BIOLOGY · MCAS + FINAL EXAM PREP · PRINTABLE BOOKLET

Biology Study Guide

The full study guide in one document. 12 sections, in the order we cover them in class. Use your browser's Print command (Ctrl + P / Cmd + P) to print or save as PDF — each section starts on a fresh page.

Contents

What you need to know cold

- **dna** is shaped like a twisted ladder — a **double-helix**.
- The "rungs" of the ladder are pairs of **nitrogenous-base**. **A pairs with T. C pairs with G.** Always.
- The information in DNA lives in the **order of the bases**, not in the sugar-phosphate backbone.
- The building block of DNA is a **nucleotide**: phosphate + sugar + one base.
- **replication** = the helix unzips, new bases pair to each old strand, and you get two new helixes (each with one old + one new strand). This is called **semiconservative**.
- **Chargaff's rule:** %A = %T and %C = %G. All four percentages add to 100.

The Big Rule for this block

A pairs with T. C pairs with G. Always.

This rule is the foundation of base pairing, replication, transcription, translation, mutations, and genetics. If you only remember one thing from this block, remember this.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory — many science words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
DNA	ADN	DNA / ADN	ADN	DNA	ADN	ADN / DNA	الدنا / DNA *(dī-en-ey / ad-dinā)*
nucleic acid	ácido nucleico	ácido nucleico	acide nucléique	acido nucleico	asid nikleyik	axit nucleic / axit nuclêic	حمض نووي *(ḥamḍ nawawī)*
nucleus	núcleo	núcleo	noyau	nucleo	nwayo	nhân (tế bào)	نواة *(nawāh)*
chromosome	cromosoma	cromossomo	chromosome	cromosoma	kwomozòm	nhiễm sắc thể	كروموسوم / صبغي *(krūmūsūm / ṣibghī)*
gene	gen	gene	gène	gene	jèn	gen / gien	جين / مورثة *(jīn / muwarritha)*
allele	alelo	alelo	allèle	allele	alèl	alen	أليل *(alīl)*
mutation	mutación	mutação	mutation	mutazione	mitasyon	đột biến	طفرة *(ṭafra)*

Vietnamese and Arabic translations were verified by ChatGPT-5 and Gemini. Romance language translations rely on cognate consistency. If a term feels unfamiliar to a native speaker, please tell Ms Brandolini.

The full picture

How DNA is built and how it copies itself

READING

What this reading is about

Every living thing — every plant, every animal, every bacterium, you — runs on instructions stored inside its cells. Those instructions are written in a molecule called **dna**. To understand how life works, you have to understand how DNA is built and how it copies itself.

This reading covers two things:

1. **The structure of DNA** — what it is made of, what shape it takes.
2. **DNA replication** — how a cell copies its DNA before it divides.

The structure of DNA

DNA is a long, thin molecule. If you could pull all the DNA out of one of your cells and stretch it out, it would be about 2 meters long. To fit inside the tiny nucleus of a cell, DNA is twisted, coiled, and folded many times.

The shape of DNA is a **double-helix** — a twisted ladder. Two long strands wind around each other in a spiral. The two sides of the ladder are made of sugar and phosphate molecules linked together. The rungs across the middle are pairs of **nitrogenous-base**.

DNA is built from small repeating units called **nucleotide**. Each nucleotide has three parts: a phosphate group, a sugar, and one nitrogenous base. There are four possible bases: **adenine (A)**, **thymine (T)**, **cytosine (C)**, and **guanine (G)**. Many nucleotides linked end-to-end make up a single strand of DNA.

The bases on one strand always pair with the bases on the other strand in the same way:

- **A pairs with T.**
- **C pairs with G.**

This rule is called **complementary base pairing**. It is one of the most important rules in biology. The bases pair this way because of their shapes — only A and T fit together, and only C and G fit together. They are held together by hydrogen bonds: A and T have 2 hydrogen bonds between them; C and G have 3.

The information in DNA is stored in the order of the bases — not in the sugar or the phosphate. The order along one strand might be `A-T-G-C-C-A-T-G`... and that order is the genetic code.

> **Watch this misconception.** The sugar-phosphate backbone holds the strand *together*, but it does **not** carry the information. The information is in the **bases**.

DNA replication

Before a cell divides, it has to copy its DNA. Each new cell needs a complete set. The process of copying DNA is called **replication**.

DNA replication has three main steps:

1. **Unzip.** The two strands of the double helix come apart in the middle. The hydrogen bonds between the bases break. Now there are two single strands, each with bases sticking out and exposed.

2. **Match.** Free nucleotides floating around in the cell pair up with the exposed bases. The pairing rule still holds: A pairs with T, C pairs with G. The new nucleotides are linked together to form a new strand alongside each old strand.
3. **Two new helixes.** When the matching is done, the cell has **two complete double helixes** where it had one before. Each new helix has **one old strand and one new strand**.

This kind of copying has a special name: **semiconservative** replication. The word *semi* means half. Half of each new DNA molecule is "saved" from the original. This was a famous discovery — scientists in the 1950s ran a clever experiment (the Meselson–Stahl experiment) to prove that this is how DNA copies itself.

Chargaff's rule

Because A always pairs with T, and C always pairs with G, the **percentages** of these bases in any DNA molecule always follow a rule:

- The amount of A always equals the amount of T.
- The amount of C always equals the amount of G.
- All four percentages add up to 100%.

This is called **Chargaff's rule** (after Erwin Chargaff, who discovered it in the 1940s).

> **Worked example.** A DNA sample has 30% adenine. What are the other percentages?
>
> 1. A = T. So thymine = **30%**.
> 2. A + T already equals 30 + 30 = 60%. That leaves 40% for C + G.
> 3. C = G. Half of 40% goes to each. So C = **20%** and G = **20%**.
>
> Check: 30 + 30 + 20 + 20 = 100. ✓

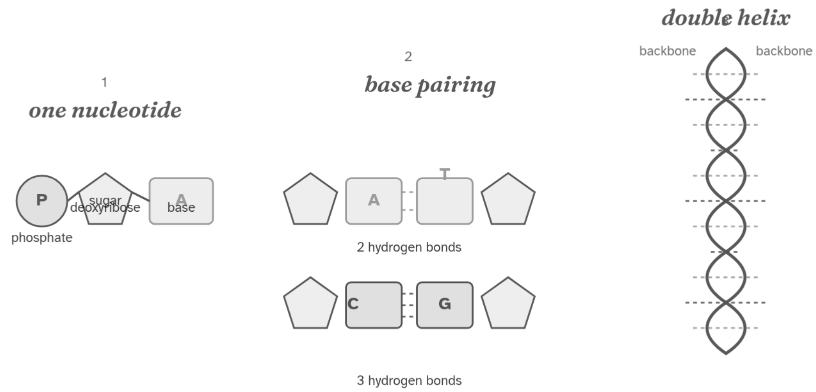
Why this matters

DNA structure and DNA replication matter because they are the foundation of everything else in genetics. The order of bases in your DNA is what makes you you. The fact that DNA can copy itself is what lets cells divide, lets bodies grow, and lets parents pass traits to their children.

In the next section of the study guide, you will see how the order of bases gets read out into proteins (transcription and translation). After that, you will see how DNA mistakes (mutations) lead to changes that natural selection can act on. All of that depends on understanding what DNA is and how it copies itself first.

Diagram: how DNA is built

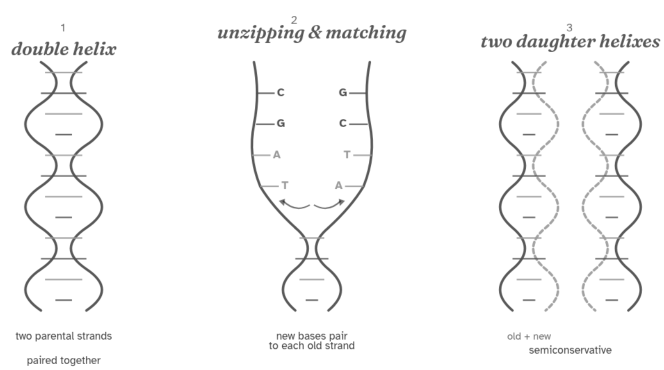
Three views, building up from the smallest piece to the whole molecule. Panel 1 is one nucleotide. Panel 2 shows how two nucleotides pair across the strands. Panel 3 shows the whole double-helix shape.



DNA anatomy: nucleotide, base pair, double helix

Diagram: how DNA copies itself

Watch panel 2 — new bases drift in from the sides and pair with each exposed base on the parental strands. The result (panel 3) is two daughter helixes, each made of one old strand (solid line) and one new strand (dashed line). This is what "semiconservative" means.



DNA replication: semiconservative copying at a fork

Pictures to recognize on the test

The picture shows...	The answer is...
A twisted ladder shape.	**Double helix** (DNA).
One DNA helix at the top, becoming two helixes at the bottom — each new helix has one strand from the original.	**DNA replication** (new DNA being made).
A small molecule with three labeled parts: phosphate, sugar, base.	**Nucleotide** — the building block of DNA.
Two bases held together by 2 dashed lines (hydrogen bonds).	An **A–T pair**. (C–G pairs use 3 hydrogen bonds.)

Pattern rules

If the question says...	Pick...
"What part of DNA holds the genetic information?"	**The nitrogenous bases.** (Not the sugar. Not the phosphate.)
"Ladder-like, twisted" structure.	**Double helix.**
"30% adenine — find the rest of the percentages."	**30% T, 20% C, 20% G.** (A = T, C = G, total = 100%.)
"Find the complementary strand of A–T–G–C."	Pair each base. **T–A–C–G.**
"Each new DNA molecule has one old strand and one new strand. What is this called?"	**Semiconservative** replication.
"What is NOT a base in DNA?"	**Uracil (U).** (Uracil is in RNA. DNA has A, T, C, G.)

Where to practice

Practice questions for this block live in **Pear Assessment**. Open Canvas → your Biology section → Pear → Block 1 — DNA Structure & Replication. Try the practice *without* looking at this page first. If you get stuck, come back, look up the topic, then try again.

What you need to know cold

- The **central-dogma**: **DNA → mRNA → protein**. Information flows in one direction.
- **transcription** happens in the **nucleus**. DNA is copied into **mrna**. **T becomes U.**
- **translation** happens at the **ribosome**. mRNA is read to build a protein.
- A **codon** is **3 mRNA bases**. Each codon codes for one **amino-acid**.
- **Codon math:** Number of mRNA bases ÷ 3 = number of codons = number of amino acids.
- **trna** brings amino acids to the ribosome — one tRNA per codon, each carrying the matching amino acid.
- Stop codons (UAA, UAG, UGA) end translation. They do not code for an amino acid.

The Big Rules for this block

DNA → mRNA → protein

The central dogma. One direction. Always.

3 mRNA bases = 1 amino acid

A codon is three bases. Each codon codes for one amino acid.

Almost every question on this block reduces to one of these two rules. If you only remember two things: this block is what to remember.

Codon math (memorize this formula)

Number of bases ÷ 3 = number of codons = number of amino acids

Example. An mRNA strand has **12 bases**. 12 ÷ 3 = **4 codons**. The protein has **4 amino acids**.
The MCAS asks this in many forms: "How many codons in this mRNA?", "How many amino acids does this gene code for?", "If a protein has 5 amino acids, how many bases were in the mRNA?" (Answer: 5 × 3 = 15.) All of them are this one rule.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory — many of these words are similar across languages because they share Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
protein	proteína	proteína	protéine	proteina	pwoteyin	protein / prô-tê-in	بروتين *(brūtīn)*
RNA / mRNA	ARN	RNA / ARN	ARN	RNA	ARN	ARN / RNA	الرنا / RNA *(ar-RNA / ar-rinā)*
transcription	transcripción	transcrição	transcription	trascrizione	transkripsyon	phiên mã	نسخ *(naskh)*
translation	traducción	tradução	traduction	traduzione	tradiksyon	dịch mã	ترجمة *(tarjama)*
ribosome	ribosoma	ribossomo	ribosome	ribosoma	ribozòm	ribosome / ribôxôm	ريبوسوم *(rībūsūm)*
codon	codón	códon	codon	codone	kodon	côđon / bộ ba mã hóa	كودون / رامزة *(kūdūn / rāmiza)*
amino acid	aminoácido	aminoácido	acide aminé	amminoacido	asid amine	axit amin	حمض أميني *(ḥamḍ amīnī)*
nucleus	núcleo	núcleo	noyau	nucleo	nwayo	nhân (tế bào)	نواة *(nawāh)*

Vietnamese and Arabic translations were verified by ChatGPT-5 and Gemini. Romance language translations rely on cognate consistency. If a term feels unfamiliar to a native speaker, please tell Ms Brandolini.

The full picture

How cells use DNA to build proteins

READING

What this reading is about

In the last block, you learned that **dna** is the molecule that carries the genetic instructions for life. But how does a cell actually *use* those instructions? How do the bases A, T, C, and G turn into eyes, muscles, blood, and bone?

The answer is: cells use DNA to build **proteins**, and proteins do almost every job in the body. The process of building proteins from DNA is called **protein synthesis**.

This reading covers two steps:

1. **Transcription** — copying a section of DNA into **mrna**.
2. **Translation** — reading the mRNA at a **ribosome** to build a protein.

The central dogma

The big rule for this whole topic is called the **central-dogma**:

DNA → mRNA → protein

Information flows in one direction. DNA gets copied into mRNA, and mRNA gets read to make a protein. This is true for nearly every living thing on Earth, from bacteria to plants to you. It is one of the strongest pieces of evidence that all life on Earth shares a common ancestor.

The two steps each happen in a different place inside the cell:

- **Transcription** happens in the **nucleus**, where the DNA lives.
- **Translation** happens at a **ribosome**, outside the nucleus.

The mRNA is the messenger that travels between the two — it carries the message from the gene out to the ribosome.

Step 1: Transcription (DNA → mRNA)

transcription is the first step. It happens inside the nucleus. A section of DNA — a **gene** — gets copied into a strand of mRNA.

The steps are:

1. The DNA **unzips** in the region of the gene. The two strands separate.
2. One strand acts as a **template**. RNA bases float in and pair up with the exposed DNA bases.
3. The pairing rule for transcription has one big change from DNA pairing: **T becomes U.**

The pairing chart for transcription:

- DNA **A** pairs with mRNA **U**
- DNA **T** pairs with mRNA **A**
- DNA **C** pairs with mRNA **G**
- DNA **G** pairs with mRNA **C**

RNA does not have thymine (T). It uses uracil (U) instead. Wherever the DNA template strand has a base, the mRNA has its complement — but with U replacing T.

> **Worked example.** Transcribe the DNA template strand `T-A-C-G-G-A` into mRNA.

> 1. T pairs with A. So the first mRNA base is **A**.
> 2. A pairs with U. So the second mRNA base is **U**.
> 3. C pairs with G. Third mRNA base: **G**.
> 4. G pairs with C. Fourth mRNA base: **C**.
> 5. G pairs with C. Fifth mRNA base: **C**.
> 6. A pairs with U. Sixth mRNA base: **U**.
>
> Final mRNA: **A-U-G-C-C-U**.

When transcription is done, the new mRNA strand leaves the nucleus through a pore in the nuclear membrane. The DNA zips back up unchanged. The original gene is still there, ready to be transcribed again the next time the cell needs that protein.

Step 2: Translation (mRNA → protein)

translation is the second step. It happens at a **ribosome**, in the cytoplasm of the cell, outside the nucleus. The ribosome reads the mRNA and builds a protein from *An amino acid is a small molecule that is the **building block of a protein**. Proteins are long chains of amino acids linked together. There are about 20 different amino acids that living things use. Each codon on an mRNA strand codes for one amino acid.* s.

The steps are:

1. The mRNA arrives at the ribosome. The ribosome locks onto one end.
2. The ribosome reads the mRNA **three bases at a time**. Each group of three bases is called a **codon**.
3. For each codon, a matching **trna** arrives, carrying one amino acid.
4. The amino acids link together in the order set by the codons. This growing chain is the protein.
5. When the ribosome reads a **stop codon** (UAA, UAG, or UGA), it releases the finished protein.

Each codon codes for one amino acid. To find which amino acid a codon codes for, you look it up on a **codon chart**. You will have a codon chart for the test if you need to translate a sequence — you do not memorize codons.

> **Watch this misconception.** Translation does **not** happen in the nucleus, and it does **not** happen in mitochondria. Translation happens at the **ribosome**. If a question asks where proteins are built, the answer is the ribosome.

Codon math: 3 bases = 1 amino acid

The most important number rule for protein synthesis is:

3 mRNA bases = 1 amino acid

This means:

- Number of **codons** = number of mRNA bases ÷ 3.
- Number of **amino acids** = number of codons.

> **Worked example.** An mRNA strand has 12 bases. How many codons does it have? How many amino acids does it code for?
>
> 1. 12 ÷ 3 = **4 codons**.
> 2. Each codon codes for one amino acid. So the protein has **4 amino acids**.

For some questions you may also need to start from DNA. If a DNA gene has 24 bases, it transcribes into an mRNA with 24 bases, which gets read as 24 ÷ 3 = 8 codons, which builds a protein with 8 amino acids.

Why this matters

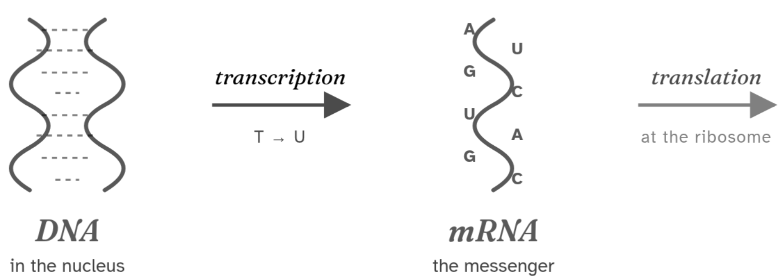
Protein synthesis matters because **proteins do almost every job in your body**. They are enzymes that speed up chemical reactions. They are antibodies that fight infection. They are hormones that send signals. They are the muscle fibers that let you move and the keratin in your hair and nails. Without proteins, life as we know it does not work.

