

AP Biology Unit 5

Heredity & Genetics

One-page sprint review
Free at Sophriva

EXAM WEIGHT

8-11%

MCQs

5-7

FRQ APPEARANCE

Very Frequent

SPRINT TIME

~2 hours

Inside this pack

- Quick Glance at every Unit topic with priority + format
- Topic-by-topic key traps, must-know rules, and exam frames
- Worked example questions on the highest-yield topics

Get your AP Bio FRQ marked free

Upload, scored against the published rubric, point-by-point feedback.

sophriva.com/register



AP Biology Unit 5 — Heredity & Genetics



Sprint Review • Exam in 3 Days

Sprint Review • Free at Sophriva

AP BIO UNIT 5 • SOPHRIVA.COM



Exam Weight

8–11%



~MCQs

**5–7
questions**



FRQ Appearance

**Very
Frequent**



Sprint Time

~2 hours

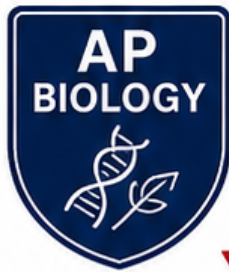
Quick Glance — All Topics at a Glance

Topic	Priority	Exam Format	Key Trap or Must-Know
5.1–5.2 Meiosis & Diversity	★★★	MCQ, FRQ	Meiosis I = homologs separate; Meiosis II = sister chromatids separate. After Meiosis I: n chromosomes but STILL duplicated.
5.3 Mendelian Genetics	★★★	MCQ, Calc, FRQ	'Fail to reject H_0 ' — NEVER say 'accept.' Chi-square $p=0.05$ critical value at $df=3$ is 7.815.
5.4 Non-Mendelian Genetics	★★★	MCQ, FRQ	Incomplete dominance = NEW intermediate phenotype; codominance = BOTH original phenotypes expressed. Mitochondrial = maternal only.
5.5 Environmental Effects	★★	MCQ	Phenotypic change \neq genetic change; same genotype can produce different phenotypes in different environments.



Best last-3-day focus: Meiosis I vs II. probability shortcuts.

Get your AP Bio FRQ marked free at sophriva.com



5.1–5.2 Meiosis & Genetic Diversity



Know exactly what separates, when, and why

1 Meiosis I vs II — The Critical Distinction		
	Meiosis I	Meiosis II
What separates?	Homologous chromosomes separate	Sister chromatids separate
Key prophase event	Synapsis + crossing over (chiasmata)	No synapsis, no crossing over
Metaphase alignment	Bivalents line up	Individual chromosomes line up
Result (per cell)	2 cells, each n chromosomes but chromosomes still duplicated	4 cells total, each n unduplicated chromosomes
Ploidy change	$2n \rightarrow n$	$n \rightarrow n$
DNA content	$4C \rightarrow 2C$	$2C \rightarrow 1C$

Key idea:
after Meiosis I, cells are haploid in chromosome count but still duplicated.

2 Mitosis vs Meiosis — Exam Comparison		
	Mitosis	Meiosis
Purpose	growth-repair-asexual reproduction	gamete production
Divisions	1 division	2 divisions
Daughter cells	2 diploid identical cells	4 haploid unique cells
Genetic outcome	Genetically identical to parent cell	Genetically unique due to variation
Synapsis & crossing over	No synapsis, no crossing over	Synapsis and crossing over in Prophase I
Homolog separation	No homolog separation	Homologs separate in Anaphase I
Sister chromatid separation	Sister chromatids separate in Anaphase	Sister chromatids separate in Anaphase II
Where it occurs	Somatic cells	Gonads

EXAM SNIPER

- End of Meiosis I in a $2n = 8$ organism \rightarrow 4 chromosomes each still duplicated.
- Crossing over in Prophase I shuffles alleles within chromosomes.
- FRQ on genetic variation should mention crossing over, independent assortment, and random fertilization.

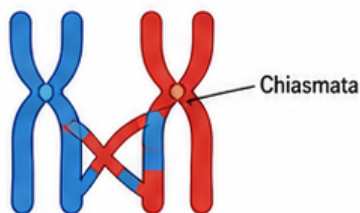
TRAP ALERT

- DNA is not fully reduced to final gamete DNA level until Meiosis II.
- Crossing over does NOT happen in Meiosis II or mitosis.
- Independent assortment shuffles whole chromosomes, not alleles within one chromosome.

