The Simple AP® Biology Unit 6 Cheat Sheet

6.1 DNA & RNA Structure

Building Blocks

Nucleotide = sugar + phosphate + base. Linked into a sugar-phosphate backbone.
Base pairs: A–T and G–C in DNA. In RNA, A pairs with U (uracil) instead of with T.

Feature	DNA	RNA
Sugar	Deoxyribose	Ribose
Bases	A, T, G, C	A, U, G, C
Strands	2	1
Types	1	mRNA, tRNA, rRNA

Double Helix

Antiparallel: the 2 strands run opposite ways (one 5'→3', the other 3'→5'), like 2-way traffic.
Chargaff's rule: %A = %T and %G = %C.
Example: G = 22% → C = 22%, A = T = 28%.

Genomes

Prokaryotes: 1 circular chromosome + small extra DNA rings called **plasmids** (in bacteria).
Eukaryotes: many linear chromosomes, wrapped around proteins called **histones**.
Mitochondria & chloroplasts have their own circular DNA, just like bacteria.
G–C has 3 H-bonds; A–T has only 2 → GC-rich DNA holds together more tightly.
DNA is the genetic material in all cells; some viruses use RNA as theirs instead.

⚠ Chargaff's rule only works for double-stranded DNA, not RNA or a single DNA strand.

✓ Write base pairs carefully; label 5' and 3' ends.

6.2 DNA Replication

Semiconservative

Semiconservative: each new DNA molecule = 1 old (parent) strand + 1 newly made strand.
Origins: replication starts at many spots in eukaryotes, but at just 1 in bacteria.

Enzymes

Enzyme	Job
Helicase	Unzips DNA
Topoisomerase	Stops overtwisting
Primase	Adds RNA primer
DNA polymerase	Adds nucleotides
Ligase	Seals gaps

Leading vs Lagging

New strands grow 5'→3' only.
Primer needed: DNA polymerase can't start a new strand from nothing; primase adds one.
Leading strand: made in one smooth piece.
Lagging strand: made in short **Okazaki fragments**; ligase joins them together.

Accuracy & Ends

Proofreading: DNA polymerase checks its own work as it goes and fixes most mistakes.
Telomeres: protective caps on chromosome ends; they get shorter with each cell division.
Telomerase rebuilds telomeres in stem cells (and in many cancer cells, so they keep dividing).
When: S phase, before the cell divides.

⚠ New DNA is always built 5'→3'.

✓ Lagging = fragments + many primers + ligase.

6.3 Transcription & RNA Processing

Transcription

Where: in the nucleus (eukaryotes). RNA polymerase makes mRNA from a DNA gene.
Promoter: start signal where **RNA polymerase** binds (helped by transcription factors).
Template strand is the one RNA polymerase reads; mRNA is its complement (U in place of T).
Direction: mRNA is built 5'→3'. No primer needed.
Example: template 3'-TAC-5' → mRNA 5'-AUG-3'.

Eukaryotic Processing

Change	Purpose
5' cap	Protects; helps ribosome
Poly-A tail	Protects; export
Splicing	Removes introns

Introns are cut out; **exons** are kept and joined.
Alternative splicing: one gene → several proteins.
Spliceosome: the complex that cuts out introns.

Prokaryotes

No nucleus: transcription and translation happen at the same time in the cytoplasm.
No processing: no cap, tail or introns.
Operons: several genes on one mRNA (bacteria).
Other RNAs: tRNA and rRNA are also transcribed from genes, but never translated.

⚠ mRNA matches the coding strand (U for T), not the template strand it was copied from.

✓ Intron mutations usually don't change the protein, b/c introns get cut out.

6.4 Translation

The Players

mRNA: read in **codons** (3 bases each).
tRNA: its **anticodon** pairs with an mRNA codon; it carries the matching amino acid.
Ribosome: rRNA + protein; it reads the mRNA and links amino acids together in order.

Steps

Start: ribosome finds **AUG** (methionine).
Elongation: tRNAs bring amino acids one by one; peptide bonds join them into a chain.
Stop: a stop codon (UAA, UAG, UGA) is reached → the finished protein is released.

Site	Holds
A	Incoming tRNA
P	tRNA with chain
E	Empty tRNA exits

Code Facts

Redundant: several different codons can code for the same amino acid (e.g., 6 for Leu).
Universal: nearly all living things use the same genetic code → evidence of common ancestry.
Polyribosomes: many ribosomes on one mRNA at once → many copies of a protein fast.
Shared code lets bacteria make human insulin.
Loading: an enzyme attaches the right amino acid to each tRNA; this step uses ATP.
Secreted proteins start on ribosomes on rough ER.