And proteins all start the same way: a gene in your DNA gets transcribed into mRNA, the mRNA travels to a ribosome, and the ribosome translates the codons into a chain of amino acids. The order of bases in the gene decides the order of amino acids in the protein, which decides the protein's shape, which decides its job.

This is also why **mutations** matter — which is the next topic. A small change in the DNA bases can change one codon, which can change one amino acid, which can change the shape of a protein, which can change what it does (or whether it works at all). Sickle-cell disease, for example, comes from a single-base change in one gene. The next block builds on this one.

Diagram: the central dogma

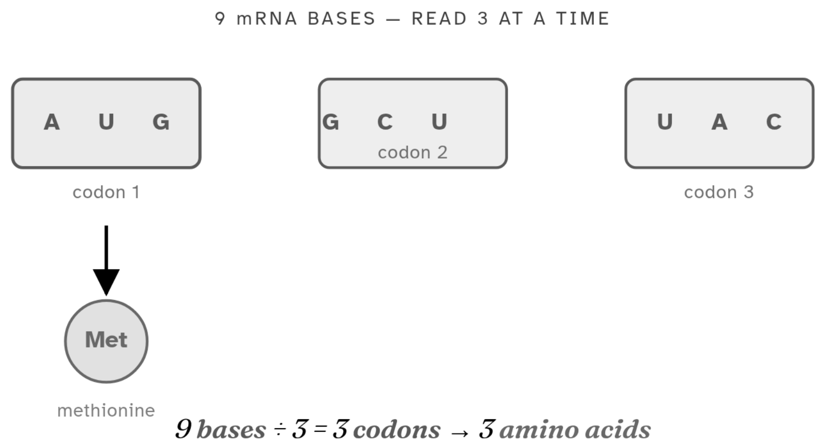
Information flows in one direction: DNA gets copied into mRNA in the nucleus (transcription), and the mRNA gets read at the ribosome to build a protein (translation).



Central dogma: DNA to mRNA to protein

Diagram: how codons become amino acids

A 9-base mRNA strand. Read three at a time, that is 3 codons. Each codon looks up to one amino acid on the codon chart. The amino acids link together in order to form a small protein. **9 bases ÷ 3 = 3 amino acids.**



Codon math: 9 mRNA bases code for 3 amino acids

Pictures to recognize on the test

The picture shows...	The answer is...
A horizontal flow: DNA (in nucleus) → mRNA → protein.	**The central dogma.** Information flows in one direction.
A DNA strand unzipping, with a single-stranded RNA molecule pairing with one of the open strands inside the nucleus.	**Transcription.** DNA → mRNA.
A round structure (ribosome) sitting on an mRNA strand, with a chain of small circles (amino acids) coming off it.	**Translation.** mRNA → protein, at the ribosome.
A short mRNA strand with the bases grouped in threes.	Each group of 3 bases is a **codon**. Each codon = 1 amino acid.
A small molecule with three bases at one end (anticodon) and an amino acid at the other end.	**tRNA.** Brings amino acids to the ribosome.

Pattern rules

If the question says…	Pick…
"Sequence of events to make a protein."	**DNA → mRNA → protein.** (Or: gene → transcription → mRNA → translation → protein.)
"Where does transcription happen?"	**The nucleus.**
"Where does translation happen?"	**The ribosome.**
"What does mRNA do?"	Carries the message from **DNA to the ribosome.**
"Transcribe this DNA strand: T-A-C-G-G-A."	Pair each base — but T becomes U. **A-U-G-C-C-U.**
"How many codons in an mRNA with 12 bases?"	**12 ÷ 3 = 4 codons.**
"How many amino acids does an mRNA with 9 bases code for?"	**9 ÷ 3 = 3 amino acids.**
"If a protein has 5 amino acids, how long was the mRNA?"	**5 × 3 = 15 bases.**
"Translate these codons: AUG-GCU-UAC."	Look up each codon on the codon chart. (You'll have one for the test.)
"What does tRNA do?"	Brings **amino acids** to the ribosome during translation.
"What is NOT a base in mRNA?"	**Thymine (T).** (T is in DNA. mRNA has A, U, C, G.)

Where to practice

Practice questions for this block live in **Pear Assessment**. Open Canvas → your Biology section → Pear → Block 2 — Protein Synthesis. Try the practice *without* looking at this page first. If you get stuck, come back, look up the topic, then try again. **You will have a codon chart on the test** if you need to translate a sequence. You do *not* memorize codons. What you memorize is the *process*: where it happens, what direction it goes, and the math (3 bases = 1 amino acid).

What you need to know cold

- An **allele** is a version of a gene. You inherit two — one from each parent.
- Your **genotype** is the alleles you have (BB, Bb, bb). Your **phenotype** is the trait you see (brown eyes, pink flower).
- **Simple dominance:** Bb shows the dominant trait. The recessive b is hidden.
- **codominance:** both alleles visible AT THE SAME TIME. Roan cattle = red AND white hairs.
- **incomplete-dominance:** alleles BLEND. Red snapdragon × white snapdragon = pink offspring.
- **sex-linked:** trait on the X chromosome. Recessive sex-linked traits are MORE common in males because males only have one X (color blindness, hemophilia).
- A Bb × Bb **punnett-square** always gives **1 : 2 : 1** genotypes and **3 : 1** phenotypes.
- On a **pedigree**: square = male, circle = female, filled-in = has the trait.

The Big Rule for this block

Look at the heterozygote. The way it looks tells you the pattern.

Simple dominance **hides** the recessive. Codominance shows **both**. Incomplete dominance **blends** them. Sex-linked changes the male-vs-female math.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory. Many of these words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
allele	alelo	alelo	allèle	allele	alèl	alen	أليل *(alīl)*
dominant	dominante	dominante	dominant	dominante	dominan	trội	سائد *(sāʾid)*
recessive	recesivo	recessivo	récessif	recessivo	resesif	lặn	متنحٍّ *(mutanaḥḥin)*
genotype	genotipo	genótipo	génotype	genotipo	jenotip	kiểu gen	نمط جيني *(namaṭ jīnī)*
phenotype	fenotipo	fenótipo	phénotype	fenotipo	fenotip	kiểu hình	نمط ظاهري *(namaṭ ẓāhirī)*
codominance	codominancia	codominância	codominance	codominanza	kodominans	đồng trội	سيادة مشتركة *(siyāda mushtaraka)*
incomplete dominance	dominancia incompleta	dominância incompleta	dominance incomplète	dominanza incompleta	dominans enkonplè	trội không hoàn toàn	سيادة ناقصة *(siyāda nāqiṣa)*
sex-linked	ligado al sexo	ligado ao sexo	lié au sexe	legato al sesso	lye ak sèks	liên kết giới tính	مرتبط بالجنس *(murtabiṭ bil-jins)*
Punnett square	cuadro de Punnett	quadro de Punnett	échiquier de Punnett	quadrato di Punnett	kare Punnett	lưới Punnett	مربع بانيت *(murabbaʿ bānit)*
pedigree	árbol genealógico	árvore genealógica	arbre généalogique	albero genealogico	ab jenealojik	phả hệ	شجرة العائلة الوراثية *(shajarat al-ʿāʾila al-wirāthiyya)*

*The allele row uses the verified translation from the Quick Reference vocabulary. The other 9 rows are **new for Block 3** and have NOT yet been independently verified by GPT-5 / Gemini per Ms Brandolini's verification cycle — they rely on cognate consistency (Romance languages) and standard scientific-vocabulary equivalents (Vietnamese, Arabic, Haitian Kreyòl). If a term feels unfamiliar to a native speaker, please tell Ms Brandolini.*

The full picture

Inheritance patterns beyond simple dominance

READING

What this reading is about

In Block 1 you learned that **dna** is the molecule that holds genetic information. In Block 2 you learned how cells use that DNA to build proteins. Now we ask: **how do traits actually pass from parents to children?**

You already know the basic answer from earlier work: parents pass **allele**s to their children, and the child's **genotype** determines their **phenotype**. You've used **punnett-square**s for simple dominance, and you've read **pedigree**s. This reading **extends** that work to three patterns that don't follow simple dominance:

1. **codominance** — both alleles fully visible at once
2. **incomplete-dominance** — alleles blend into a new in-between trait
3. **sex-linked** — trait carried on the X chromosome

The biggest skill for MCAS is recognizing which pattern a question is showing you. The end of this reading has a quick decision guide.

Quick review: alleles and simple dominance

Every **gene** is a section of DNA that holds instructions for one trait. Most genes have more than one version. These versions are called **allele**s.

You inherit **two alleles for each gene** — one from your mother and one from your father. The two alleles together make up your **genotype**. The trait you actually show is your **phenotype**.

If both alleles are the same, you are **homozygous** (BB or bb). If the two alleles are different, you are **heterozygous** (Bb).

In **simple dominance**, one allele masks the other. We write the **dominant** allele with a capital letter (B) and the **recessive** allele with a lowercase letter (b). The genotype Bb shows the dominant trait — the recessive b is hidden.

The classic Punnett square for two heterozygous parents (Bb × Bb) gives:

- 1 BB : 2 Bb : 1 bb (genotype ratio, **1:2:1**)
- 3 dominant : 1 recessive (phenotype ratio, **3:1**)

This is the result you should know cold. It comes up over and over.

Pattern 1: Codominance — both at once

codominance is a pattern where **both alleles are fully visible at the same time**. They don't blend, and one doesn't mask the other. The "co-" means *together*.

The classic example is **roan cattle**. A red bull (genotype $R^R R^R$) crossed with a white cow ($R^W R^W$) gives all roan offspring ($R^R R^W$). A roan animal has **red AND white hairs side by side** — both colors visible at the same time, not blended.

> **Example:** Look at a roan cow up close. You can pick out individual red hairs and individual white hairs. The cow looks pinkish-grey from far away, but the colors are not actually blended — they're just so close together your eye averages them.

Another example is the human **ABO blood type system**. The I^A and I^B alleles are codominant. A person with one of each has **type AB blood**. Their red blood cells carry both A markers and B markers at the same time. (The third allele, i, is recessive to both.)

How to recognize codominance on MCAS:

- The question describes both traits being visible **at the same time**.
- The offspring shows both parent traits — not a blend, not just one.
- The notation often uses **two capital letters** (R^R and R^W, or I^A and I^B) to show neither is recessive.

Pattern 2: Incomplete dominance — blended

incomplete-dominance is a pattern where the two alleles **blend together** into a new in-between phenotype. Neither allele wins — they mix.

The classic example is **snapdragon flower color**. A red snapdragon (RR) crossed with a white snapdragon (WW) gives **all pink offspring** (RW). The pink is a true blend — not partly red and partly white, but a middle color.

> **What if two pink snapdragons cross?** RW × RW gives 1 RR : 2 RW : 1 WW. That's **1 red : 2 pink : 1 white**. Same 1:2:1 ratio as any heterozygous × heterozygous cross — but here the heterozygotes are pink, not red.

Another example is **wavy hair**. A curly-haired parent (CC) and a straight-haired parent (SS) can have wavy-haired children (CS) — wavy is the blend.

> **Don't confuse codominance with incomplete dominance!** Both involve heterozygotes with a different phenotype from either homozygote. The difference:
>
> - **Codominance:** Both traits visible at once. Roan cow has red AND white hairs side by side.
> - **Incomplete dominance:** Traits blend into a new color. Pink snapdragon is a third color, not red AND white separately.

Pattern 3: Sex-linked traits

A **sex-linked** trait is carried on a sex chromosome — almost always the **X chromosome**.

Females have two X chromosomes (XX). Males have one X and one Y (XY). The Y is much smaller than the X and doesn't carry most of the genes that are on the X. So **males have only one copy** of every X-linked gene.

Why does this matter for inheritance? Because it changes the math:

- For an X-linked **recessive** trait, a **female** needs the recessive allele on **both** her X chromosomes (X^bX^b) to show it.
- A **male** needs the recessive allele on his **one** X (X^bY) to show it.

That's why **X-linked recessive traits are far more common in males than in females**. About 1 in 12 males is red-green color-blind, but only about 1 in 200 females is.

> **Color-blind father example:** A color-blind father has the genotype X^bY. He passes:
>
> - His X^b to **all his daughters** — they all become at least carriers.
> - His Y to **all his sons** — they get nothing from him for color vision.
>
> So **fathers do NOT pass sex-linked traits to their sons.** This is one of the most reliable patterns to spot on MCAS.

A female with one recessive X-linked allele (X^BX^b) is a **carrier**. She doesn't have the trait — her normal X^B masks it — but she can pass X^b to half her children.

Pedigrees: reading the family tree

A **pedigree** shows how a trait passes through generations. The symbols:

- **Square** = male
- **Circle** = female
- **Filled-in shape** = person has the trait
- **Empty shape** = person does not have the trait
- **Horizontal line** between a male and a female = partners
- **Vertical line down** = their children

Generations are labeled with Roman numerals (I, II, III) on the left.

The skill on MCAS is to **look at the pattern of filled vs empty shapes** and figure out how the trait is inherited:

- **Trait skips a generation?** (Grandparents have it, parents don't, grandkids do.) Probably **recessive**.
- **Every affected person has at least one affected parent?** Probably **dominant**.
- **Far more common in males than females?** Possibly **sex-linked recessive**.
- **An affected father has all affected daughters and no affected sons?** Almost certainly **X-linked dominant**.

How to spot the pattern (the decision guide)

When MCAS shows you a question about a non-simple inheritance pattern, walk this path:

1. Are **both traits visible at the same time** in the heterozygote? → **codominance** (red AND white hairs).
2. Do the two traits **blend into a new color or trait**? → **incomplete dominance** (red + white = pink).
3. Is the trait **much more common in males**, or do affected fathers pass it to all daughters but no sons? → **sex-linked**.
4. None of the above, just dominant masking recessive? → **simple dominance**.

The Big Rule for this block: **look at the heterozygote**. The way the heterozygote looks tells you which pattern is in play. Simple dominance hides the recessive. Codominance shows both. Incomplete dominance blends them. Sex-linked involves the X chromosome and changes the male-vs-female ratio.

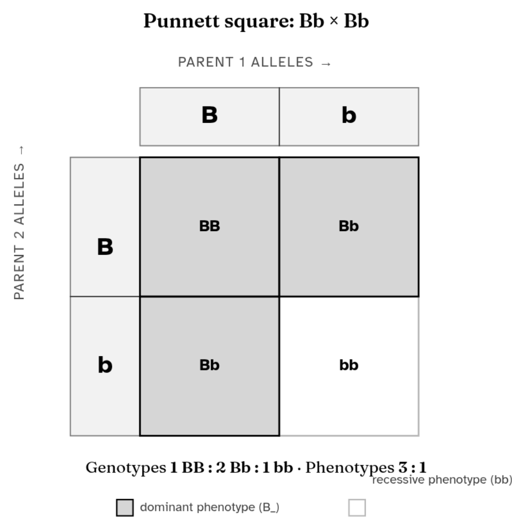
Why this matters

Most real-world inheritance is more complex than the simple BB/Bb/bb model. Many traits — eye color, height, skin color, blood type, intelligence, risk of disease — depend on **many genes** working together (called *polygenic inheritance*) and on environment. The patterns in this reading are stepping stones toward understanding that complexity.

For MCAS, knowing the three "non-simple" patterns and being able to recognize each from a description, a Punnett square result, or a pedigree is the goal. The questions are pattern-recognition questions: *which inheritance pattern is this?*

Diagram: a heterozygous cross (Bb × Bb)

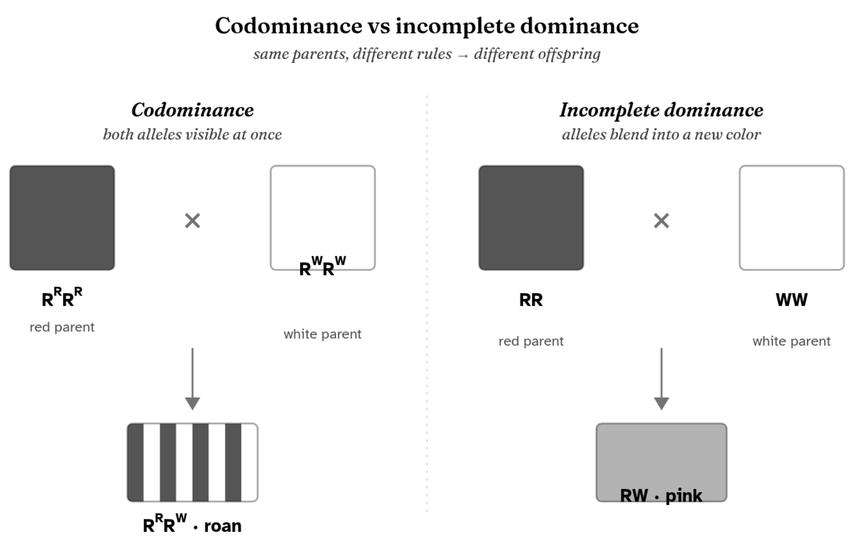
The most common Punnett square on the test. Both parents are heterozygous. The four boxes show every possible offspring genotype. Three boxes (BB, Bb, Bb) show the dominant phenotype. One box (bb) shows the recessive phenotype. Genotype ratio **1 : 2 : 1**; phenotype ratio **3 : 1**.



Punnett square: heterozygous cross (Bb × Bb)

Diagram: codominance vs incomplete dominance

Both panels show the same parental cross — a homozygous red parent crossed with a homozygous white parent. The offspring is what changes. On the left, codominance: the offspring shows BOTH colors at once (red and white side by side). On the right, incomplete dominance: the colors blend into pink. The visual contrast IS the lesson.