5.2 Sources of Genetic Diversity + Nondisjunction

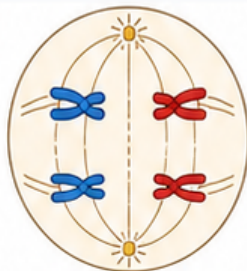
Three sources of variation and what happens when chromosomes fail to separate.

1 Source 1 — Prophase I: Crossing Over (Recombination)



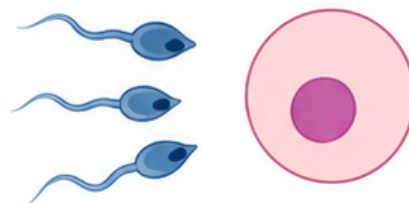
- Non-sister chromatids exchange segments at chiasmata.
- Creates recombinant chromosomes.
- Shuffles alleles on the same chromosome.
- More distance = higher recombination frequency.
- Recombination frequency (%) = map distance in centimorgans (cM).
- 50% recombination behaves like unlinked genes.

2 Source 2 — Metaphase I: Independent Assortment



- Each bivalent orients randomly.
- One homolog pair does not affect another.
- 2^n possible gamete chromosome combinations.
- Humans $2^{23} \approx 8.4$ million gametes.
- Basis of Mendel's law.
- Applies to genes on different chromosomes or very far apart on the same chromosome.

3 Source 3 — Fertilization: Random Fertilization



- Any sperm can fertilize any egg.
- $(2^{23})^2 \approx 70$ trillion possible zygotes.
- Helps make each individual genetically unique.

Nondisjunction → Aneuploidy

	Meiosis I Failure	Meiosis II Failure
What fails	Homologs do not separate. 	Sister chromatids do not separate.
Gametes produced	2 gametes $n+1$ and 2 gametes $n-1$ (all 4 abnormal)	1 gamete $n+1$, 1 gamete $n-1$, 2 gametes n (normal) (only 2 of 4 abnormal)
Fertilization outcome	After fertilization with a normal gamete: 2 zygotes $2n+1$ (trisomic) and 2 zygotes $2n-1$ (monosomic) (all 4 abnormal)	After fertilization with a normal gamete: 1 zygote $2n+1$ (trisomic), 1 zygote $2n-1$ (monosomic), 2 zygotes $2n$ (normal) (only 2 of 4 abnormal)

Key Aneuploidies — AP Examples



- Trisomy 21 — Down syndrome
- Klinefelter — XXY
- Turner — XO
- Triple X — XXX
- Most autosomal trisomies lethal.
- Extra X chromosomes are tolerated because of Barr bodies.



Exam Sniper



- Nondisjunction in Meiosis I makes **all 4** gametes abnormal.
- Nondisjunction in Meiosis II makes **only 2** of 4 abnormal.



Trap Alert



- After Meiosis I, cells are n but still duplicated.
- Trisomy = $2n+1$
- Monosomy = $2n-1$







5.3 Mendelian Genetics



Ratios, laws, Punnett logic, and probability shortcuts

Key Ratios to Memorize

Cross	Phenotypic Ratio	Genotypic Ratio	Shortcut
 Monohybrid F2 (Aa × Aa)	3:1	1AA:2Aa:1aa	3/4 dominant, 1/4 recessive.
 Dihybrid F2 (AaBb × AaBb)	9:3:3:1	—	9 A ₋ B ₋ : 3 A ₋ bb : 3 aaB ₋ : 1 aabb.
 Test cross (A ₋ × aa)	1:1 if Aa or all dominant if AA	—	reveals unknown genotype.
 Monohybrid F1 (AA × aa)	all dominant	all Aa	F1 all heterozygous.

Punnett Square Quick Reference

		Aa × Aa				Aa × aa	
		A	a			a	a
A		AA	Aa	A		Aa	aa
a		Aa	aa	a		Aa	aa

Mendel's Two Laws



- **Law of Segregation:** The two alleles for each gene separate during gamete formation so each gamete gets only one allele.
- **Law of Independent Assortment:** Alleles of different genes assort independently into gametes.
- **Dominant allele:** expressed with one copy.
- **Recessive allele:** only expressed in the homozygous state.

Probability Rules — Faster Than Punnett Squares



- **AND rule** = multiply.
- **OR rule** = add.
- Treat each gene independently in a dihybrid cross.
- Example: $P(A_B_) = \frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$.
- Faster than a 16-box Punnett.

