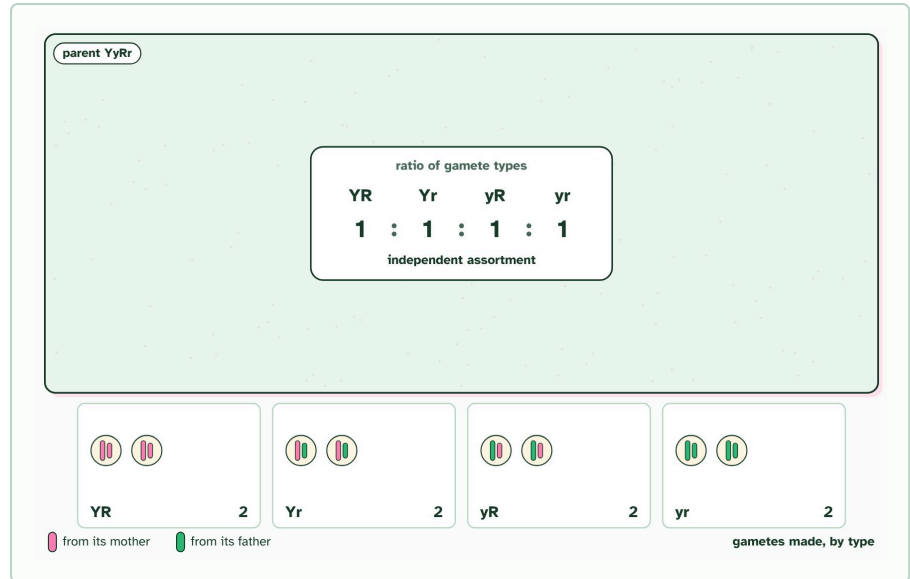
Number the 5 steps on the figure and note what happens at each.

Two genes, two pairs of chromosomes



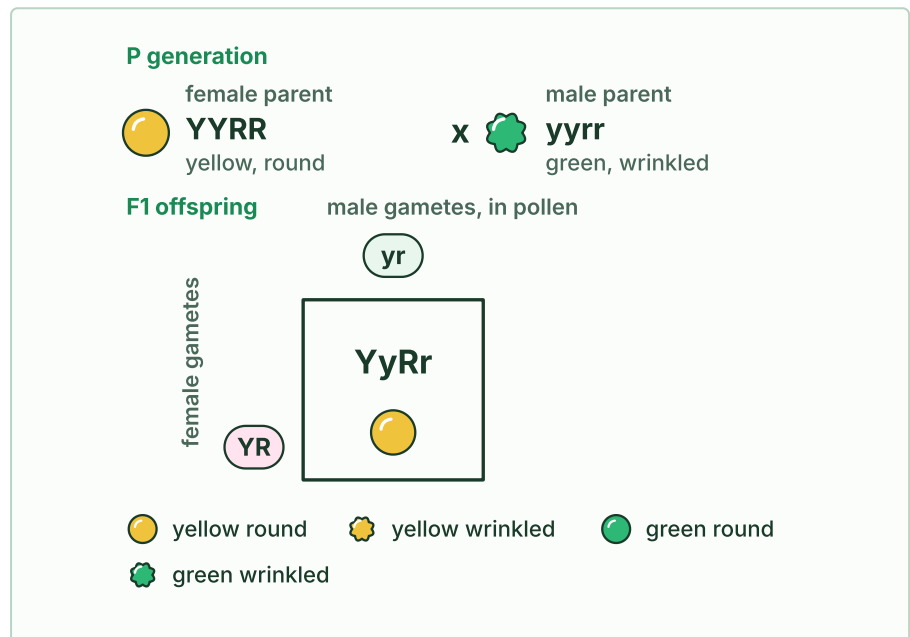
ANNOTATE THE FIGURE

Annotate this still from the animation (Watch it happen: two genes line up independently): what is happening, and why?



ANNOTATE THE FIGURE

Number the 2 steps on the figure and note what happens at each.



SUMMARY

Sum up section 13 in two or three sentences of your own.

14 Genes that travel together

D3.2.18 HL D3.2.19 HL D3.2.20 HL

CUES

Predict: A test cross $AaBb \times aabb$ gives 48 AB, 47 ab, 3 Ab and 2 aB. What does this suggest?