Codominance vs incomplete dominance

Pictures to recognize on the test

The picture shows…	The answer is…
An animal with red AND white hairs visible side by side (a roan cow).	**Codominance.** Both alleles visible at once.
A red parent flower × a white parent flower → all pink offspring.	**Incomplete dominance.** The alleles blend.
A 2 × 2 Punnett square with B and b across the top and B and b down the side.	A **Bb × Bb cross**. Genotypes 1 : 2 : 1, phenotypes 3 : 1.
A pedigree with a filled-in square in generation I, no affected children in generation II, and filled-in shapes again in generation III.	A **recessive** trait. (It "skipped" generation II — generation II must be carriers.)
A pedigree where most affected individuals are male.	Possibly **sex-linked recessive**. (Color blindness, hemophilia.)
A pedigree where an affected father has affected daughters and unaffected sons.	**X-linked dominant** (or possibly autosomal dominant — look at the broader family).

Pattern rules

If the question says…	Pick…
"Both traits visible at the same time, NOT blended."	**Codominance.** (Orange + black cat hairs visible side by side. AB blood with both A and B markers.)
"Two traits blend into a new color or trait."	**Incomplete dominance.** (Red + white snapdragon → pink.)
"Trait more common in males than in females."	**Sex-linked recessive.** (Males only have one X, so one recessive allele is enough.)
"Punnett square — 1 Bb × 1 Bb."	**3 : 1** ratio of dominant to recessive phenotypes.
"Pedigree with a filled-in shape."	That person **has the trait**.
"What is the genotype of a heterozygote?"	**Bb** — one dominant, one recessive allele.
"Where do new alleles come from?"	**Mutations.** (From Block 1 / Topic 7.)
"A color-blind father has children. Which children get the color-blindness allele from him?"	**All his daughters** (who become carriers); **none of his sons** (who get his Y, not his X).

Where to practice

Practice the Block 3 — Complex inheritance test on **Pear Assessment**. You can retake it as many times as you want — the questions and answer choices shuffle each time, so every attempt feels a little different. Try it *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

What you need to know cold

- **mitosis** = **2 identical** body cells. For growth and repair.
- **meiosis** = **4 unique** sex cells (**gamete**s). For reproduction.
- Body cells are **diploid** (2n). Gametes are **haploid** (n = half).
- The four stages of mitosis in order: **prophase**, **metaphase**, **anaphase**, **telophase** (**P-M-A-T**).
- **M**etaphase = **M**iddle. **A**naphase = **A**part.
- **crossing-over** during meiosis = homologous chromosomes swap pieces = **increases genetic variation**.
- Father → daughter = **X**. Father → son = **Y**.
- Diploid/haploid math: body cell has 28 chromosomes → gamete has **14**.

The Big Rule for this block

Mitosis copies. Meiosis halves.

If the question is about growth, repair, or identical cells → **mitosis**. If the question is about gametes, half the chromosomes, or genetic variation → **meiosis**.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory. Many of these words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
mitosis	mitosis	mitose	mitose	mitosi	mitoz	nguyên phân	انقسام متساوٍ *(inqisām mutasāwin)*
meiosis	meiosis	meiose	méiose	meiosi	meyoz	giảm phân	انقسام منصف *(inqisām munaṣṣaf)*
gamete	gameto	gameta	gamète	gamete	gamèt	giao tử	خلية جنسية *(khalīyya jinsiyya)*
diploid	diploide	diploide	diploïde	diploide	diplowid	lưỡng bội	ثنائي الصيغة الصبغية *(thunāʾī aṣ-ṣīgha aṣ-ṣibghiyya)*
haploid	haploide	haploide	haploïde	aploide	aplowid	đơn bội	أحادي الصيغة الصبغية *(uḥādī aṣ-ṣīgha aṣ-ṣibghiyya)*
chromosome	cromosoma	cromossomo	chromosome	cromosoma	kwomozòm	nhiễm sắc thể	كروموسوم *(krūmūsūm)*
crossing over	entrecruzamiento	crossing over / permutação	enjambement / crossing-over	crossing over	kwazman	trao đổi chéo	عبور كروموسومي *(ʿubūr krūmūsūmī)*

*The mitosis, meiosis, gamete, diploid, haploid, and chromosome rows use verified translations from the Quick Reference vocabulary table. The crossing over row is **new for Block 4** and has NOT yet been independently verified by GPT-5 / Gemini per Ms Brandolini's verification cycle — it relies on cognate consistency (Romance languages) and standard scientific-vocabulary equivalents (Vietnamese, Arabic, Haitian Kreyòl). If a term feels unfamiliar to a native speaker, please tell Ms Brandolini.*

The full picture

Mitosis vs meiosis — the two kinds of cell division

READING

What this reading is about

Your body has two reasons to divide cells: **growth and repair** (making more body cells) and **making sex cells** (eggs and sperm for reproduction). These two jobs use two different processes:

- **mitosis** — makes 2 identical body cells
- **meiosis** — makes 4 unique sex cells (**gamete**s)

This reading walks through both, the math that goes with them, and the reason meiosis creates genetic variation.

Mitosis: growth and repair

mitosis is how your body grows and fixes itself. When you need new skin cells, new root cells in a plant, or new blood cells, mitosis is the process.

The key fact: mitosis makes **two cells that are identical to the parent cell**. Both new cells have the same number of **chromosome**s as the original. If the parent cell was **diploid** (2n = 46 in humans), both daughter cells are also diploid (2n = 46).

The four stages of mitosis: P-M-A-T

Mitosis has four stages that always happen in the same order. MCAS may show you pictures and ask you to identify or order them.

1. **prophase** — Chromosomes condense and become visible as X-shaped structures. The nuclear membrane starts to break down.
2. **metaphase** — Chromosomes line up along the **middle** of the cell. Think: **M**etaphase = **M**iddle.
3. **anaphase** — Chromosomes pull **apart** toward opposite ends. Think: **A**naphase = **A**part.
4. **telophase** — Two new nuclei form. The cell splits in two (cytokinesis).

> **Ordering trick:** If MCAS gives you four pictures and asks you to put them in order, find the one where chromosomes are condensing but scattered (prophase), then lined up in the middle (metaphase), then pulling apart (anaphase), then two groups with new nuclei forming (telophase). **P-M-A-T**.

Meiosis: making gametes

meiosis is different from mitosis in three important ways:

	Mitosis	**Meiosis**
How many cells?	2	4
Identical or different?	Identical to parent	Different from parent and from each other
Chromosome number?	**diploid** (2n) — full set	**haploid** (n) — half set

	Mitosis	Meiosis
Purpose?	Growth and repair	Make **gamete**s (eggs and sperm)

The diploid/haploid math

Body cells are **diploid** — they have the **full set** of chromosomes, written as **2n**. In humans, 2n = 46.

Gametes (eggs and sperm) are **haploid** — they have **half**, written as **n**. In humans, n = 23.

When egg and sperm combine at fertilization: n + n = 2n. That's 23 + 23 = 46. The new organism has the full set again.

> **MCAS math example:** "A body cell has 28 chromosomes. How many chromosomes does an egg cell have?" Answer: **14** (28 ÷ 2 = 14). The egg is haploid — half the body-cell number.

What does a father pass to his children?

A father has 22 pairs of autosomes plus one pair of sex chromosomes (XY). He makes sperm through meiosis. Each sperm gets:

- 22 autosomes (one from each pair) plus **either** an X **or** a Y.
  So:

- **Father → daughter:** 22 autosomes + the **X** chromosome.
- **Father → son:** 22 autosomes + the **Y** chromosome.
  The father's sperm determines the sex of the child. If the sperm carries X, the child is female (XX). If the sperm carries Y, the child is male (XY).

Crossing over: why siblings are different

crossing-over happens during meiosis. When homologous chromosomes (matching pairs — one from mom, one from dad) line up, they **swap small sections of DNA**. After the swap, each chromosome has a new combination of alleles.

This is a major source of **genetic variation**. Even though two siblings have the same parents, each egg and each sperm carries a different mix of genetic material because of crossing over.

> **MCAS asks this a lot:** "What does crossing over do?" → **Increases genetic variability.** "What is the evidence?" → **Homologous chromosomes exchange genetic material during meiosis.**

Quick check: mitosis or meiosis?

- "Makes new root cells" → **mitosis**
- "Makes new skin cells" → **mitosis**
- "Makes eggs or sperm" → **meiosis**
- "Daughter cells are identical" → **mitosis**
- "Daughter cells are haploid" → **meiosis**
- "Increases genetic variation" → **meiosis** (crossing over)

Why this matters for MCAS

Cell division questions appear in both the **Heredity** and **Molecules to Organisms** reporting categories. The most common question types are:

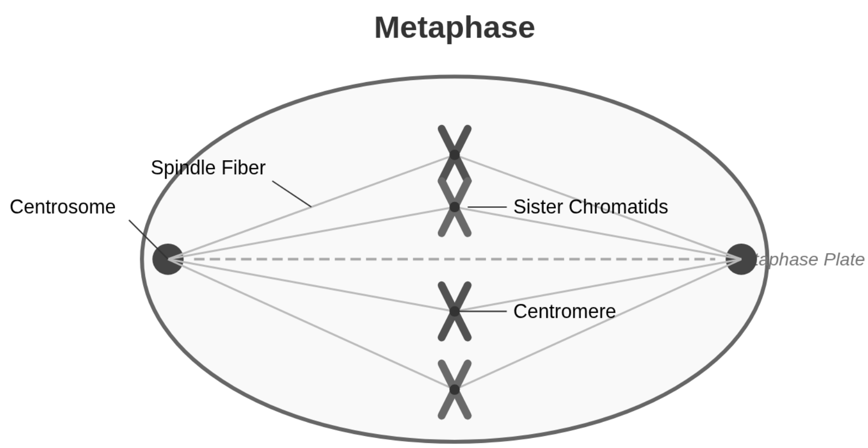
1. Order the stages of mitosis from pictures (P-M-A-T).
2. "What is the direct product of meiosis?" → gametes, never body cells.

3. Diploid/haploid math — body cell has X chromosomes, how many in a gamete?
4. "Why does meiosis exist?" → to make haploid gametes with half the chromosomes from each parent.
5. "What does crossing over do?" → increases genetic variation.

If you can answer those five, you have the cell-division portion of MCAS covered.

Diagram: what mitosis looks like at the middle

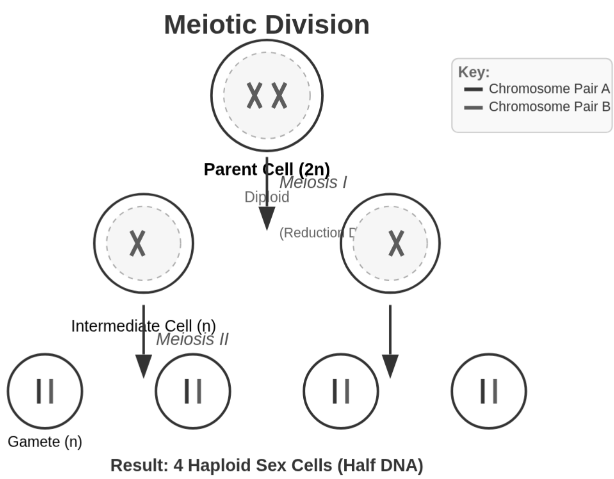
The picture you'll see most on the test: chromosomes lined up in a straight row across the middle of the cell. This is **metaphase** — M = Middle. If you can recognize this single image, you can usually answer two or three questions about mitosis stages.



biology/cell-division/metaphase

Diagram: the whole path of meiosis

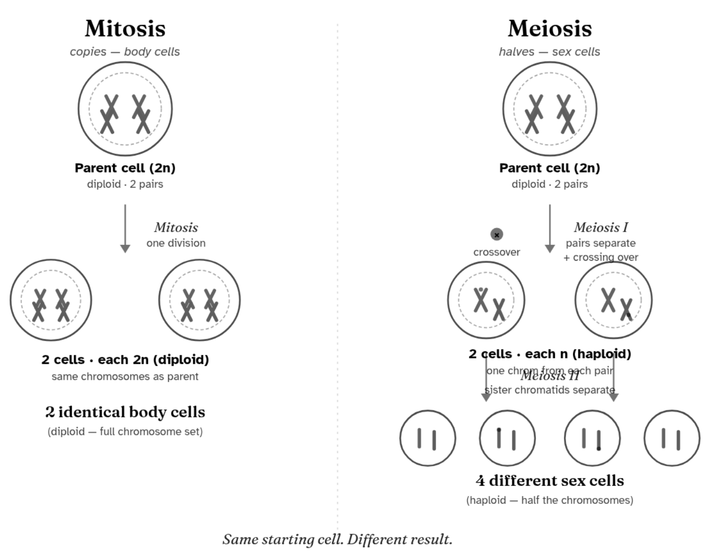
One parent cell at the top (diploid, 2n). Two divisions later, four gametes (haploid, n) at the bottom. Notice that meiosis takes *two* divisions to get there — Meiosis I separates the pairs, Meiosis II separates the sister chromatids. The two chromosome colors show the two pairs you start with.



biology/cell-division/meiosis

Diagram: mitosis vs meiosis, side by side

Both columns start with the same cell. Read down each column to see what happens. Mitosis (left): one division, two identical daughter cells. Meiosis (right): two divisions, four *different* gametes — different because of crossing over (the orange dot) in meiosis I. The Big Rule for this block lives at the bottom of this picture.



Mitosis vs meiosis: side-by-side comparison

Pictures to recognize on the test

The picture shows...	The answer is...
Chromosomes condensed into X shapes, scattered in the cell (not lined up).	**Prophase.** First stage of mitosis.
Chromosomes lined up in a straight row across the middle of the cell.	**Metaphase.** M = Middle.
Chromosomes being pulled apart toward opposite ends of the cell.	**Anaphase.** A = Apart.
Two groups of chromosomes with new nuclei forming; cell pinching in the middle.	**Telophase.** Two new nuclei, cell about to split.
Two chromosomes swapping pieces.	**Crossing over** (increases genetic variability).
Karyotype with 22 pairs + XY.	**Male.** Father gives X to daughters, Y to sons.
Karyotype with 22 pairs + XX.	**Female.**

Pattern rules

If the question says...	Pick...
"Order of mitosis stages" (4 pictures).	Find **P-M-A-T** order: condensing → middle → apart → two nuclei.
"Process that makes new root cells / skin cells / growth."	**Mitosis.**
"Mitosis daughter cells are..."	**Identical to the parent** (same chromosome number).
"Direct product of meiosis."	**Egg or sperm** (NEVER muscle / nerve / skin).
"Importance of meiosis."	Makes **haploid gametes** with half from each parent.
"Body cell has 28 chromosomes — egg has?"	**Half = 14.**
"What does a father pass to his daughter?"	**22 autosomes + the X.**
"Crossing over does what?"	**Increases genetic variability.** Homologous chromosomes exchange genetic material.

Where to practice

Practice the Block 4 — Mitosis vs meiosis test on **Pear Assessment**. You can retake it as many times as you want — the questions and answer choices shuffle each time, so every attempt feels a little different. Try it *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

What you need to know cold

- **prokaryote** = no nucleus (bacteria). **eukaryote** = has a **nucleus** (animals, plants, fungi).
- **mitochondria** make **atp** (energy). **chloroplast** does **photosynthesis**. Ribosomes make **protein**.
- All organic molecules have **carbon** as the backbone.
- Words ending in **-ose** = **carbohydrate**. Words ending in **-ase** = **enzyme**.
- **diffusion** = high to low, no energy. **osmosis** = water diffusing. **active-transport** = low to high, needs ATP.
- **photosynthesis** and **cellular-respiration** are **opposites**. Products of one = reactants of the other.
- Photosynthesis: CO_2 + H_2O + light → **glucose** + O_2 (in the **chloroplast**).
- Cellular respiration: glucose + O_2 → CO_2 + H_2O + **atp** (in the **mitochondria**).

The Big Rule for this block

Carbon is the backbone. Enzymes speed things up. Energy flows from light → glucose → ATP.

If the question says "speeds up a reaction," the answer is **enzyme**. If it says "against the gradient" or "pump," the answer is **active transport**. If it asks where energy comes from, trace the chain: sunlight → photosynthesis → glucose → cellular respiration → ATP.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory. Many of these words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
prokaryote	procariota	procarionte	procaryote	procariote	pwokaryòt	sinh vật nhân sơ	بدائي النواة *(badāʾī an-nawāh)*
eukaryote	eucariota	eucarionte	eucaryote	eucariote	ekaryòt	sinh vật nhân thực	حقيقي النواة *(ḥaqīqī an-nawāh)*
ribosome	ribosoma	ribossomo	ribosome	ribosoma	ribozòm	ribosome / ribôxôm	ريبوسوم *(rībūsūm)*
mitochondria	mitocondria	mitocôndria	mitochondrie	mitocondrio	mitokondri	ty thể	ميتوكندريا *(mītūkundriyā)*
chloroplast	cloroplasto	cloroplasto	chloroplaste	cloroplasto	kloroplas	lục lạp	بلاستيدة خضراء *(blāstīda khaḍrāʾ)*
protein	proteína	proteína	protéine	proteina	pwoteyin	protein / prô-tê-in	بروتين *(brūtīn)*
enzyme	enzima	enzima	enzyme	enzima	anzim	enzym / enzim	إنزيم *(inzīm)*
carbohydrate	carbohidrato	carboidrato	glucide / hydrate de carbone	carboidrato	kabidrat	cacbohiđrat / gluxit	كربوهيدرات *(karbūhīdrāt)*
lipid	lípido	lipídio	lipide	lipide	lipid	lipid	ليبيدات / دهون *(lībīdāt / duhūn)*
glucose	glucosa	glicose	glucose	glucosio	glikoz	glucose / glucôzơ	جلوكوز / غلوكوز *(jlūkūz / ghulūkūz)*
diffusion	difusión	difusão	diffusion	diffusione	difizyon	khuếch tán	انتشار *(intishār)*
osmosis	ósmosis	osmose	osmose	osmosi	osmoz	thẩm thấu	تناضح / الخاصية الأسموزية *(tanāḍuḥ)*
active transport	transporte activo	transporte ativo	transport actif	trasporto attivo	transpò aktif	vận chuyển chủ động	نقل نشط *(naql nashiṭ)*
photosynthesis	fotosíntesis	fotossíntese	photosynthèse	fotosintesi	fotosentèz	quang hợp	البناء الضوئي *(al-bināʾ al-ḍawʾī)*
respiration	respiración celular	respiração celular	respiration cellulaire	respirazione cellulare	respirasyon selilè	hô hấp tế bào	تنفس خلوي *(tanaffus khalawī)*

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
ATP	ATP	ATP	ATP	ATP	ATP	ATP	ATP *(ATP)*

All rows in this table are sourced from the Quick Reference Section 1 vocabulary, which was verified through Ms Brandolini's GPT-5 / Gemini cycle (Vietnamese and Arabic) or relies on cognate consistency (Romance languages and Haitian Kreyòl).