Exam Sniper



- 9/16 both dominant phenotypes in AaBb × AaBb.
- Test cross 1:1 means heterozygous.
- AA × aa gives all Aa.

Worked Mini MCQ



$$YyRr \times YyRr \text{ — probability of } yyrr \\ = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$$




Show the multiplication method for AP exam method points.





5.3 Chi-Square Hypothesis Test


Know the steps, the formula, and the exact wording


The 5-Step Chi-Square Process

- 

State H_0 : no significant difference between observed and expected ratios.
- 

Calculate expected values:
 $E = \text{total} \times \text{expected fraction}$.
- 

Calculate chi-square:
 $\chi^2 = \sum \left[\frac{(O - E)^2}{E} \right]$.
- 

Degrees of freedom:
 $df = \text{number of phenotypic classes} - 1$.
- 

Compare with critical value and conclude:
 $\chi^2 < \text{critical value} \rightarrow \text{fail to reject } H_0$
 $\chi^2 > \text{critical value} \rightarrow \text{reject } H_0$

CHI-SQUARE FORMULA

$$\chi^2 = \sum \left[\frac{(O - E)^2}{E} \right]$$


CRITICAL LANGUAGE — COSTS POINTS EVERY YEAR

 **CORRECT** (Use this wording)

- fail to reject H_0
- reject H_0

 **WRONG** (Do not use)





- accept H_0
- prove the hypothesis





 $p = 0.05$ means only 5% chance of a deviation this large if H_0 were true.

WORKED EXAMPLE

Expected 9:3:3:1 ratio

Observed (160 total):


-  Round yellow 90
-  Round green 30
-  Wrinkled yellow 32
-  Wrinkled green 8

Phenotypic Class	Expected Fraction	Expected (E)	Observed (O)	$\frac{(O - E)^2}{E}$
 Round yellow	9/16	90	90	0
 Round green	3/16	30	30	0
 Wrinkled yellow	3/16	30	32	0.133
 Wrinkled green	1/16	10	8	0.4
Totals		160	160	0.533

$$\chi^2 = 0 + 0 + 0.133 + 0.4 = 0.533$$

$$df = \text{number of classes} - 1 = 4 - 1 = 3$$

Critical value at $p = 0.05$ and $df = 3$ is 7.815

 Since $0.533 < 7.815$, **fail to reject H_0** .
The data are consistent with the expected 9:3:3:1 ratio.

MINI REFERENCE

Critical values for χ^2
($p = 0.05$)

df	Critical Value ($p = 0.05$)
1	3.841
3	7.815

★ Common df in dihybrid (4 classes): 3

Always check df before picking the critical value.



EXAM SNIPER: Never say “accept H_0 ”. Say “fail to reject H_0 ”.



5.4 Non-Mendelian Genetics

When inheritance patterns are more than simple dominance

Dominance Patterns — The Big Three

	COMPLETE DOMINANCE one allele masks the other	INCOMPLETE DOMINANCE heterozygote has a NEW intermediate phenotype	CODOMINANCE both alleles fully expressed simultaneously
How the heterozygote looks	<p>TT (tall) = Tt (tall)</p>	<p>RR (red) × Rr (pink) × rr (white)</p>	<p>AB blood type Roan cattle</p> <p>● A antigen ● B antigen</p>
F ₂ ratio	<p>3 : 1 (Dominant : Recessive)</p>	<p>1 : 2 : 1 (Red : Pink : White)</p>	<p>1 : 2 : 1 (Two types : Both : Other two types)</p>
Example	<p>TT tall and Tt tall</p>	<p>red × white → pink snapdragon</p> <p><i>Alleles are not blended; heterozygote is a distinct, intermediate phenotype.</i></p>	<p>ABO blood type (AB) and roan cattle</p> <p><i>Both alleles are expressed at the same time.</i></p>

More Non-Mendelian Patterns

<p>PLEIOTROPY</p> <p>One gene affects multiple traits. Example: Sickle cell disease (HBB gene).</p>	<p>POLYGENIC INHERITANCE</p> <p>Many genes control one trait. Produces continuous, bell-curve traits like height and skin color. Not 3:1 ratios.</p>	<p>GENE LINKAGE</p> <p>Genes on the same chromosome tend to be inherited together. Recombination frequency < 50% means linked. (Closer genes = lower recombination.)</p>	<p>EPISTASIS</p> <p>One gene masks expression of another gene. Can create modified 9:3:3:1 ratios.</p>
--	---	--	---



EXAM SNIPER

- ★ Pink snapdragons = **INCOMPLETE DOMINANCE**, not codominance.
- ★ AB blood type = **CODOMINANCE**.



