The Simple AP® Biology Unit 5 Cheat Sheet

5.1 Meiosis

Key Terms

Diploid (2n): 2 sets of chromosomes (human 46).
Haploid (n): 1 set (gametes, 23).
Homologous chromosomes: same genes, one from each parent; may have different **alleles**.
Sister chromatids: identical DNA copies made in S phase, joined at the centromere.

Meiosis I: Pairs Separate

Prophase I: homologs pair up side by side; **crossing over** swaps pieces between them.
Metaphase I: PAIRS line up in the middle.
Anaphase I: homologs pulled to opposite ends; then cytokinesis → 2 haploid cells.
Sister chromatids stay together in anaphase I.

Meiosis II: Like Mitosis

Meiosis II: sister chromatids split → 4 haploid cells, each one genetically different.

Stage	Chrom. #
Start	2n = 46
After meiosis I	n = 23
After meiosis II	n = 23

Fertilization: sperm (n) + egg (n) → zygote (2n).
Sperm vs egg: 4 sperm per meiosis; only 1 egg (plus small polar bodies that break down).

⚠ Chromosome # halves in meiosis I, not in meiosis II. Meiosis II just splits chromatids.

✓ Pairs lined up = metaphase I. Single file = mitosis or metaphase II of meiosis.

5.2 Meiosis & Genetic Diversity

Three Sources of Variation

1) Crossing over (prophase I): homologs swap pieces → new combos of alleles on each.
2) Independent assortment (metaphase I): pairs line up randomly → 2^{23} combos in humans.
3) Random fertilization: any sperm + any egg.
Total: ~70 trillion possible zygotes per couple, even before crossing over adds more.
Why it matters: variation lets populations adapt.

Mitosis vs Meiosis

Feature	Mitosis	Meiosis
Divisions	1	2
Cells made	2 diploid	4 haploid
Genetics	Identical	Unique
Crossing over	No	Yes
Purpose	Growth	Gametes

Errors

Nondisjunction: chromosomes don't separate → gametes with one extra or missing.
Meiosis I error → all 4 gametes abnormal. **Meiosis II error** → only 2 of the 4 gametes abnormal.
Asexual reproduction: clones → fast, but no new combos when conditions change.

⚠ Crossing over happens between homologs, never between the 2 sister chromatids.

✓ FRQ: name the event, the phase it happens in, and exactly how it adds variation.

5.3 Mendelian Genetics

Vocabulary

Genotype = alleles (AA, Aa, aa). **Phenotype** = the trait you can see or measure (e.g., tall).
Homozygous = 2 of the same allele (AA, aa); **heterozygous** = 2 different alleles (Aa).
Dominant allele hides the **recessive** one in Aa.
Dominant ≠ common: some dominant alleles are rare (e.g., Huntington's disease).
F_1 = first offspring generation; F_2 = their offspring.

Mendel's Laws

Segregation: each gamete gets 1 allele per gene. Happens when homologs split in anaphase I.
Independent assortment: genes on different chromosomes sort into gametes separately.

Ratios to Know

Cross	Phenotype ratio
Aa × Aa	3:1
Aa × aa	1:1
AA × aa	All dominant
AaBb × AaBb	9:3:3:1

Testcross: cross the unknown with aa. Any aa offspring → the unknown was Aa.
Punnett square: one parent's gametes across the top, the other parent's down the side.
AaBb gametes: AB, Ab, aB, ab (¼ each).

⚠ Ratios are chances. Small families rarely match 3:1 exactly; big samples get much closer.

✓ Unknown genotype? Do a testcross with a homozygous recessive (aa) parent.

5.3 Probability & Pedigrees

Probability Rules

AND → multiply: P(aa) from Aa × Aa = ½ × ½ = ¼.
OR → add: P(Aa) = P(Aa) + P(aA) = ¼ + ¼ = ½.
Many genes: do each gene alone, then multiply.
Example: AaBb × AaBb → P(aabb) = ¼ × ¼ = 1/16.
Unaffected child of Aa × Aa → 2/3 chance of being a carrier (aa is ruled out).

Pedigrees

Symbols: □ male, ○ female, shaded = affected.

Pattern	Clue
Auto. dominant	Every generation
Auto. recessive	Skips generations
X-linked rec.	Mostly males
X-linked dom.	Dad → all daughters
Mitochondrial	Mom → all kids

Two unaffected parents with an affected child → the trait must be recessive (both are Aa).
Recessive examples: cystic fibrosis, sickle cell, Tay-Sachs. **Dominant**: Huntington's.
Carriers: unaffected Aa people; often both parents of an affected child are carriers.
Generations: Roman numerals (I, II, III) down the side; people numbered left → right.
X-linked clue: sons get it from carrier moms; it is never passed straight from dad → son.