The full picture

Molecules to Organisms — cells, biomolecules, transport, and energy

READING

What this reading is about

"Molecules to Organisms" is **MCAS Reporting Category 1** — the biggest slice of the test. It covers everything from the parts of a cell to how cells get energy. This block reviews four sub-topics in one pass:

1. Cell types and **organelle** functions.
2. The four macromolecules and **enzyme** rules.
3. How things cross the **cell-membrane** (transport).
4. How cells make and use energy (**photosynthesis** and **cellular-respiration**).

Part 1: Cells

Two kinds of cells

Every living thing is made of cells. There are two main types:

- **prokaryote** — no **nucleus**. DNA floats freely. Bacteria are prokaryotes. They are small and simple.
- **eukaryote** — has a nucleus. DNA is inside the nucleus. Animals, plants, and fungi are eukaryotes. They are bigger and more complex.

Key organelles

Eukaryotic cells have organelles — small parts inside the cell, each with a specific job:

- **nucleus** — the control center. Holds the DNA.
- **Ribosome** — makes **protein**. Found in ALL cells (prokaryotes too).
- **mitochondria** — makes **atp** (energy). The inner membrane has folds for more surface area. Found in both plant and animal cells.
- **chloroplast** — does **photosynthesis**. Found only in plant cells.
- **cell-membrane** — the flexible outer boundary of every cell. Controls what enters and leaves.

> **Test tip:** If a question shows a cell with NO nucleus and free-floating DNA, that is a **prokaryote** (bacterium). If it has a nucleus, it is a eukaryote. If it also has chloroplasts and a cell wall, it is a **plant cell**.

Part 2: Macromolecules

The four types

All living things are built from four types of large molecules. All of them have **carbon** as the backbone — carbon is what makes a molecule "organic."

- **carbohydrate** — sugars and starches. Building block: **glucose** (a monosaccharide). Quick energy. Words ending in **-ose** = carbohydrate.
- **lipid** — fats and oils. Building block: fatty acid + glycerol. Long-term energy storage and cell membranes.
- **protein** — does many jobs (enzymes, antibodies, structure). Building block: amino acid.
- **Nucleic acid** — DNA and RNA. Building block: nucleotide. Holds genetic information.

Enzymes

An **enzyme** is a protein that speeds up a chemical reaction. Words ending in **-ase** are enzymes (lipase, sucrase, amylase). Enzymes work best at one specific temperature — too hot or too cold and they stop working. On a graph, enzyme activity looks like a bell curve.

> **MCAS shortcut:** "What speeds up a reaction?" → **enzyme**. "Backbone of organic molecules?" → **carbon**. "Building block of a protein?" → **amino acid**.

Part 3: Transport across the membrane

The **cell-membrane** is selectively permeable — it lets some things through but not everything. There are three main ways molecules cross:

- **diffusion** — molecules move from HIGH concentration to LOW concentration. No energy needed. Small molecules (like O_2) can pass right through.
- **osmosis** — the diffusion of **water** across a membrane. Still high to low, still no energy.
- **active-transport** — molecules move from LOW to HIGH concentration (against the gradient). Requires **atp** energy and a protein pump. The sodium-potassium pump is the classic example.

> **Memory trick:** Diffusion = DOWN the gradient (free). Active transport = AGAINST the gradient (costs ATP). If the question says "pump" or "against the gradient" or "low to high," the answer is **active transport**.

Part 4: Cellular energy

The two equations

These two processes are **opposites**. The products of one are the reactants of the other:

- **photosynthesis**: 6 CO_2 + 6 H_2O + light energy → **glucose** + 6 O_2. Happens in the **chloroplast**.
- **cellular-respiration**: glucose + 6 O_2 → 6 CO_2 + 6 H_2O + **atp**. Happens in the **mitochondria**.

Plants do BOTH — photosynthesis during the day (when there is light) and cellular respiration all the time. Animals only do cellular respiration.

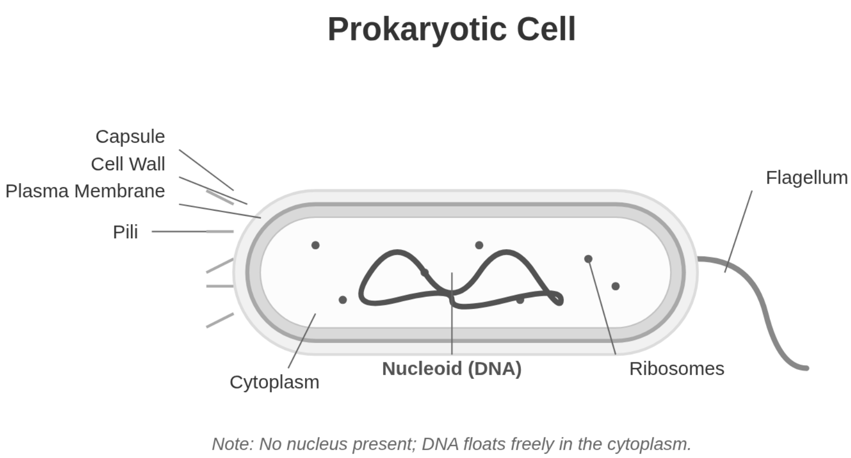
> **Common MCAS question:** "What process speeds up during exercise to make ATP?" → **Cellular respiration.** "Where does photosynthesis happen?" → **Chloroplast.** "More light → more glucose?" → **Yes** (until the plant maxes out).

Connecting it all

These four sub-topics connect. Cells need energy → energy comes from cellular respiration → respiration needs glucose → plants make glucose via photosynthesis → photosynthesis happens in chloroplasts (organelles) → the glucose and oxygen cross the membrane via transport. One topic feeds the next.

Diagram: a prokaryote (no nucleus)

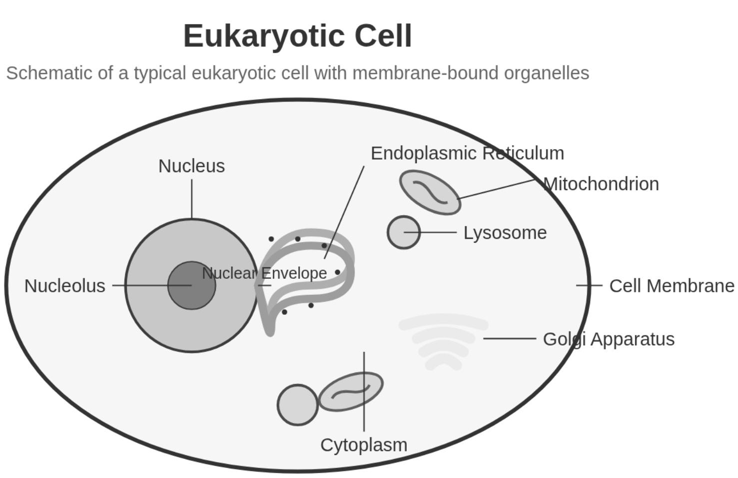
A **prokaryote** is a bacterium. The DNA floats free — there is **no nucleus**. You can also see a **cell wall**, a **capsule** around the the outside, and a long whip called a **flagellum** for moving. If the test shows a cell with no nucleus and free-floating DNA, pick *prokaryote*.



biology/cells/prokaryote

Diagram: a eukaryote (has a nucleus)

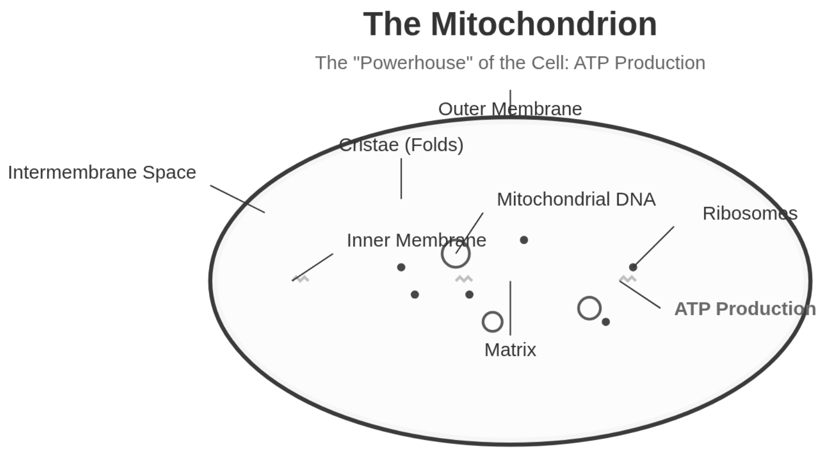
A **eukaryote** has a real **nucleus** holding the DNA, plus little machines inside called **organelles** — the **mitochondria** (makes ATP), the **ribosomes** (build proteins), and others. Plant cells and animal cells are both eukaryotes. Plant cells also have a **cell wall** and **chloroplasts**; animal cells do not.



biology/cells/eukaryote

Diagram: inside a mitochondrion

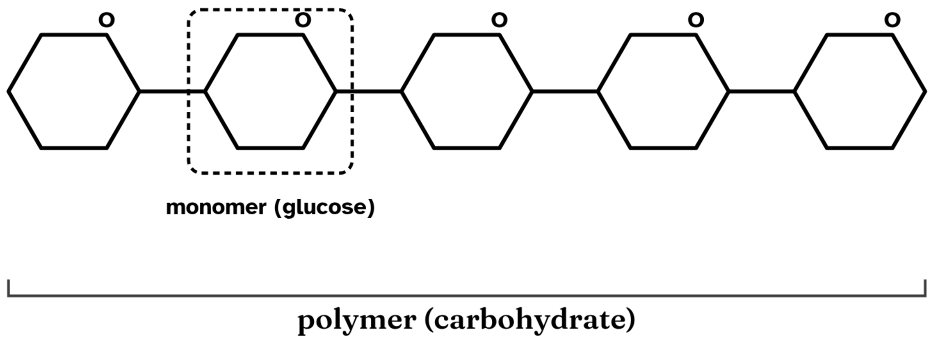
The **mitochondrion** is where cellular respiration happens — where the cell makes **ATP**. The inside membrane is **folded**, and those folds give more **surface area**. More surface area = more room to do the reaction = more ATP. If the test shows a folded inner membrane, the answer is about *ATP* and *surface area*.



biology/cells/mitochondria

Diagram: a carbohydrate is a chain of rings

A **carbohydrate** is a chain of **six-sided rings**. Each ring is one **glucose**. Many glucose rings linked together = a carbohydrate like *starch* or *glycogen*. If the picture shows a row of six-sided rings, the answer is *carbohydrate*, and the building block is *glucose*.

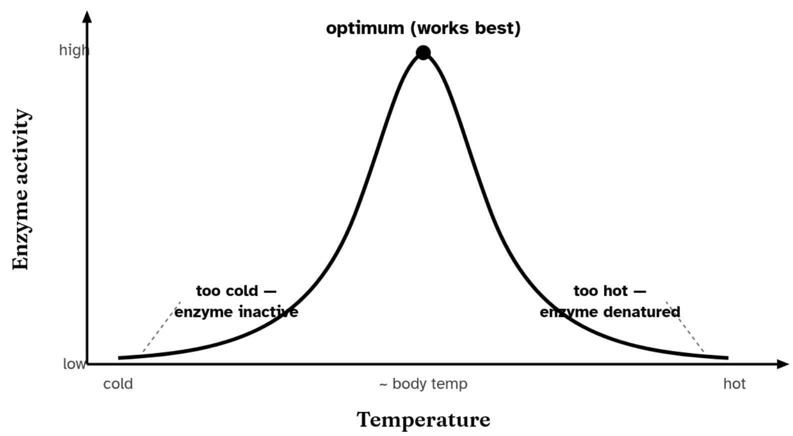


A chain of six-sided rings = carbohydrate. Each ring is a glucose.

Carbohydrate — a chain of repeating six-sided rings

Diagram: enzymes have an optimal temperature

An **enzyme** works best at one temperature — usually around body temperature. If it gets **too cold**, the enzyme slows down. If it gets **too hot**, the enzyme is **denatured** (broken) and stops working altogether. On a graph of activity vs temperature this makes a **bell curve** with one peak. If the test shows a bell curve, the answer is about *optimal temperature* and *denaturing*.

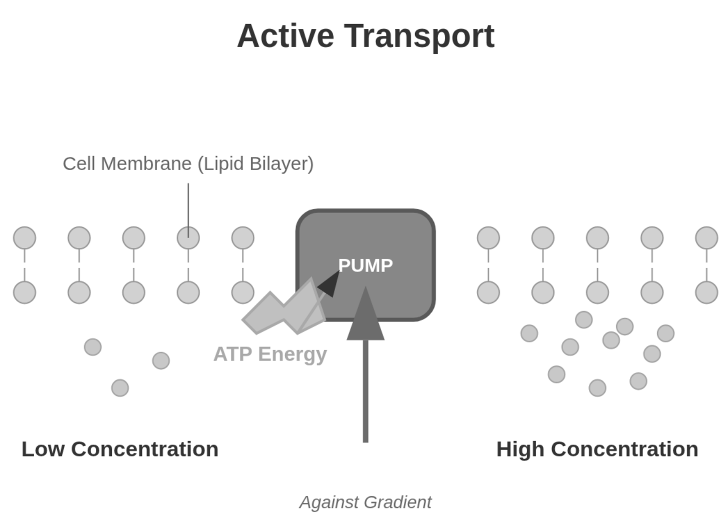


Enzymes work in a narrow temperature range. Outside it, activity stops.

Enzyme activity vs temperature — bell curve

Diagram: active transport (uses ATP)

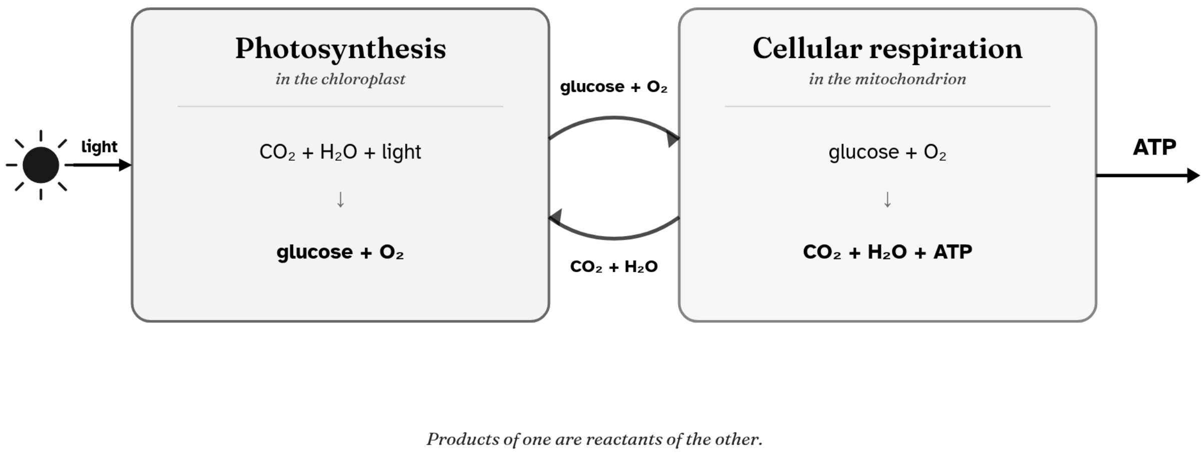
In **active transport**, a **protein pump** moves molecules across the membrane from **LOW** concentration to **HIGH** concentration — the *wrong* direction. Going the wrong way costs energy, so the cell spends **ATP**. If the picture shows a pump and molecules going LOW → HIGH, the answer is *active transport*.



biology/transport/active-transport

Diagram: photosynthesis and respiration are opposites

The two reactions are a **cycle**. The products of one are the reactants of the other. **Photosynthesis** takes in CO_2, water, and **light**, and makes glucose and O_2. **Cellular respiration** takes that glucose and O_2 and breaks it back down to CO_2 and water — and releases **ATP**. Light goes in; ATP comes out. Everything else loops.



Photosynthesis and cellular respiration as a cycle

Pictures to recognize on the test

The picture shows…	The answer is…
Cell with NO nucleus, has flagella + capsule + free DNA.	**Prokaryote** (bacterium).
Cell WITH nucleus, chloroplast, cell wall.	**Plant cell** (eukaryote).
Cell WITH nucleus, NO chloroplast, NO cell wall.	**Animal cell** (eukaryote).
Mitochondrion with folded inner membrane.	The folds = surface area = more **ATP**.
Chain of repeating six-sided rings.	**Carbohydrate.** Building block = glucose.
Bell-curve graph (enzyme activity vs temperature).	Enzyme works best at one temperature; too hot or cold = stops.
Membrane with protein pump, molecules going LOW → HIGH.	**Active transport** (uses ATP).
Equation: 6 CO_2 + 6 H_2O + **X** → glucose + 6 O_2.	**X = light energy** (photosynthesis).