TRAP ALERT

- Incomplete dominance and codominance both can yield **1:2:1**, but the **heterozygote phenotype is different**.
- Bell-curve distributions suggest **polygenic inheritance**.

5.4 X-Linked Inheritance + Maternal Inheritance

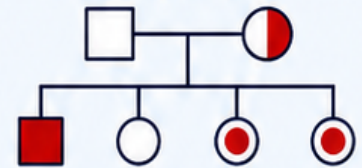
Pedigree rules you must recognize fast

1 X-Linked Recessive — Pedigree Rules

Genotype	Sex	Phenotype	Exam Notes
$X^A X^A$	♀ Female	✓ Normal	cannot be carrier
$X^A X^a$	♀ Female	✓ Normal (Carrier)	passes X^a to 50% of offspring
$X^a X^a$	♀ Female	✗ Affected	must receive X^a from both parents
$X^A Y$	♂ Male	✓ Normal	—
$X^a Y$	♂ Male	✗ Affected	hemizygous, no carrier state

How to Identify X-Linkage

- appears more often in males
- affected sons get X^a from mother
- affected daughters need X^a from both parents
- affected father cannot pass trait directly to sons
- father passes X^a to all daughters
- examples: colorblindness, hemophilia A, Duchenne muscular dystrophy



2 Organelle Inheritance — Maternal Only

- mitochondrial DNA inherited from mother through egg cytoplasm
- sperm mitochondria destroyed after fertilization
- all children of an affected mother inherit mtDNA mutation
- affected father passes none
- chloroplast DNA usually maternal in plants
- pedigree clue = all children of affected mothers, none of affected fathers

Affected Mother



Affected Father



Exam Sniper

- colorblind man × woman whose father was colorblind → sons can be affected, but daughters are colorblind only if father is affected and mother provides X^a .

- mitochondrial disease in mother affects all children.

Worked Mini MCQ

A woman with normal vision but a colorblind father marries a normal-vision man.
Probability their first child is a colorblind daughter = 0,
 because father cannot provide X^a .

		Father ($X^A Y$)	
		X^A	Y
Mother ($X^A X^a$)	X^A	$X^A X^A$ (normal ♀)	$X^A Y$ (normal ♂)
	X^a	$X^A X^a$ (carrier ♀)	$X^a Y$ (colorblind ♂)

No genotype $X^a X^a$ possible → P = 0.

Trap Alert

- X-linked recessive CAN appear in females if $X^a X^a$.

- mitochondrial inheritance is strictly maternal in animals.

5.4–5.5 Linkage, Recombination & Environment

Linked genes and phenotypic plasticity

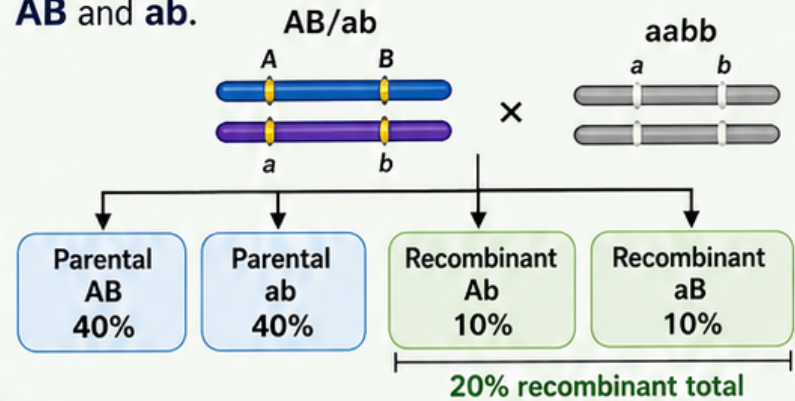


Gene Linkage & Recombination

- Genes on the same chromosome tend to be inherited together.
- **Recombination frequency (%)** = map distance in centimorgans.
- **1 cM = 1%** recombination.
- **<50%** recombinant = linked genes.
- **50%** behaves as if unlinked.
- **Test cross** directly reveals gametes of the heterozygous parent.