⚠ Use mRNA codons with the codon chart.

✓ DNA → mRNA → codon chart → amino acids.

6.5 Regulation of Gene Expression

Prokaryotes: Operons

Operon: promoter + operator + genes. **Repressor** sitting on the operator → genes OFF.

Operon	Normally	Switch
lac	Off	Lactose → on
trp	On	Tryptophan → off

lac: lactose pulls the repressor off → genes ON.
trp: lots of tryptophan binds and activates the repressor → genes OFF (no more made).
Why: bacteria make enzymes only when they're needed → saves energy and materials.

Eukaryotes

Methylation (on DNA) → genes OFF. **Acetylation** (on histones) → genes turned ON.
Epigenetic: these changes can be inherited without changing DNA sequence.
Transcription factors: proteins that bind DNA near genes to turn their transcription up or down.
Enhancers: DNA spots (can be far away) where activators bind → more transcription.
Small RNAs (miRNA) block or destroy mRNA.
After translation: proteins can be modified, activated, or tagged and destroyed.
Genes with shared control sequences switch on together as a group (e.g., stress response).

⚠ Methylation → OFF. Acetylation → ON.

✓ Is the repressor on the operator? Genes OFF. Off the operator? Genes ON, transcribed.

6.6 Gene Expression & Cell Specialization

Same DNA, Different Cells

All body cells have the same DNA.
Differential gene expression: each cell turns on different genes → different proteins.
Result: nerve, muscle and liver cells look different and do different jobs, though their DNA matches.

Development

Transcription factors: each cell type's mix of them decides which of its genes get used.
Hox genes set the body plan (head to tail).
Cell signals from neighbors change which genes turn on (cell communication, Unit 4).
Apoptosis (planned cell death) shapes body parts, e.g., it removes the finger webbing.

Cell	Gene on
Red blood cell precursor	Hemoglobin
Pancreas	Insulin
Muscle	Actin, myosin
Lens cell	Crystallin

Evidence

Cloning: a specialized body cell's nucleus can still make a whole animal (Dolly the sheep).
Stem cells can become many cell types.

⚠ Specialized cells keep all of their genes; they just silence the ones they don't use.

✓ Different TFs → different genes on → different proteins → different cell jobs and shapes.

6.7 Mutations

Point Mutations

Type	Effect
Silent	Same amino acid
Missense	Different amino acid
Nonsense	Early stop
Frameshift	Changes all after

Frameshift: adding or removing 1 or 2 bases shifts the whole reading frame after it.
Sickle cell: one base change → one amino acid change → misshapen hemoglobin.

Causes & Effects

Causes: DNA copying errors, UV light, chemicals, radiation, and even some viruses.
Effects: harmful, neutral or helpful; it depends on the environment the organism lives in.
Only gamete mutations pass to offspring.
Body-cell mutations affect only that person, not their kids, and can lead to cancer.

Bacteria Share Genes

Transformation, transduction, conjugation move DNA between bacteria → resistance spreads.
Mutations are the raw material for natural selection and evolution (see Unit 7).

⚠ Adding 3 bases adds one amino acid but keeps the reading frame intact.

✓ Translate the sequence before and after the mutation, then compare the two proteins.

6.8 Biotechnology & Exam Strategy

Core Tools

Tool	Does
PCR	Copies DNA
Gel	Sorts DNA by size
Restriction enzyme	Cuts DNA
CRISPR	Edits genes

PCR: heat, cool, warm; doubles DNA each cycle.
Gel: DNA moves toward the + end; small pieces slip through the gel and travel the farthest.
Why: DNA is negative (from its phosphates) → it's pulled toward the positive end.
Ladder: known sizes to compare against.
Transformation: put a gene in a plasmid → bacteria make the protein (insulin).
Same restriction enzyme cuts the gene and the plasmid → their sticky ends fit together.
Uses: medicine (insulin), forensics (DNA fingerprints), GMO crops, paternity tests.

Exam Moves

Central dogma: DNA → mRNA → protein → trait.
Predict: where's the change (DNA, mRNA or protein), and what happens next in the chain?
Links: Unit 1 nucleic acids, Unit 4 cell signals, Unit 5 alleles, Unit 7 mutation & evolution.
Paternity gels: each of the child's bands must match a band from either mom or dad.

⚠ Farthest band on a gel = smallest piece.

✓ PCR: copies = start × 2^n (n = cycles).