Pattern rules

If the question says…	Pick…
"Which is a prokaryote?" + image with NO nucleus.	The bacteria-looking one (free DNA + flagella).
"Backbone of organic compounds" or "most important element for macromolecules."	**Carbon.**
Word ending in **-ose** (glucose, fructose, sucrose).	**Carbohydrate.**
"Speeds up a reaction" or word ending in **-ase**.	**Enzyme.**
"Sodium-potassium pump energy source" or anything with "pump" + energy.	**ATP.**
HIGH → LOW, no protein needed.	**Simple diffusion.**
LOW → HIGH, with protein pump.	**Active transport** (pick BOTH "low to high" AND "protein pump").
"What process speeds up during exercise to make ATP?"	**Cellular respiration.**

Where to practice

Practice the Block 5 — Molecules to Organisms test on **Pear Assessment**. You can retake it as many times as you want — the questions and answer choices shuffle each time, so every attempt feels a little different. Try it *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

What you need to know cold

- **dna** is a **double-helix**. The **bases** (A, T, C, G) hold the information. A pairs with T. C pairs with G.
- The **central-dogma**: **DNA → mRNA → protein**. **transcription** copies DNA into mRNA (in the nucleus). **translation** reads mRNA at a **ribosome** to build a protein.
- A **codon** is 3 mRNA bases = 1 **amino-acid**. Codon math: divide the number of bases by 3.
- A **mutation** is a change in the DNA base sequence. It directly affects the **nucleic acid sequence**. Downstream it may change the protein and the trait.
- **mitosis** = 2 identical body cells (growth/repair). **meiosis** = 4 unique **haploid** gametes (eggs/sperm).
- **crossing-over** during meiosis increases genetic variation.
- Each parent passes one **allele** per gene. **codominance** = both visible. **incomplete-dominance** = blend. **sex-linked** = on the X, more common in males.
- Mutations in **gamete**s can be inherited. Mutations in body cells cannot.

The Big Rule for this block

DNA → RNA → Protein. This is the order. Always.

Every heredity question lives somewhere in the chain from DNA to trait. A mutation changes the DNA. Transcription copies DNA to mRNA. Translation builds a protein from mRNA. The protein determines the trait. Cell division passes the DNA to new cells or offspring. Inheritance patterns describe how the trait shows up in a family.

Key vocabulary in 8 languages

Review words from across all heredity topics. Use the row in your home language to help your memory. All rows below come from the verified Quick Reference vocabulary table.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
DNA	ADN	DNA / ADN	ADN	DNA	ADN	ADN / DNA	الدنا / DNA *(dī-en-ey / ad-dinā)*
gene	gen	gene	gène	gene	jèn	gen / gien	جين / مورثة *(jīn / muwarritha)*
allele	alelo	alelo	allèle	allele	alèl	alen	أليل *(alīl)*
mutation	mutación	mutação	mutation	mutazione	mitasyon	đột biến	طفرة *(ṭafra)*
codon	codón	códon	codon	codone	kodon	côđon / bộ ba mã hóa	كودون / رامزة *(kūdūn / rāmiza)*
transcription	transcripción	transcrição	transcription	trascrizione	transkripsyon	phiên mã	نسخ *(naskh)*
translation	traducción	tradução	traduction	traduzione	tradiksyon	dịch mã	ترجمة *(tarjama)*
mitosis	mitosis	mitose	mitose	mitosi	mitoz	nguyên phân	انقسام متساوٍ *(inqisām mutasāwin)*
meiosis	meiosis	meiose	méiose	meiosi	meyoz	giảm phân	انقسام منصف / انقسام اختزالي *(inqisām munaṣṣaf / inqisām ikhtizālī)*

All 9 rows above come from the Quick Reference Section 1 vocabulary and have been verified through the GPT-5 / Gemini translation cycle.

The full picture

Heredity — how genetic information flows from DNA to traits to offspring

READING

What this reading is about

Heredity is one of the four MCAS reporting categories. It covers everything from the shape of **dna** to the inheritance patterns you see in a **pedigree**. Blocks 1–4 covered these pieces one at a time. This reading puts them together so you can see how one piece connects to the next.

The big chain that runs through all of heredity:

DNA → mRNA → protein → trait → inheritance

Every heredity question on MCAS lives somewhere in that chain. If you know where in the chain a question is asking, you can find the answer.

Link 1: DNA holds the information

dna is a **double-helix** — a twisted ladder. The sides are sugar-phosphate backbone (not important for information). The rungs are pairs of **nitrogenous-base**s: **A pairs with T, C pairs with G**. The **order of the bases** is the genetic code. That sequence is what holds all the information.

When a cell needs to copy its DNA (before dividing), it uses **replication**: the helix unzips, and each strand acts as a template for a new partner. The result is two identical copies of the original DNA.

Link 2: DNA → mRNA → protein

This is the **central-dogma**: **DNA → RNA → protein**.

- **transcription** (in the nucleus): a **gene** is copied into **mrna**. The rule changes slightly — RNA uses U instead of T. So A in DNA pairs with U in mRNA.
- **translation** (at a **ribosome**): the mRNA is read in groups of three bases called **codon**s. Each codon codes for one **amino-acid**. The chain of amino acids folds into a **protein**.

Codon math: count the mRNA bases, divide by 3. That is how many codons — and how many amino acids — you get. An mRNA with 12 bases has 4 codons = 4 amino acids.

Link 3: Mutations change the DNA

A **mutation** is any change in the DNA base sequence. A base can be inserted, deleted, or swapped for a different one. Because DNA is the starting point of the whole chain, a mutation can ripple forward:

Changed DNA → changed mRNA → changed protein → changed trait.

But not every mutation changes the trait. Some changes to DNA don't alter the protein, and some protein changes don't affect how the organism looks or functions.

> **Common MCAS trap:** "A mutation directly affects what?" The answer is always **the nucleic acid sequence** — the DNA bases. It does NOT directly affect the protein or the trait. Those are downstream effects.

Where the mutation happens matters:

- **Body cell** — affects only that individual. Not inherited.
- **Gamete (sex cell)** — can be passed to offspring. This is how **new alleles** enter a population.

Link 4: Cell division passes the DNA along

Two kinds of cell division, two different purposes:

	Mitosis	Meiosis
Purpose	Growth and repair	Making gametes (eggs/sperm)
Result	2 identical **diploid** cells	4 unique **haploid** cells
Chromosome number	Same as parent (2n)	Half of parent (n)
Genetic variation?	No — copies are identical	Yes — **crossing-over** + random assortment

Diploid/haploid math: if a body cell has 28 chromosomes (2n = 28), then a gamete has 14 (n = 14). Fertilization brings two gametes together: 14 + 14 = 28 again.

crossing-over happens during meiosis when homologous chromosomes swap pieces. This creates new combinations of alleles on each chromosome, which is why siblings from the same parents are not identical.

Link 5: Inheritance — how traits pass from parent to offspring

Each parent passes one **allele** per gene to each offspring. The combination of alleles is the **genotype**. The visible trait is the **phenotype**.

Four inheritance patterns to know:

- **Simple dominance:** one allele masks the other. Bb looks the same as BB.
- **codominance:** both alleles are visible at the same time. A red-and-white roan cow shows both colors side by side.
- **incomplete-dominance:** alleles blend. Red × white = pink.
- **sex-linked:** the gene is on the X chromosome. Recessive traits are more common in males because males have only one X.

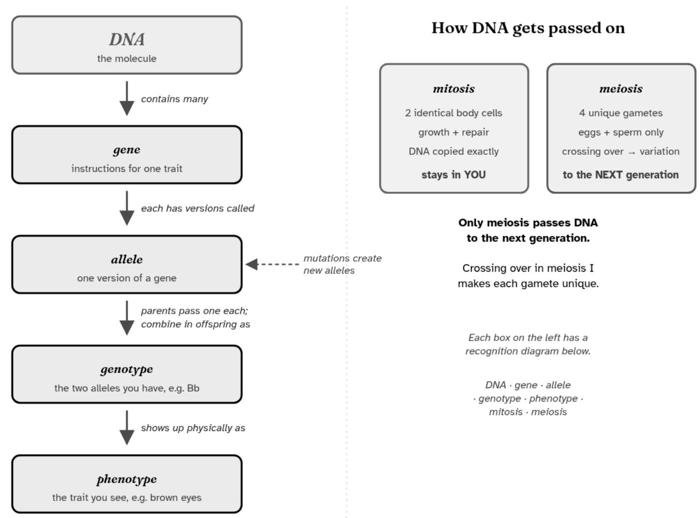
A **punnett-square** predicts offspring ratios. A Bb × Bb cross always gives a **3:1** phenotype ratio (3 dominant : 1 recessive). A **pedigree** tracks traits through a family: squares are male, circles are female, filled-in means the person has the trait.

The whole chain in one sentence

DNA is copied into mRNA, which is read by a ribosome to make a protein that determines a trait, which is inherited through gametes made by meiosis — and mutations are the only way new alleles are born.

Diagram: the whole map of heredity, in one picture

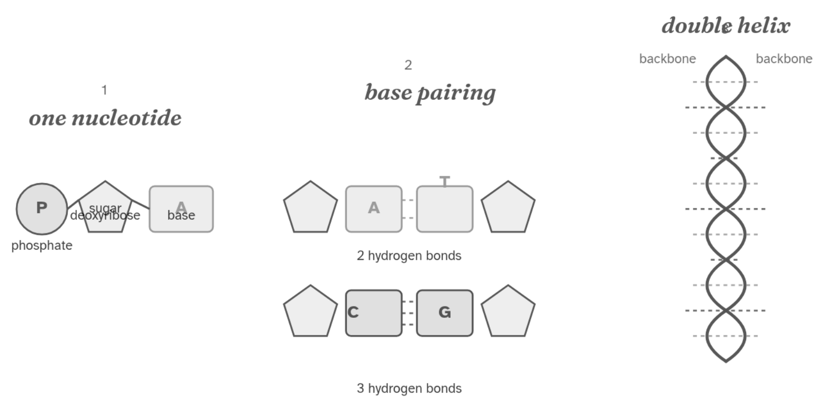
Block 6 is a review of Blocks 1–4. Before the five recognition diagrams below, here is the conceptual map that connects them. Read the left column top to bottom: **dna** → **gene** → **allele** → **genotype** → **phenotype**. That is how information in the molecule becomes a trait you can see. The right side shows how DNA gets *passed on*: **mitosis** keeps DNA inside one body (growth and repair); **meiosis** sends DNA forward to the next generation, as eggs and sperm.



Heredity tree: from DNA to trait, and how DNA passes to the next generation

Diagram: what DNA looks like

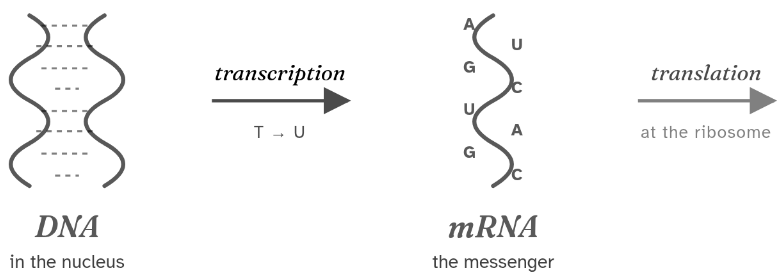
Three views of the same molecule, zoomed in to zoomed out: a single **nucleotide** (phosphate + sugar + base); two **base pairs** (A–T held by two bonds, C–G held by three); and a section of the full **double helix**. If a test image looks like a twisted ladder, the answer is DNA. If it shows letters paired up, remember: A with T, C with G.



DNA anatomy: nucleotide, base pair, double helix

Diagram: how genes make traits

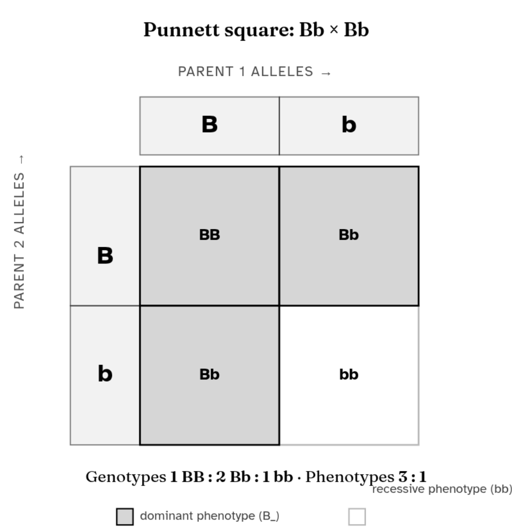
The **central-dogma** in one picture: DNA in the nucleus is copied into mRNA (**transcription**), then mRNA is read at the **ribosome** to build a protein (**translation**). When the test asks the order of events to make a protein, this is the answer: **DNA → RNA → protein**. The protein then does the job that shows up as a trait.



Central dogma: DNA to mRNA to protein

Diagram: how a cross works

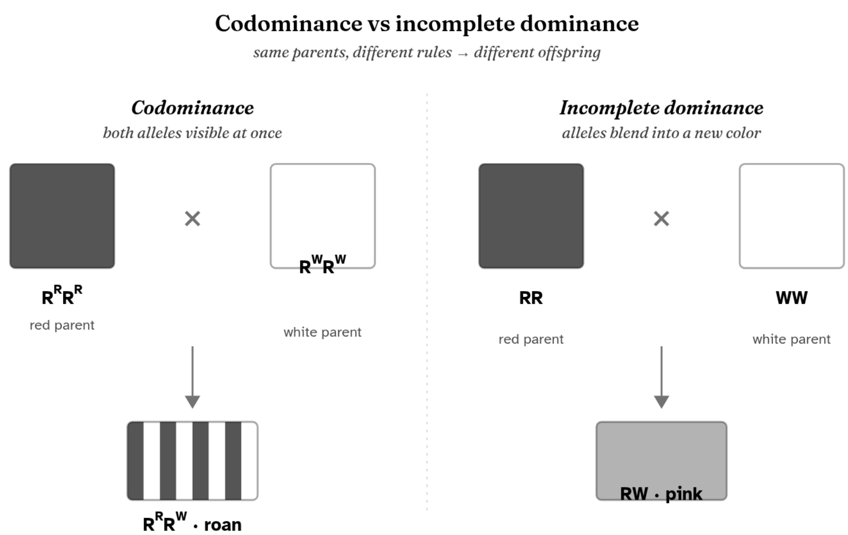
A 2×2 **punnett-square** for a heterozygous cross (Bb × Bb). Parents' **allele**s go on the top and side; each inner cell shows one possible offspring **genotype**. The 1 BB : 2 Bb : 1 bb genotype ratio gives the classic 3 : 1 **phenotype** ratio for a simple dominant/recessive trait. If a test question gives you parents and asks about offspring, draw this grid.



Punnett square: heterozygous cross (Bb × Bb)

Diagram: codominance vs incomplete dominance

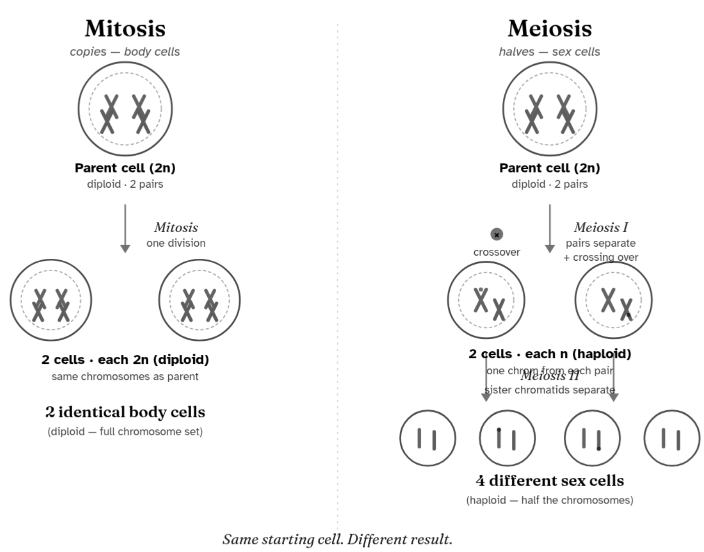
Same red × white parents, two different outcomes. On the left, **codominance**: the offspring shows **both** colors at once — red and white patches, separately visible. On the right, **incomplete-dominance**: the colors *blend* into pink. The MCAS clue is right there in the picture — separate colors means codominant, blended color means incomplete dominance.



Codominance vs incomplete dominance

Diagram: how DNA gets passed on — mitosis vs meiosis

Both columns start with the same parent cell. **mitosis** (left): one division, two identical body cells — for growth and repair. **meiosis** (right): two divisions, four *different* **gamete**s — different because of **crossing-over** in meiosis I. Meiosis is the only way DNA gets passed to the next generation.



Mitosis vs meiosis: side-by-side comparison

Pictures to recognize on the test

The picture shows...	The answer is...
A twisted ladder shape (two strands wound around each other).	**Double helix** — DNA. The rungs are base pairs (A–T, C–G).
A diagram showing DNA → mRNA → protein in sequence.	The **central dogma**. Transcription (DNA → mRNA) then translation (mRNA → protein).
An mRNA strand with bases grouped in threes, each group pointing to an amino acid.	**Codons.** Each group of 3 bases = 1 amino acid. Count bases ÷ 3 = number of codons.
Two chromosomes swapping pieces during cell division.	**Crossing over** during meiosis. Increases genetic variation.
A family chart with squares (males) and circles (females), some filled in.	A **pedigree**. Filled-in = has the trait. If it skips a generation, the trait is likely recessive.
An animal showing BOTH red and white patches (not blended).	**Codominance.** Both alleles visible at the same time.