What is meant by linked?

What is meant by recombinant?

What is meant by test cross?

NOTES

- 1 Genes on the same chromosome are _____: they travel together in meiosis because they sit on the same piece of DNA.
- 2 With no crossing over, only two kinds of gamete form, AB and ab: the combinations that were already on the chromosomes, called _____ types.
- 3 A gamete, a genotype or a phenotype with a combination of alleles that differs from the combinations on the parent's chromosomes is a _____.
- 4 The _____ shows this.
- 5 The _____ is the recombinants divided by all the offspring.

Your own notes

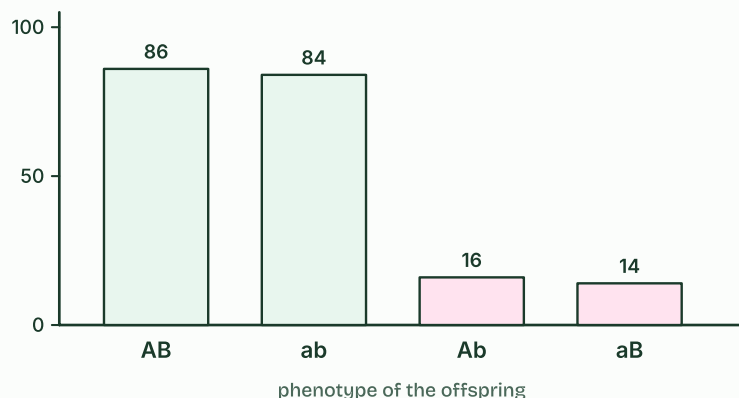
ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each: 1 Unlinked; 2 Linked, parental; 3 Crossing over, recombinant; 4 test cross.

Genes on one chromosome travel together

200 offspring of $AaBb \times aabb$ (made-up numbers)

number of offspring



recombinants: $16 + 14 = 30$ of 200, which is 15%

SPOT THE MISTAKE

What do students often get wrong about gene loci, linkage and recombinants? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 14 in two or three sentences of your own.

15 Is it chance? The chi-squared test

D3.2.21 HL

CUES

Predict: A chi-squared value of 2.1 with 3 degrees of freedom is compared with a critical value of 7.81. What do you conclude?

What is meant by chi-squared test?

What is meant by null hypothesis?

NOTES

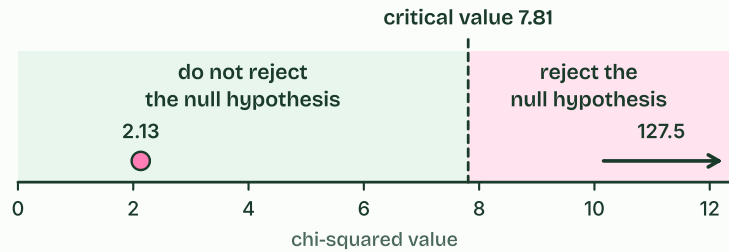
- 1 A _____ answers that.
- 2 The _____ says there is no real difference between observed and expected: the genes are unlinked, and chance explains the scatter.
- 3 160 F2 plants: the _____ counts from 9 : 3 : 3 : 1 (90, 30, 30 and 10) against _____ counts (made up).
- 4 χ^2 is the sum of $(O - E)^2 \div E$ over the four classes: _____.
- 5 With 3 degrees of freedom and $p = 0.05$ the _____ is 7.81. 2.13 is below it, so you do not reject the null hypothesis: chance can explain the difference.
- 6 A test cross of linked genes (made-up counts 112, 21, 18 and 109 from 260 offspring) gives $\chi^2 =$ _____, far past 7.81. Reject the null: the genes are probably linked.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each: 1 expected, observed; 2 2.13; 3 critical value; 4 127.5.

Observed against expected



df = 4 classes - 1 = 3, at p = 0.05

REMEMBER IT

The five steps of a chi-squared test

H Hungry	E Elves	C Cook	D Delicious	C Cakes
H _____	E _____	C _____	D _____	C _____

SPOT THE MISTAKE

What do students often get wrong about the chi-squared test? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 15 in two or three sentences of your own.



Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on D3.2 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

biologybybradford.com/exam-maker/sit?topics=D3.2&level=HL&paper=quiz&marks=15&src=ep

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.