WORKED EXAMPLE

AB/ab test crossed with **aabb**,
genes **20 cM** apart →
20% recombinant offspring total,
10% Ab and **10% aB**,
while **80%** parental types
AB and **ab**.



Genotype + Environment = Phenotype

- Same genotype can produce different phenotypes in different environments.
- **Phenotypic plasticity** = one genotype, multiple possible phenotypes.
- Environment does **NOT** change the DNA sequence.
- **Norm of reaction** = range of phenotypes a genotype can show.

Phenotypic Plasticity Cases



- Himalayan rabbit dark fur in cold regions due to temperature-sensitive tyrosinase.
- Hydrangea flower color depends on soil pH. Acidic soil → blue; alkaline soil → pink.
- Tanning = UV stimulates melanin production in skin.
- Nutrition affects final height within genetic potential.
- Temperature-dependent sex determination in reptiles is environmental, not genetic.

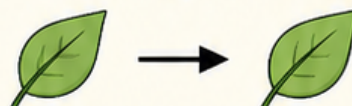
EXAM SNIPER



Same genotype, different phenotype **does not** mean mutation.

Environmental effects change **expression**, not genotype.

Phenotypic change



Can be caused by environmental factors.

≠

genetic change



Involves a change in the DNA sequence.



Final Review — Unit 5 Exam Traps + Checklist

Use this page the night before and the morning of the exam

1 Unit 5 High-Frequency Exam Traps

- **Meiosis I** = homologs separate; **Meiosis II** = sister chromatids separate; after Meiosis I cells are **haploid** but chromosomes **still** duplicated.
- **Never** say “accept H_0 ”; say “**fail to reject H_0** ”.
- **Incomplete dominance** \neq **codominance**; incomplete = new intermediate phenotype, codominance = both phenotypes expressed.
- **X-linked** recessive traits can appear in females if homozygous.
- **Mitochondrial** inheritance is strictly **maternal**; affected father passes nothing.
- Independent assortment applies to genes on **different chromosomes** or **very far apart**.
- Environmental change **does not** equal **genetic change**.

2 Pre-Exam 10-Minute Checklist

- | A. Meiosis & Diversity | B. Mendelian & Chi-Square | C. Non-Mendelian |
|--|---|---|
| <input type="checkbox"/> Meiosis I vs II (what separates) | <input type="checkbox"/> Monohybrid cross outcome = 3:1 | <input type="checkbox"/> Incomplete dominance = new intermediate phenotype |
| <input type="checkbox"/> After Meiosis I: haploid but chromosomes still duplicated | <input type="checkbox"/> Dihybrid cross outcome = 9:3:3:1 | <input type="checkbox"/> Codominance = both phenotypes expressed |
| <input type="checkbox"/> Crossing over occurs in Prophase I | <input type="checkbox"/> Use probability rules (product, sum, complementary) | <input type="checkbox"/> X-linked recessive = can appear in females if homozygous |
| <input type="checkbox"/> Independent assortment in Metaphase I | <input type="checkbox"/> Chi-square formula: $\chi^2 = \sum \frac{(O-E)^2}{E}$ | <input type="checkbox"/> Mitochondrial inheritance = strictly maternal |
| <input type="checkbox"/> Nondisjunction causes aneuploidy | <input type="checkbox"/> Degrees of freedom (df) = categories - 1 | <input type="checkbox"/> Polygenic traits show continuous variation |
| <input type="checkbox"/> Down syndrome = trisomy 21 | <input type="checkbox"/> If df = 3, critical value = 7.815 (at $\alpha = 0.05$) | <input type="checkbox"/> Recombination frequency in centimorgans (cM) |
| <input type="checkbox"/> Klinefelter syndrome = XXY | <input type="checkbox"/> Correct conclusion wording: “Fail to reject H_0 ” or “Reject H_0 ” (with reason) | |
| <input type="checkbox"/> Turner syndrome = XO | | |








3 Final Sprint Strategy for Unit 5

- Top 5 Must-Master Topics**
 - 1) Meiosis & genetic diversity
 - 2) Mendelian genetics & chi-square
 - 3) Non-Mendelian inheritance
 - 4) Pedigrees & sex-linked traits
 - 5) Connections across units (4, 6, 7)
- Use Multiplication, Not Giant Punnett Squares**
 - Break problems into probabilities and multiply. It’s faster, cleaner, and less error-prone.
- Pedigree Reading Strategy (Always Identify First)**
 - Determine: (1) trait is autosomal or sex-linked (2) dominant or recessive
 - Then trace and answer questions.
- Connections to Other Units**
 - **Unit 4 (Cell Cycle)**: Meiosis follows mitosis; nondisjunction arises during anaphase.
 - **Unit 6 (Gene Expression)**: Genes \rightarrow proteins \rightarrow traits.
 - **Unit 7 (Hardy-Weinberg)**: Populations in equilibrium if no evolution.