Pattern rules

If the question says...	Pick...
"A pairs with ___. C pairs with ___."	**T** and **G**. Always. (In RNA, A pairs with U instead of T.)
"What is the sequence of events to make a protein?"	**DNA → RNA → amino acids → protein.** (Central dogma.)
"How many codons in this mRNA?"	**Number of bases ÷ 3.** (12 bases = 4 codons = 4 amino acids.)
"A mutation directly affects what?"	**The nucleic acid sequence** (the DNA bases). NOT the protein — that is a downstream effect.
"Where do new alleles come from?"	**Mutations.** A change in DNA creates a new version of a gene.
"Mitosis makes ___ cells. Meiosis makes ___ cells."	**2 identical diploid** (mitosis). **4 unique haploid** (meiosis).
"Body cell has 28 chromosomes. How many in an egg?"	**14.** Gametes have half the diploid number.
"Trait more common in males than females."	**Sex-linked recessive.** Males have only one X — one recessive allele is enough.

Where to practice

Practice the Block 6 — Heredity full review test on **Pear Assessment**. You can retake it as many times as you want — the questions and answer choices shuffle each time, so every attempt feels a little different. Try it *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

What you need to know cold

- **natural-selection** needs four things: **variation**, **heritability**, **differential reproduction**, and **selection pressure**.
- The **best evidence** for how closely two species are related: **comparing DNA or amino acid sequences**. Not fossils. Not anatomy. DNA.
- **homologous** structures = same bone pattern, different function = **common ancestor**.
- **convergent-evolution** = unrelated species look alike because they live in **similar environments**.
- **speciation** = populations get isolated → evolve differently → can no longer interbreed → two species.
- An **adaptation** is a trait that helps survival. It develops over generations through natural selection.
- High-diversity populations survive environmental changes better than low-diversity populations.
- Mass extinctions happen when environments change faster than organisms can adapt.

The Big Rule for this block

Natural selection needs four things. No exceptions.

Variation, heritability, differential reproduction, selection pressure. If the question asks "what does natural selection require?" or gives you a scenario and asks "is this natural selection?" — check for all four.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory. Many of these words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
evolution	evolución	evolução	évolution	evoluzione	evolisyon	tiến hóa	تطور *(taṭawwur)*
natural selection	selección natural	seleção natural	sélection naturelle	selezione naturale	seleksyon natirèl	chọn lọc tự nhiên	انتقاء طبيعي *(intiqāʾ ṭabīʿī)*
adaptation	adaptación	adaptação	adaptation	adattamento	adaptasyon	đặc điểm thích nghi	صفة تكيفية *(ṣifa takayyufiyya)*
speciation	especiación	especiação	spéciation	speciazione	espesyasyon	sự hình thành loài	انتواع *(intiwāʿ)*
homologous	homólogo	homólogo	homologue	omologo	omològ	cơ quan tương đồng	أعضاء متماثلة *(aʿḍāʾ mutamāthila)*
convergent evolution	evolución convergente	evolução convergente	évolution convergente	evoluzione convergente	evolisyon konvèjant	tiến hóa hội tụ	التطور التقاربي *(at-taṭawwur at-taqārubī)*
mutation	mutación	mutação	mutation	mutazione	mitasyon	đột biến	طفرة *(ṭafra)*

All 7 rows use verified translations from the Quick Reference vocabulary table (Section 1). Vietnamese and Arabic were verified by GPT-5 and Gemini; Romance languages rely on cognate consistency.

The full picture

Evolution and natural selection — how species change over time

READING

What this reading is about

evolution was about 6% of your class final but makes up **20% of MCAS**. This block gives it the attention it deserves. You need to understand four things:

1. What **natural-selection** is and the four conditions it needs.
2. What counts as evidence for evolution — and which evidence is strongest.
3. The difference between **convergent-evolution** and common ancestry.
4. How new species form (**speciation**).

Natural selection: the engine of evolution

natural-selection is the main process that drives **evolution**. It is not random — it is the environment "selecting" which traits work best. For natural selection to happen, four conditions must all be present:

1. **Variation** — individuals in a population are different from each other (different colors, sizes, speeds, etc.).
2. **Heritability** — those differences are genetic and can be passed from parent to offspring.
3. **Differential reproduction** — some individuals survive longer and leave more offspring than others.
4. **Selection pressure** — something in the environment (predators, disease, food scarcity, climate) favors certain traits.

When all four are present, the traits that help survival become more common in the population over generations. That is natural selection.

> **Example:** A population of beetles has green and brown individuals (variation). Color is inherited (heritability). Birds eat the green beetles more easily on brown soil (selection pressure). Brown beetles survive and reproduce more (differential reproduction). Over many generations, the population becomes mostly brown.

What happens when the environment changes?

If the environment changes, the traits that are "fit" may change too. A population with **high diversity** (lots of variation) has a better chance of surviving because some individuals may already have traits that work in the new environment. A population with **low diversity** is more vulnerable — if no individuals have the right traits, the whole population may decline or go extinct.

This is why **genetic variation matters**. It is the raw material for natural selection. Without variation, there is nothing to select.

Evidence for evolution: which is strongest?

Scientists use several types of evidence to support evolution and to figure out how species are related:

Type of evidence	What it tells us	How strong?
DNA / amino acid sequences	Species with more similar DNA are more closely related.	**STRONGEST** — most precise and direct.

Type of evidence	What it tells us	How strong?
Anatomy (homologous structures)	Same bone pattern, different function = common ancestor.	Good
Embryology	Early embryos of related species look very similar.	Good
Fossils	Show what ancient organisms looked like; show transitions over time.	Good

> **MCAS loves this question:** "Which is the BEST evidence for how closely two species are related?" The answer is always **comparing DNA or amino acid sequences**. Not fossils. Not anatomy. DNA.

Homologous structures vs convergent evolution

This is a common MCAS distinction. Two species can look similar for two very different reasons:

	Homologous structures	Convergent evolution
Why they look similar	Same ancestor	Same environment
DNA comparison	DNA is similar	DNA is different
Internal structure	Same bone/tissue pattern	Different internal structure
Example	Human arm and bat wing (same bones)	Dolphin and ichthyosaur (both streamlined, but mammal vs reptile)

The test: if two species look alike, check their DNA. Similar DNA = common ancestor (**homologous**). Different DNA = **convergent-evolution** (similar environment pushed them to look alike independently).

Speciation: how new species form

speciation happens when one species splits into two. The usual path:

1. A population gets **separated** by a barrier (river, mountain, ocean).
2. Each group faces **different environments** and different selection pressures.
3. Over many generations, the groups become so different they **can no longer interbreed**.
4. Two species now exist where one used to.

This is why islands and isolated habitats often have unique species found nowhere else — populations arrived, were cut off, and evolved separately.

Mass extinctions

When the environment changes faster than organisms can adapt, populations decline. A **mass extinction** happens when a large-scale environmental change (asteroid impact, volcanic eruptions, rapid climate shift) kills off many species at once.

After a mass extinction, surviving species often diversify rapidly to fill the empty niches — this is called an **adaptive radiation**.

Why this matters for MCAS

Evolution questions make up about **20% of MCAS Biology**. The most common question types are:

1. "What four things does natural selection need?" → variation, heritability, differential reproduction, selection pressure.
2. "Best evidence for relatedness?" → DNA / amino acid sequences.
3. "Two unrelated species look alike — why?" → **convergent-evolution** (similar environments).
4. "How do new species form?" → **speciation** (isolation + different selection pressures + time).
5. Scenario questions: "Environment changes — what happens to the population?" → best-adapted survive; diversity decreases; population may shift.

If you can answer those five question types, you have the evolution portion of MCAS covered.

Pictures to recognize on the test

The picture shows...	The answer is...
A table comparing DNA or amino acid sequences between species, with percentages or counts of differences.	**Evidence for relatedness.** More similar DNA = more closely related.
Four forelimbs (human arm, bat wing, whale flipper, cat leg) with the same bone pattern highlighted.	**Homologous structures.** Same origin, different function = common ancestor.
Two unrelated animals that look similar (dolphin and ichthyosaur, or bird wing and bat wing).	**Convergent evolution.** Similar environments → similar shapes, but NOT related.
A population graph showing diversity decreasing after an environmental change.	**Natural selection in action.** Best-adapted survive; diversity drops.
A branching tree diagram (phylogenetic tree / cladogram) connecting multiple species.	**Evolutionary relationships.** Closer branches = more closely related species.
A series of fossils showing gradual change over time (e.g., horse evolution, whale ancestors).	**Fossil evidence for evolution.** Species change over geologic time.

Pattern rules

If the question says...	Pick...
"Best evidence for how closely two species are related."	**Comparing DNA or amino acid sequences.** Always. Not fossils, not anatomy.
"High-diversity population faces a new environment."	**Best-adapted survive — diversity decreases.** The population shifts toward the favored trait.
"Two unrelated species look alike — why?"	**Convergent evolution.** Similar environments select for similar traits.
"What makes natural selection happen?"	**Variation + heritability + differential reproduction + selection pressure.** All four.
"How do new species form?"	**Speciation.** Populations get isolated, evolve separately, can no longer interbreed.
"Why do dolphins and ichthyosaurs look alike?"	**Convergent evolution** — same aquatic environment, not same ancestor.
"What causes mass extinctions?"	**Environmental changes** organisms cannot adapt to fast enough.
"Where do new alleles come from?"	**Mutations.** Mutations are the ultimate source of genetic variation.

Where to practice

Practice the Block 7 — Evolution full review test on **Pear Assessment**. You can retake it as many times as you want — the questions and answer choices shuffle each time, so every attempt feels a little different. Try it *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

What you need to know cold

- Food web arrows point **from the organism being eaten TO the eater**.
- **Energy decreases** at each food chain level — ~90% is lost as heat. Only ~10% passes up.
- **Matter is recycled** (by **decomposer**s). Energy is NOT recycled.
- **producer**s make their own food (plants). **consumer**s eat other organisms. **decomposer**s break down dead things.
- **biotic** = living. **abiotic** = non-living. **Fungi are biotic** (living!).
- **mutualism** = both helped (+/+). **commensalism** = one helped, other unaffected (+/0). **parasitism** = one helped, other harmed (+/–).
- **population** change = (births + immigrants) – (deaths + emigrants).
- **carrying-capacity**: the max population size. At carrying capacity, birth rate = death rate.
- **homeostasis** = body stays stable. Works through **feedback-loop**s.
- **Negative feedback** = brings the system back to the setpoint = most homeostasis.

The Big Rule for this block

Energy flows one way and shrinks at every level. Matter cycles. Negative feedback keeps things stable.

In a food web, energy moves from eaten to eater and 90% is lost as heat at each step. Nutrients cycle back through decomposers. Inside organisms, negative feedback loops maintain homeostasis by bringing values back to a setpoint.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory. Many of these words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
ecosystem	ecosistema	ecossistema	écosystème	ecosistema	ekosistèm	hệ sinh thái	نظام بيئي *(niẓām bīʾī)*
producer	productor	produtor	producteur	produttore	pwodiktè	sinh vật sản xuất	كائن منتج *(kāʾin muntij)*
consumer	consumidor	consumidor	consommateur	consumatore	konsomatè	sinh vật tiêu thụ	كائن مستهلك *(kāʾin mustahlik)*
decomposer	descomponedor	decompositor	décomposeur	decompositore	dekonpozè	sinh vật phân hủy	كائن محلل *(kāʾin muḥallil)*
biotic	biótico	biótico	biotique	biotico	byotik	nhân tố hữu sinh	عامل حيوي *(ʿāmil ḥayawī)*
abiotic	abiótico	abiótico	abiotique	abiotico	abyotik	nhân tố vô sinh	عامل لا حيوي *(ʿāmil lā ḥayawī)*
population	población	população	population	popolazione	popilasyon	quần thể	جماعة حيوية *(jamāʿa ḥayawiyya)*
carrying capacity	capacidad de carga	capacidade de suporte	capacité de charge	capacità portante	kapasite chaj	sức chứa môi trường	القدرة الاستيعابية *(al-qudra al-istīʿābiyya)*
mutualism	mutualismo	mutualismo	mutualisme	mutualismo	mityalis	hỗ sinh / cộng sinh	تبادل المنفعة / التقايض *(tabādul al-manfaʿa / at-taqāyuḍ)*
commensalism	comensalismo	comensalismo	commensalisme	commensalismo	komensalis	hội sinh	تعايش *(taʿāyush)*
parasitism	parasitismo	parasitismo	parasitisme	parassitismo	parazitis	ký sinh	تطفل *(taṭafful)*

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
homeostasis	homeostasis	homeostase	homéostasie	omeostasi	omeyostazi	cân bằng nội môi	اتزان داخلي / توازن داخلي *(ittizān dākhilī / tawāzun dākhilī)*
feedback loop	retroalimentación	retroalimentação / feedback	rétroaction / boucle de rétroaction	retroazione / feedback	fidbak	cơ chế điều hòa ngược	حلقة تغذية راجعة *(ḥalqat taghdhiya rājiʿa)*

All 13 rows use the verified translations from the Quick Reference vocabulary table. Vietnamese and Arabic translations were verified by GPT-5 and Gemini. Romance-language translations (Spanish, Portuguese, French, Italian, Haitian Kreyòl) rely on cognate consistency. If a term feels unfamiliar to a native speaker, please tell Ms Brandolini.

The full picture

Ecology, populations, and homeostasis — how living systems work together

READING

What this reading is about

This block covers three big areas that MCAS tests together:

1. **Ecosystems** — food webs, energy flow, and species interactions.
2. **Populations** — how populations grow, shrink, and level off.
3. **homeostasis** — how organisms keep their bodies stable.

These topics connect: an **ecosystem** is the big picture (all organisms + their environment), **population**s are groups within that ecosystem, and homeostasis is how individual organisms stay alive inside it all.

Ecosystems: who eats whom?

An **ecosystem** includes all the **biotic** (living) and **abiotic** (non-living) factors in an area. Energy flows through the ecosystem in one direction: from the sun → **producer**s → **consumer**s → **decomposer**s.

Food web rules:

- Arrows point **from the organism being eaten TO the eater** (the direction energy flows).
- Energy **decreases** at each level — about 90% is lost as heat. Only ~10% passes up.
- Matter (nutrients) is **recycled** by decomposers. Energy is NOT recycled.

> **Common MCAS trap:** "If producers are removed from a food web, what happens?" Answer: BOTH primary AND secondary consumers decrease. Everything above the producers depends on them.

The correct food chain order

Producer → primary consumer → secondary consumer → tertiary consumer.

Example: grass → rabbit → hawk → eagle.

Every food chain starts with a **producer**. **decomposer**s connect to every level because they break down dead organisms from all trophic levels and return nutrients to the soil.

Species interactions: who helps whom?

Species in an ecosystem interact in different ways. MCAS tests three types:

Interaction	Species A	Species B	Example
mutualism	Helped (+)	Helped (+)	Bee pollinates flower; bee gets nectar
commensalism	Helped (+)	Unaffected (0)	Bird nests in tree; tree is fine

Interaction	Species A	Species B	Example
parasitism	Helped (+)	Harmed (–)	Tick feeds on dog; dog loses blood

> **How to tell them apart:** Ask two questions. (1) Is either species hurt? If yes → **parasitism**. (2) Are both helped? If yes → **mutualism**. If only one is helped and the other is fine → **commensalism**.

Biotic vs abiotic — the MCAS trap

biotic = living. **abiotic** = non-living. Most of the time this is obvious. But watch for: **fungi are biotic** (living). They don't move, they don't look like animals, but they are alive. If a question asks "which is NOT abiotic?" and fungi is a choice, pick fungi.

Populations: growth and limits

A **population** is all the members of one species in one area.

The population change formula:

Change = (births + immigrants) – (deaths + emigrants)

- If births + immigrants > deaths + emigrants → population **grows**.
- If deaths + emigrants > births + immigrants → population **shrinks**.
- If they're equal → population stays the same.

Carrying capacity and the S-curve

carrying-capacity is the maximum population an environment can support. On a graph, you see it as the flat top of an **S-curve** (logistic growth).

At carrying capacity, **birth rate = death rate**. The population stops growing — not because organisms stop reproducing, but because deaths balance births.

Limiting factors that determine carrying capacity: food, water, space, predators, disease. If resources decrease, carrying capacity drops and the population may decline.

Homeostasis: keeping the body stable

homeostasis is the body's ability to maintain stable internal conditions. Your body has setpoints — target values it tries to maintain. When something pushes a value away from the setpoint, a **feedback-loop** brings it back.

System	Setpoint	If too high	If too low
Body temperature	~37°C	Sweat, blood vessels widen	Shiver, blood vessels narrow
Blood glucose	~90 mg/dL	Insulin → cells absorb glucose	Glucagon → liver releases glucose
Water balance	Normal blood concentration	Excrete more water	Save water

Feedback loops: negative vs positive

Negative feedback = the most common type. It brings the system back to the setpoint. This is how **homeostasis** works. Think of it as a balancing loop.

Positive feedback = rare. It pushes the system further from the starting point. Example: blood clotting — one clot factor activates more clot factors until the wound is sealed.

> **MCAS key:** If a question asks "what kind of feedback maintains stability?" the answer is always **negative feedback**. If it shows a diagram with sensor → control → effector bringing a value back to a setpoint, that is negative feedback / homeostasis.

Two systems that deliver oxygen

MCAS often asks: "Which TWO systems deliver oxygen to cells?" The answer is always **respiratory + circulatory**. The respiratory system (lungs) brings oxygen into the body. The circulatory system (heart + blood) delivers it to every cell.