⚠ Multiply for AND, add for OR.

✓ Test each pattern one by one; rule out any pattern that a single family breaks.

5.3 Chi-Square Analysis

When & Why

Chi-square (χ^2): is the gap between observed and expected counts just due to chance?
Null hypothesis: no real difference; the data fit the expected ratio, and any gap is chance.
Use it when data are close to a ratio but not exact.

Steps

1) Expected = total × ratio fraction.
Example: 160 offspring, 3:1 → expect 120 : 40.
2) $\chi^2 = \Sigma\ (o - e)^2 / e$, added across categories.
3) df = # of categories − 1 (not sample size).
Example: 4 groups (9:3:3:1 ratio) → df = 3 → critical value 7.81 at p = 0.05 in the table.
4) Compare to the critical value at p = 0.05.

df	1	2	3
Critical	3.84	5.99	7.81

Reading the Result

χ^2 below critical → fail to reject the null → random chance explains the gap; data fit the ratio.
χ^2 above critical → reject the null → something besides chance is going on here.
Worked: observed 130 : 30 vs 120 : 40 → 100/120 + 100/40 = 3.33. df = 1; below 3.84 → fits 3:1.
Wording: say "fail to reject", never "prove".
Reject can point to linked genes or selection.

⚠ Use counts, not percentages.

✓ Show expected values, each term, the sum, df, critical value and your conclusion.

5.4 Non-Mendelian Genetics

Beyond Simple Dominance

Pattern	Example
Incomplete dom.	Red × white → pink
Codominance	AB blood type
Multiple alleles	A, B, O blood
Polygenic	Height, skin color

Incomplete dominance: a blend (pink).
Codominance: both alleles show fully.
Blood type: A and B alleles are codominant; both are dominant to O. Type O = ii (2 recessive).

Sex-Linked Traits

X-linked recessive: males have one X → show the trait more (colorblindness, hemophilia).
Dads pass X to daughters, Y to sons.
Carrier mom × normal dad → ½ of sons affected; no daughters affected (½ are carriers).

Linked Genes

Linked genes: close together on one chromosome → usually inherited together as a unit.
Recombination % = recombinants ÷ total × 100 = map distance between 2 genes, in map units.
Map: bigger recombination % = the 2 genes are farther apart on the chromosome.
Mitochondrial genes come only from mom.

⚠ Linked genes don't give 9:3:3:1. Most offspring look like the parents; only a few are recombinant.

✓ Recombinants = the 2 smallest groups. Add them, then divide by the total × 100.

5.5 Environmental Effects on Phenotype

Genes + Environment

Phenotypic plasticity: one genotype, different traits in different environments.
Norm of reaction: the full range of traits one genotype can show in different settings.

Example	Effect
Hydrangea	Soil pH → color
Himalayan rabbit	Cold → dark fur
Arctic fox	Season → fur color
Sea turtles	Nest temp → sex
Daphnia	Predators → spines
PKU	Diet → healthy

PKU: a special low-phenylalanine diet prevents harm without changing any genes.
Himalayan rabbits: fur pigment enzyme works only when cold → dark ears and paws.

Why It Matters

Identical twins (same genes) can still differ in traits → environment shapes phenotype too.
Plasticity helps organisms handle changing conditions without new mutations.
Epigenetics: environment can turn genes on or off without changing the DNA sequence itself.

⚠ Environment changes phenotype, not genotype. The alleles stay the same.

✓ Same genes + different traits → the environment caused the difference in phenotype.

5.6 Chromosomal Inheritance & Strategy

Chromosome Theory

Genes are on chromosomes; their behavior in meiosis explains Mendel's laws.
Karyotype: picture of chromosomes sorted by size → spots extra or missing ones.
Sex chromosomes: XX female, XY male in humans; SRY gene on the Y → male traits.

Chromosome Disorders

Condition	Karyotype
Down	Extra chrom. 21
Turner	XO
Klinefelter	XXY
Cri du chat	Part of 5 deleted

Cause of extra or missing chromosomes: nondisjunction during meiosis I or II.
Risk of nondisjunction rises with mother's age.
Structure changes: deletion, duplication, inversion, translocation of chromosome pieces.

Exam Moves

Genetics math: genotypes → gametes → multiply/add → simplify the fraction.
Pedigree first: find genotypes, then do the cross.
Use χ^2 to decide if data fit your predicted ratio.
Links: Unit 4 mitosis, Unit 6 mutation, Unit 7 Hardy-Weinberg & natural selection.

⚠ Meiosis I errors affect all 4 gametes; meiosis II errors affect only 2 of the 4 gametes made.

✓ Show the genotypes, the cross, and the ratio or probability, then explain what it means.