Unit 5 Final Cheat Sheet

Formulas, ratios, and two worked AP-style problems

RAPID-FIRE MUST-KNOW

 <p>Meiosis I homologs, Meiosis II sister chromatids.</p>	 <p>After Meiosis I: n but duplicated.</p>	 <p>Crossing over in Prophase I; independent assortment in Metaphase I.</p>									
<table border="1" data-bbox="79 533 236 676"> <tr><td></td><td>A</td><td>a</td></tr> <tr><td>A</td><td>AA</td><td>Aa</td></tr> <tr><td>a</td><td>Aa</td><td>aa</td></tr> </table> <p>Monohybrid $F_2 = 3:1$, dihybrid $F_2 = 9:3:3:1$.</p>		A	a	A	AA	Aa	a	Aa	aa	 <p>Incomplete dominance and codominance both 1:2:1 but differ in heterozygote expression.</p>	 <p>X-linked recessive males are hemizygous (one X chromosome).</p>
	A	a									
A	AA	Aa									
a	Aa	aa									
 <p>Mitochondrial inheritance = maternal only.</p>	 <p>Phenotype = genotype + environment.</p>										

KEY FORMULAS

 $\chi^2 = \sum \frac{(O - E)^2}{E}$	 <p>df = categories - 1</p>	 <p>Recombination frequency (%) = map distance (cM)</p>	 <p>$P(A \text{ and } B) =$ multiply</p>	 <p>$P(A \text{ or } B) =$ add</p>
--	--	--	--	--

1) CHI-SQUARE MINI PROBLEM


Cross: $Yy \times Yy$ Total offspring = 80

Phenotype	Observed (O)	Expected (E)	$(O - E)^2 / E$
Yellow ($Y_$)	64	60	$(64 - 60)^2 / 60 = 0.267$
Green (yy)	16	20	$(16 - 20)^2 / 20 = 0.800$

$$\chi^2 = 0.267 + 0.800 = 1.067$$

$$df = 1$$

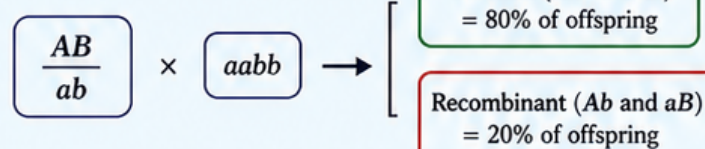
Critical value at $\alpha = 0.05$ (df = 1) = 3.841


 **Conclusion:** $1.067 < 3.841$, so fail to reject H_0 . The data fit the expected 3:1 ratio.

2) LINKAGE MINI PROBLEM

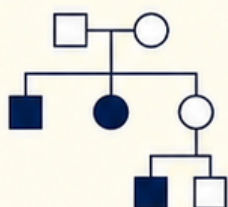
Genes A and B are 20 cM apart.

Cross: $\frac{AB}{ab}$ (in coupling) \times $aabb$







 **Conclusion:** Recombinant offspring = 20% of total, which equals the map distance (20 cM).

PEDIGREE READING STRATEGY



- Compare males vs females affected: Are both sexes equally affected?
- Can unaffected parents have an affected child?: If yes, consider recessive inheritance.
- Affected father to sons rules out X-linked transmission to sons: Sons get Y from dad.
- Affected mother to all children suggests mitochondrial inheritance.

-  = Unaffected male
-  = Unaffected female
-  = Affected male
-  = Affected female



TOP 5 MUST-MASTER: meiosis distinctions, chi-square wording, codominance vs incomplete dominance, X-linked rules, maternal inheritance.

10 / 10

Done with the sheet? Now get marked.

We don't give you questions to grind through.
Upload your own AP Bio FRQ — we score it like an AP Reader
and show you the exact rubric points you missed.

1

Score

Marked against the
published College Board
rubric.

2

See

The exact rubric point
you gained or dropped,
line by line.

3

Practice

Turn around your weak
rubric points before
exam day.



Scan to register — free, no card required