The carbon cycle

Carbon cycles through ecosystems:

1. **producer**s absorb CO_2 from the air during photosynthesis.
2. **consumer**s eat producers and use the carbon.
3. **decomposer**s break down dead organisms and release carbon back to the soil and air.
4. Cellular respiration by all organisms releases CO_2 back to the atmosphere.

Key point: **energy flows one way** (sun → producers → consumers → lost as heat). **Matter cycles** (carbon, nitrogen, water move in loops).

Why this matters for MCAS

Ecology and population questions make up about **30% of MCAS Biology** (Reporting Categories 3 and 4 combined). The most common question types:

1. "Food web arrows point from ___?" → from eaten to eater.
2. "Loss of producers → what happens?" → all consumers decrease.
3. "Which is NOT abiotic?" → fungi (living!).
4. "Population rising — why?" → births + immigrants > deaths + emigrants.
5. "What maintains stability?" → negative feedback / homeostasis.
6. "Two systems deliver oxygen?" → respiratory + circulatory.
7. "Two species, one helped, one unaffected?" → commensalism.

Pictures to recognize on the test

The picture shows...	The answer is...
Energy pyramid with arrows pointing outward (heat) at each level.	**Energy lost as heat (~90%).** Only ~10% passes to the next level.
Food web with arrows connecting organisms.	Arrows point **from eaten → to eater** (direction energy flows).
Population graph rising, then leveling off into an S-shape.	**Carrying capacity** reached. Births = deaths. Logistic growth.
Population graph steadily rising (J-curve).	**Exponential growth** — births + immigrants > deaths + emigrants. Has not yet hit carrying capacity.
Diagram with sensor → control center → effector bringing a value back to a target.	**Negative feedback loop** / homeostasis.
Graph showing body temperature going up, then returning to 37°C.	**Homeostasis** — negative feedback brought temperature back to setpoint.

Pattern rules

If the question says...	Pick...
"Loss of producers in a food web — what happens?"	**Both primary AND secondary consumers decrease.** Everything depends on producers.
"Which is NOT abiotic?" with fungi as a choice.	**Fungi.** Fungi are biotic (living).
"Energy at each trophic level..."	**Decreases.** ~90% lost as heat at each step.
"Why are decomposers important?"	**They recycle nutrients** (matter) back to the soil so producers can use them.
"Population is rising — why?"	**(Births + immigrants) > (deaths + emigrants).**
"Population at carrying capacity — what's true?"	**Birth rate = death rate.** Population levels off.
"What kind of feedback maintains stability?"	**Negative feedback.**
"Two systems that deliver oxygen to cells?"	**Circulatory + respiratory.** (Both needed.)

Where to practice

Practice the Block 8 — Ecology, populations & homeostasis test on **Pear Assessment**. You can retake it as many times as you want — the questions and answer choices shuffle each time, so every attempt feels a little different. Try it *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

What you need to know cold

- The final does NOT give you a **codon** chart. You must know: **AUG = start**, **UAA / UAG / UGA = stop**.
- **mitosis** phases in order: **P-M-A-T** (Prophase, Metaphase, Anaphase, Telophase). The final shows pictures — you name or order them.
- Food web arrows go from **eaten** → **eater**. Remove a species → trace the effect up and down the web.
- Everything else on the final is the same material you already studied for MCAS: cells, macromolecules, transport, DNA, inheritance, evolution, ecology.
- Blocks 12 and 13 drill the codon chart and mitosis phases in detail. Blocks 14–15 are practice finals.

The Big Rule for this block

The final tests what you can do without a reference — translate a codon from memory, order phases from a picture, trace a food web without help.

If you studied for MCAS, you've done most of the work. The final just asks you to do three specific things **from memory** instead of from a chart.

Key vocabulary in 8 languages

Words from this block. These span all three areas the final tests differently. Use the row in your home language to help your memory.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
codon	codón	códon	codon	codone	kodon	côđon / bộ ba mã hóa	كودون / رامزة *(kūdūn / rāmiza)*
transcription	transcripción	transcrição	transcription	trascrizione	transkripsyon	phiên mã	نسخ *(naskh)*
translation	traducción	tradução	traduction	traduzione	tradiksyon	dịch mã	ترجمة *(tarjama)*
mitosis	mitosis	mitose	mitose	mitosi	mitoz	nguyên phân	انقسام متساوٍ *(inqisām mutasāwin)*
meiosis	meiosis	meiose	méiose	meiosi	meyoz	giảm phân	انقسام منصف *(inqisām munaṣṣaf)*
producer	productor	produtor	producteur	produttore	pwodiktè	sinh vật sản xuất	كائن منتج *(kāʾin muntij)*
consumer	consumidor	consumidor	consommateur	consumatore	konsomatè	sinh vật tiêu thụ	كائن مستهلك *(kāʾin mustahlik)*
decomposer	descomponedor	decompositor	décomposeur	decompositore	dekonpozè	sinh vật phân hủy	كائن محلل *(kāʾin muḥallil)*

All 8 rows use verified translations from the Quick Reference vocabulary table.

The full picture

Final exam preview — what's different from MCAS

READING

What this reading is about

MCAS is done. Now we have the course final exam. The final covers the **same biology** as MCAS, but it tests some things **differently**. This reading walks you through the three biggest differences so you know exactly what to practice.

Difference 1: Codon chart from memory

On MCAS, you get a codon chart. On the final, **you do not.** That means you need to know the key codons without looking them up.

What you must memorize:

- **AUG** = methionine (Met) = **START**. Every protein begins with AUG.
- **UAA, UAG, UGA** = **STOP**. They do not code for any amino acid.
- The process: DNA → **transcription** → mRNA → **translation** → protein.
- **codon** math still applies: count the mRNA bases, divide by 3 = number of codons.

On the final, you may be given a short mRNA strand and asked to identify where **translation** starts (find the AUG) and where it stops (find UAA, UAG, or UGA). You will NOT have the full chart to look up every amino acid — but you will usually only need to recognize start and stop.

Difference 2: Mitosis phase identification from pictures

MCAS tests **mitosis** vs **meiosis** at a conceptual level — "which makes 2 identical cells?" The final goes deeper: you see a picture and must **name the phase**.

The four phases in order: **P-M-A-T**

1. **prophase** — chromosomes condense into visible X-shapes, scattered around the cell.
2. **metaphase** — chromosomes line up in the **M**iddle.
3. **anaphase** — chromosomes pull **A**part toward opposite ends.
4. **telophase** — **T**wo new nuclei form; the cell pinches in half.

Strategy: Find metaphase first — it's the easiest to spot (everything lined up neatly in the middle). Once you find metaphase, prophase is before it and anaphase is after it. Telophase is last.

Difference 3: Food web analysis without a reference

MCAS gives you a food web diagram and asks straightforward questions. The final may ask you to **predict what happens** when you remove or add an organism — and you need to trace the effect through the web.

Key rules for food web analysis:

- Arrows point from the **eaten** to the **eater** (from **producer** → **consumer**).
- If a **producer** disappears, **everything above it** in the food web is affected.
- If a predator disappears, its prey **increases** (nothing eating it).
- Energy **decreases** at each level (~90% lost as heat). Matter is recycled.
- **decomposer**s recycle nutrients back to the soil — they connect to **every** level.

What stays the same

Most of the final is the same material as MCAS. If you studied for MCAS, you have already done most of the work. The final still tests:

- Cell structure (prokaryote vs eukaryote, organelle functions)
- Macromolecules (carbon backbone, -ose = carb, -ase = enzyme)
- Transport (diffusion vs active transport vs osmosis)
- Photosynthesis and cellular respiration (opposites, chloroplast vs mitochondria)
- DNA structure and base pairing (A-T, C-G)
- Inheritance patterns (codominance, incomplete dominance, sex-linked)
- Evolution (four conditions for natural selection, best evidence = DNA)
- Ecology and populations (carrying capacity, feedback loops)

The difference is that the final tests a few things **without a reference** that MCAS gave you. Practice those three areas — codon starts/stops, PMAT phase pictures, and food web predictions — and you'll be ready.

Your study plan for the next 2 weeks

1. **Block 12** drills codon chart translation in detail.
2. **Block 13** drills mitosis phase identification from pictures.
3. **Blocks 14–15** are practice finals (closed-book, full format).
4. **Block 16** is targeted review of whatever you missed on the practice finals.

Use the study guide pages for Blocks 12 and 13 to review. Then take the practice finals without looking. Whatever you miss on those — that's what Block 16 is for.

Pictures to recognize on the final

The picture shows...	The answer is...
An mRNA strand with AUG near the beginning.	**AUG = start codon.** Translation begins here. Every protein starts with methionine.
An mRNA strand ending in UAA, UAG, or UGA.	**Stop codon.** Translation ends here. No amino acid is added.
Chromosomes visible as X-shapes, scattered around the cell.	**Prophase.** Chromosomes have condensed but are not yet organized.
Chromosomes lined up neatly across the middle of the cell.	**Metaphase.** "M" for middle.
Chromosomes pulling apart toward opposite ends of the cell.	**Anaphase.** "A" for apart.
Two clusters of chromosomes with new nuclear membranes forming; cell pinching.	**Telophase.** "T" for two nuclei. Cytokinesis follows.
Food web with one species removed — arrows affected.	Trace the arrows: prey of the removed species **increases**; predators **decrease**.
Energy pyramid with percentages.	Only **~10%** of energy passes to the next level. The rest is lost as **heat**.

Pattern rules

If the question says...	Pick...
"Where does translation start?"	At the **AUG** (start) codon.
"How many codons in this mRNA?"	**Number of bases ÷ 3.** (12 bases = 4 codons.)
"Order these four mitosis pictures."	Find metaphase first (middle lineup), then P before it, A after it, T last. **P-M-A-T.**
"Which process makes new skin cells / root tip cells?"	**Mitosis.** (Growth and repair = mitosis, always.)
"What is the direct product of meiosis?"	**Gametes** (egg or sperm). NEVER muscle, nerve, or skin cells.
"What happens if rabbits are removed from the food web?"	Plants rabbits ate **increase**. Foxes that ate rabbits **decrease**.
"Loss of all producers."	**Both** primary and secondary consumers decrease — no energy enters the web.
"Which is the BEST evidence for common ancestry?"	**Comparing DNA / amino acid sequences.** (Most precise evidence.)

Where to practice

Practice Block 11 questions and review items via the **2025 MCAS Biology test** on Pear Assessment. Practice block-11 specific items via the 2025 MCAS test.

What you need to know cold

- **central-dogma:** DNA → mRNA → protein. This is always the order.
- **transcription** copies DNA into **mrna** in the nucleus. The one change: **T becomes U**.
- **translation** reads mRNA at the **ribosome** to build a protein from | *An amino acid is a small molecule that is the **building block of a protein**. Proteins are long chains of amino acids linked together. There are about 20 different amino acids that living things use. Each codon on an mRNA strand codes for one amino acid.* s.
- A **codon** is **3 mRNA bases**. Each codon = 1 amino acid. Bases ÷ 3 = number of codons.
- **Start codon: AUG** = methionine. Translation begins here.
- **Stop codons: UAA, UAG, UGA** = no amino acid. Translation ends here.
- You will have a **codon chart** on the test. You do not memorize codons — you look them up.
- The final can give you a DNA strand and ask for the protein. That means: transcribe first (DNA → mRNA), then translate (mRNA → protein).

The Big Rule for this block

3 bases = 1 codon = 1 amino acid. Split from the left. Stop means stop.

Every translation problem comes down to the same three moves: split the mRNA into groups of 3 starting from the left, look each codon up on the chart, and stop when you hit UAA, UAG, or UGA.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory. Many of these words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
DNA	ADN	DNA / ADN	ADN	DNA	ADN	ADN / DNA	الدنا / DNA *(dī-en-ey / ad-dinā)*
RNA / mRNA	ARN	RNA / ARN	ARN	RNA	ARN	ARN / RNA	الرنا / RNA *(ar-RNA / ar-rinā)*
codon	codón	códon	codon	codone	kodon	côđon / bộ ba mã hóa	كودون / رامزة *(kūdūn / rāmiza)*
transcription	transcripción	transcrição	transcription	trascrizione	transkripsyon	phiên mã	نسخ *(naskh)*
translation	traducción	tradução	traduction	traduzione	tradiksyon	dịch mã	ترجمة *(tarjama)*
amino acid	aminoácido	aminoácido	acide aminé	amminoacido	asid amine	axit amin	حمض أميني *(ḥamḍ amīnī)*
ribosome	ribosoma	ribossomo	ribosome	ribosoma	ribozòm	ribosome / ribôxôm	ريبوسوم *(rībūsūm)*
protein	proteína	proteína	protéine	proteina	pwoteyin	protein / prô-tê-in	بروتين *(brūtīn)*

All 8 rows use the verified translations from the Quick Reference vocabulary table. Vietnamese and Arabic translations were verified by GPT-5 and Gemini. Romance-language translations (Spanish, Portuguese, French, Italian, Haitian Kreyòl) rely on cognate consistency. If a term feels unfamiliar to a native speaker, please tell Ms Brandolini.

The full picture

Codon chart drill — mastering translation for the final

READING

What this reading is about

You already learned **transcription** and **translation** in Block 2. This reading is a **drill review** for the final exam. The final tests codon chart use in detail — longer chains, DNA-to-protein pipelines, and start/stop codons. This page walks through the mechanics step by step so you can practice until they are automatic.

Quick review: the central dogma

The **central-dogma** is the order information flows in every cell:

DNA → mRNA → protein

- **Transcription** (DNA → **mrna**) happens in the **nucleus**.
- **Translation** (mRNA → protein) happens at the **ribosome**.

The final exam can ask you to start from a DNA strand and end at a protein. That means you need to do both steps in sequence.

Step 1 review: transcription (DNA → mRNA)

To transcribe **dna** into mRNA, pair each DNA base with its RNA complement. The one change from DNA pairing: **T becomes U**.

- DNA **A** → mRNA **U**
- DNA **T** → mRNA **A**
- DNA **C** → mRNA **G**
- DNA **G** → mRNA **C**

> **Worked example.** Transcribe the DNA template strand `T-A-C-G-C-T-A-A-T-G-G-A-A-C-T` into mRNA.
> 1. Go letter by letter: T→A, A→U, C→G, G→C, C→G, T→A, A→U, A→U, T→A, G→C, G→C, A→U, A→U, C→G, T→A.
> 2. mRNA result: **A-U-G-C-G-A-U-U-A-C-C-U-U-G-A**.

Step 2 review: translation (mRNA → protein)

The **ribosome** reads the mRNA **three bases at a time**. Each group of three is a **codon**. Each codon tells the ribosome which *An amino acid is a small molecule that is the **building block of a protein**. Proteins are long chains of amino acids linked together. There are about 20 different amino acids that living things use. Each codon on an mRNA strand codes for one amino acid.* to add to the growing protein chain.

How to read the codon chart

On the final exam, you will have a codon chart. Here is the strategy to use it efficiently:

1. **Split the mRNA into groups of 3** — start from the left and mark off every three bases. Example: `AUGCGAUUACCUUGA` becomes `AUG | CGA | UUA | CCU | UGA`.
2. **Find each codon on the chart.** Most charts are organized by the first base, then the second, then the third. Follow the chart's layout — first base picks the row, second base picks the column, third base narrows to the exact amino acid.
3. **Write down the amino acid.** Keep a running list as you go through each codon.
4. **Stop when you hit a stop codon.** UAA, UAG, and UGA code for "Stop" — no amino acid. The protein is done.

> **Common trap.** Students sometimes split from the wrong end or lose track of their groups of 3. Always start grouping from the **left** (the 5' end). If the total number of bases isn't divisible by 3, something is wrong — go back and recount.

Start and stop codons

Two special codons you must know for the final:

- **Start codon: AUG** — codes for methionine. This is where translation begins. Almost every protein starts with methionine.
- **Stop codons: UAA, UAG, UGA** — these do NOT code for any amino acid. When the ribosome reaches a stop codon, it releases the finished protein.

On the codon chart, look up AUG and you will see "Met" (methionine). Look up UAA, UAG, or UGA and you will see "Stop."

Codon math

The math rule is simple:

Number of bases ÷ 3 = number of codons

- 6 bases → 2 codons → up to 2 amino acids
- 12 bases → 4 codons → up to 4 amino acids
- 18 bases → 6 codons → up to 6 amino acids
- 30 bases → 10 codons → up to 10 amino acids

"Up to" because one of those codons might be a stop codon, which adds no amino acid.

Full pipeline worked example: DNA to protein

> **Worked example.** A DNA template strand reads: `T-A-C-C-G-A-A-A-T-A-C-T`. What is the amino acid sequence of the protein?
>
> 1. **Transcribe DNA → mRNA:** T→A, A→U, C→G, C→G, G→C, A→U, A→U, A→U, T→A, A→U, C→G, T→A. mRNA = `AUG-CGU-AUA-CGA`.
> 2. **Split into codons:** AUG | CGU | AUA | CGA (4 codons).
> 3. **Look up each codon:** AUG = Met (start), CGU = Arg, AUA = Ile, CGA = Arg.
> 4. **Amino acid chain:** Met — Arg — Ile — Arg (4 amino acids).
>
> No stop codon appeared in this sequence, so this is a partial gene. On the final, the question will tell you where to start and stop, or there will be a stop codon in the sequence.

> **Longer example.** mRNA sequence: `AUG-UUU-GCA-CCG-UAC-UGA`. Translate it.
>
> 1. AUG = Met (start).
> 2. UUU = Phe.
> 3. GCA = Ala.
> 4. CCG = Pro.
> 5. UAC = Tyr.
> 6. UGA = **Stop**. Translation ends here.
>
> Protein: **Met — Phe — Ala — Pro — Tyr** (5 amino acids). The stop codon does not add an amino acid.

Final exam traps to watch for

- **"How many amino acids?"** — Don't forget that a stop codon adds NO amino acid. If you have 6 codons and the last one is a stop, the protein has 5 amino acids, not 6.
- **"Transcribe this DNA"** — Remember that RNA uses **U**, not T. If your answer has a T in it, go back and fix it.
- **"Where does translation happen?"** — The ribosome. Not the nucleus, not the mitochondria.
- **"What does mRNA do?"** — It carries the genetic message from the DNA in the nucleus to the ribosome in the cytoplasm.

- **DNA has two strands** — The question will tell you which strand is the template. If it just gives you one strand, use that one.

Pictures to recognize on the test

The picture shows...	The answer is...
A DNA strand being copied into a strand with U instead of T.	**Transcription.** DNA → mRNA. The U replacing T is the giveaway.
An mRNA strand split into groups of 3 bases, with amino acids attached below each group.	**Translation.** Each group of 3 = one codon = one amino acid.
A circular or grid chart with 3-letter codes (AUG, UUU, GCA...) matched to amino acid names.	**Codon chart.** Use it to look up which amino acid each codon codes for.
A ribosome sliding along an mRNA strand, with tRNA molecules bringing amino acids.	**Translation in progress.** The ribosome is reading codons and building a protein.
A chain of amino acids linked together.	**A protein** (polypeptide chain). This is the final product of translation.
The full flow: DNA → mRNA → ribosome → protein.	**Central dogma / protein synthesis.** The complete pipeline from gene to protein.

Pattern rules

If the question says...	Pick...
"Transcribe this DNA strand."	Pair each base: A↔U, T↔A, C↔G, G↔C. **Remember: T becomes U in RNA.**
"How many codons in this mRNA?"	**Number of bases ÷ 3.** (12 bases = 4 codons, 18 bases = 6 codons.)
"Translate this mRNA sequence."	**Split into groups of 3, look each up on the codon chart.** Start from the left.
"What amino acid does AUG code for?"	**Methionine** (Met). AUG is the start codon.
"What happens when the ribosome reaches UAA, UAG, or UGA?"	**Translation stops.** No amino acid is added. The protein is released.
"Where does translation happen?"	**At the ribosome.** Not the nucleus, not the mitochondria.
"What does mRNA do?"	**Carries the genetic message** from DNA in the nucleus to the ribosome.
"Given a DNA strand, what protein is produced?"	**Two steps:** first transcribe (DNA → mRNA), then translate (mRNA → protein using the codon chart).

Where to practice

Practice Block 12 codon chart and translation problems via the 2025 MCAS Biology test on Pear Assessment. Focus on the protein synthesis questions. Try the practice *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

What you need to know cold

- **mitosis** makes **2 identical body cells** (growth and repair).
- The four stages always go in the same order: **prophase**, **metaphase**, **anaphase**, **telophase** — **P-M-A-T**.
- **Prophase:** chromosomes condense into thick X-shapes. Scattered, not lined up.
- **Metaphase:** chromosomes line up in the **Middle**.
- **Anaphase:** chromosomes pull **Apart** toward opposite ends.
- **Telophase:** two new nuclei form; the cell pinches in two.
- **meiosis** makes **4 unique** **gametes** (eggs or sperm) with half the **chromosome**s.
- **crossing-over** during meiosis increases genetic variation.

The Big Rule for this block

P-M-A-T. Find the Middle first — that's Metaphase. Everything else falls into place.

Metaphase is the easiest phase to spot (clear line of chromosomes across the center). Use it as your anchor, then work backward to prophase and forward to anaphase and telophase.

Key vocabulary in 8 languages

Words from this block. Use the row in your home language to help your memory. Many of these words are similar across languages because they come from Greek and Latin roots.

English	Español	Português	Français	Italiano	Kreyòl	Tiếng Việt	العربية
mitosis	mitosis	mitose	mitose	mitosi	mitoz	nguyên phân	انقسام متساوٍ *(inqisām mutasāwin)*
meiosis	meiosis	meiose	méiose	meiosi	meyoz	giảm phân	انقسام منصف *(inqisām munaṣṣaf)*
chromosome	cromosoma	cromossomo	chromosome	cromosoma	kwomozòm	nhiễm sắc thể	كروموسوم *(krūmūsūm)*
gamete	gameto	gameta	gamète	gamete	gamèt	giao tử	خلية جنسية *(khaliyya jinsiyya)*
diploid	diploide	diploide	diploïde	diploide	diplowid	lưỡng bội	ثنائي الصيغة الصبغية *(thunāʾī aṣ-ṣīgha aṣ-ṣibghiyya)*
haploid	haploide	haploide	haploïde	aploide	aplowid	đơn bội	أحادي الصيغة الصبغية *(uḥādī aṣ-ṣīgha aṣ-ṣibghiyya)*
prophase	profase	prófase	prophase	profase	pwofaz	kỳ đầu	الطور التمهيدي *(aṭ-ṭawr at-tamhīdī)*
metaphase	metafase	metáfase	métaphase	metafase	metafaz	kỳ giữa	الطور الاستوائي *(aṭ-ṭawr al-istiwāʾī)*
anaphase	anafase	anáfase	anaphase	anafase	anafaz	kỳ sau	الطور الانفصالي *(aṭ-ṭawr al-infiṣālī)*
telophase	telofase	telófase	télophase	telofase	telofaz	kỳ cuối	الطور النهائي *(aṭ-ṭawr an-nihāʾī)*

*The first 6 rows (mitosis through haploid) use the verified translations from the Quick Reference vocabulary table. The 4 phase-name rows (prophase through telophase) are **new for Block 13** and have NOT yet been independently verified by GPT-5 / Gemini per Ms Brandolini's verification cycle — they rely on cognate consistency (Romance languages) and standard scientific-vocabulary equivalents (Vietnamese, Arabic, Haitian Kreyòl). If a term feels unfamiliar to a native speaker, please tell Ms Brandolini.*

The full picture

Mitosis phases — how to identify each stage from a picture

READING

What this reading is about

Block 4 introduced **mitosis** vs **meiosis** at a conceptual level. This block goes deeper into **what each mitosis phase looks like** so you can identify them from pictures on the final exam. You'll also review the mitosis-vs-meiosis comparison since the final tests both.

The four phases: P-M-A-T

mitosis always follows the same four stages, in the same order. The final exam will show you pictures and ask you to name or order them.

1. **prophase** — Chromosomes condense and become visible.
2. **metaphase** — Chromosomes line up in the middle.
3. **anaphase** — Chromosomes pull apart.
4. **telophase** — Two new nuclei form; the cell splits.

How to recognize each phase in a picture

When the final exam gives you a microscope image or diagram, use these visual clues:

Prophase — "getting ready"

- **chromosome**s look like **thick X-shapes** (they've condensed).
- The chromosomes are **scattered** — NOT lined up in any pattern.
- The nuclear membrane is starting to break down (may look fuzzy or absent).
- You might see spindle fibers starting to form.

Key clue: X-shaped chromosomes that are visible but disorganized = prophase.

Metaphase — "in the Middle"

- Chromosomes are lined up **along the center** of the cell (the "metaphase plate").
- They form a clear line or band across the middle.
- Spindle fibers are attached and pulling from both sides.

Memory trick: Metaphase = **M**iddle. If you see a neat line of chromosomes across the center, that's metaphase.

Anaphase — "pulling Apart"

- Chromosomes are being **pulled toward opposite ends** of the cell.
- You can see two groups moving away from the center.
- Individual chromosomes look like V-shapes (being dragged by spindle fibers).

Memory trick: Anaphase = **A**part. If chromosomes are separating into two groups heading in opposite directions, that's anaphase.

Telophase — "almost done"

- Two groups of chromosomes are at **opposite ends** of the cell.
- New nuclear membranes are forming around each group.
- The cell is **pinching in the middle** (cytokinesis beginning).
- Chromosomes may start to de-condense (look less distinct).

Key clue: Two separate nuclei forming + cell pinching = telophase.

The ordering strategy

If the final exam shows you four pictures and asks you to put them in order:

1. **Find metaphase first** — it's the easiest to spot (chromosomes lined up in the middle).
2. The picture **before** metaphase is prophase (scattered X-shapes).
3. The picture **after** metaphase is anaphase (pulling apart).
4. The last picture is telophase (two groups, cell pinching).

> **Exam tip:** Start with the most recognizable phase. Most students find metaphase easiest because of the clear line in the middle. Use it as your anchor and order everything else around it.

Review: mitosis vs meiosis

The final exam also tests whether you can tell **mitosis** apart from **meiosis**. Here is the comparison:

	Mitosis	**Meiosis**
Result	2 identical cells	4 unique cells
Chromosome number	**diploid** (2n) — same as parent	**haploid** (n) — half of parent
Purpose	Growth and repair	Make **gamete**s (eggs and sperm)
Genetic variation?	No — daughter cells are identical	Yes — **crossing-over** creates new combinations

Common final exam traps

- **"What is the direct product of meiosis?"** — The answer is ALWAYS gametes (eggs or sperm). Never muscle cells, skin cells, or nerve cells.
- **"Which process makes new skin cells?"** — Mitosis. Skin cells are body cells, not gametes.
- **Don't confuse the cell PINCHING (cytokinesis) with a mitosis phase.** Cytokinesis is the physical split; telophase is the nuclear division. They overlap but are not the same thing.
- **"Why are the daughter cells of mitosis identical?"** — Because each daughter cell receives an exact copy of all the parent's **chromosome**s.

The diploid/haploid math (quick review)

Body cells are **diploid** (2n). Gametes are **haploid** (n).

- If a body cell has 46 chromosomes, gametes have **23**.
- If a body cell has 28 chromosomes, gametes have **14**.
- Fertilization: n + n = 2n (half from each parent restores the full set).

The final exam likes to give you a body-cell chromosome number and ask for the gamete number. Always divide by 2.

Pictures to recognize on the test

The picture shows...	The answer is...
Chromosomes condensed into thick X-shapes, scattered throughout the cell. Nuclear membrane breaking down.	**Prophase.** First stage of mitosis.
Chromosomes lined up in a neat row across the middle of the cell.	**Metaphase.** M = Middle.
Chromosomes pulling apart toward opposite ends. V-shaped chromosomes being dragged by spindle fibers.	**Anaphase.** A = Apart.
Two groups of chromosomes at opposite ends. Cell pinching in the middle. New nuclear membranes forming.	**Telophase.** Two new nuclei are forming.
Two chromosomes swapping pieces during cell division.	**Crossing over** (happens during meiosis). Increases genetic variation.
One cell becoming two identical cells, each with the same number of chromosomes as the parent.	**Mitosis.** Growth and repair.
One cell becoming four cells, each with half the chromosomes of the parent.	**Meiosis.** Making gametes (eggs and sperm).

Pattern rules

If the question says...	Pick...
"Order the stages of mitosis" (4 pictures).	Find **P-M-A-T** order. Start by finding metaphase (middle line).
"Which process makes new skin cells / root cells / growth?"	**Mitosis.** Body cells = mitosis.
"Which process makes eggs or sperm?"	**Meiosis.** Gametes = meiosis.
"Mitosis daughter cells are..."	**Identical to the parent cell** (same chromosome number).
"Body cell has 28 chromosomes — gamete has?"	**14.** Gametes are haploid = half the diploid number.
"What does crossing over do?"	**Increases genetic variability.** Homologous chromosomes exchange genetic material.
"What is the direct product of meiosis?"	**Gametes** (eggs or sperm). NEVER muscle, skin, or nerve cells.
"Why are mitochondrial folds important?" (appears on mixed review)	**More surface area = more ATP production.**

Where to practice

Practice Block 13 mitosis phase identification and cell division review via the 2025 MCAS Biology test on Pear Assessment. Focus on the cell division and mitosis questions. Try the practice *without* looking at this page first. If you get stuck, come back, look up the pattern, then try again.

How to use this page

Each row is one science word. Type in the **search box** to jump to any word fast — in English *or* your language. On a phone, slide the table sideways to see more languages; the English word stays on the left.

This page has the core **Section 1** words from your Quick Reference. We are still adding more terms (like genetics words). If you can't find a word, ask Ms Brandolini — your question helps every other student too.

Search for a word

Type a word, e.g. mitosis / mitosis / mitoz...

56 words

ENGLISH	DEFINITION	ESPAÑOL	PORTUGUÊS	FRANÇAIS	ITALIANO	KREYÒL	TIẾNG VIỆT	العربية
abiotic	NON-living (factor in an ecosystem).	abiótico	abiótico	abiotique	abiotico	abyotik	nhân tố vô sinh	عامل لا حيوي *ʿāmil lā ḥayawī*
active transport	Moves LOW to HIGH. Needs ATP.	transporte activo	transporte ativo	transport actif	trasporto attivo	transpò aktif	vận chuyển chủ động	نقل نشط *naql nashiṭ*
adaptation	A trait that helps survival.	adaptación	adaptação	adaptation	adattamento	adaptasyon	đặc điểm thích nghi	صفة تكيفية *ṣifa takayyufiyya*
allele	A version of a gene.	alelo	alelo	allèle	allele	alèl	alen	أليل *alīl*
amino acid	Building block of a protein.	aminoácido	aminoácido	acide aminé	amminoacido	asid amine	axit amin	حمض أميني *ḥamḍ amīnī*
ATP	The energy molecule.	ATP	ATP	ATP	ATP	ATP	ATP	ATP *ATP*
biotic	LIVING (factor in an ecosystem).	biótico	biótico	biotique	biotico	byotik	nhân tố hữu sinh	عامل حيوي *ʿāmil ḥayawī*
carbohydrate	Sugar or starch.	carbohidrato	carboidrato	glucide / hydrate de carbone	carboidrato	kabidrat	cacbohiđrat / gluxit	كربوهيدرات *karbūhīdrāt*
carbon	The "backbone" element in all living things.	carbono	carbono	carbone	carbonio	kabòn	carbon / cacbon	كربون *karbūn*
carrying capacity	The maximum population size.	capacidad de carga	capacidade de suporte	capacité de charge	capacità portante	kapasite chaj	sức chứa môi trường	القدرة الاستيعابية *al-qudra al-istīʿābiyya*
chloroplast	In plants. Does photosynthesis.	cloroplasto	cloroplasto	chloroplaste	cloroplasto	kloroplas	lục lạp	بلاستيدة خضراء *blāstīda khaḍrāʾ*
chromosome	A package of DNA.	cromosoma	cromossomo	chromosome	cromosoma	kwomozòm	nhiễm sắc thể	كروموسوم / صبغي *krūmūsūm / ṣibghī*
codon	3 mRNA bases = 1 amino acid.	codón	códon	codon	codone	kodon	côđon / bộ ba mã hóa	كودون / رامزة *kūdūn / rāmiza*
commensalism	One helped, the other neutral (+/0).	comensalismo	comensalismo	commensalisme	commensalismo	komensalis	hội sinh	تعايش *taʿāyush*
consumer	Eats other things.	consumidor	consumidor	consommateur	consumatore	konsomatè	sinh vật tiêu thụ	كائن مستهلك *kāʾin mustahlik*
convergent evolution	Unrelated species look alike.	evolución convergente	evolução convergente	évolution convergente	evoluzione convergente	evolisyon konvèjant	tiến hóa hội tụ	التطور التقاربي *at-taṭawwur at-taqārubī*
decomposer	Breaks down dead things.	descomponedor	decompositor	décomposeur	decompositore	dekonpozè	sinh vật phân hủy	كائن محلل *kāʾin muḥallil*
diffusion	Molecules move HIGH to LOW.	difusión	difusão	diffusion	diffusione	difizyon	khuếch tán	انتشار *intishār*
diploid	Full set of chromosomes (2n).	diploide	diploide	diploïde	diploide	diplowid	lưỡng bội	ثنائي الصيغة الصبغية *thunāʾī aṣ-ṣīgha aṣ-ṣibghiyya*
DNA	The genetic code.	ADN	DNA / ADN	ADN	DNA	ADN	ADN / DNA	الدنا / DNA *dī-en-ey / ad-dinā*
ecosystem	Living + non-living things in a place.	ecosistema	ecossistema	écosystème	ecosistema	ekosistèm	hệ sinh thái	نظام بيئي *niẓām bīʾī*
enzyme	A protein that speeds up reactions.	enzima	enzima	enzyme	enzima	anzim	enzym / enzim	إنزيم *inzīm*
eukaryote	Cell WITH a nucleus.	eucariota	eucarionte	eucaryote	eucariote	ekaryòt	sinh vật nhân thực	حقيقي النواة *ḥaqīqī an-nawāh*
evolution	How species change over time.	evolución	evolução	évolution	evoluzione	evolisyon	tiến hóa	تطور *taṭawwur*
feedback loop	A system that controls itself.	retroalimentación	retroalimentação / feedback	rétroaction / boucle de rétroaction	retroazione / feedback	fidbak	cơ chế điều hòa ngược	حلقة تغذية راجعة *ḥalqat taghdhiya rājiʿa*
gamete	Egg or sperm.	gameto	gameta	gamète	gamete	gamèt	giao tử	خلية جنسية / مشيج *khaliyya jinsiyya / mashīj*
gene	One section of DNA.	gen	gene	gène	gene	jèn	gen / gien	جين / مورثة *jīn / muwarritha*
glucose	A simple sugar.	glucosa	glicose	glucose	glucosio	glikoz	glucose / glucôzơ	جلوكوز / غلوكوز *jlūkūz / ghulūkūz*
haploid	Half set of chromosomes (n).	haploide	haploide	haploïde	aploide	aplowid	đơn bội	أحادي الصيغة الصبغية *uḥādī aṣ-ṣīgha aṣ-ṣibghiyya*
homeostasis	Body stays stable.	homeostasis	homeostase	homéostasie	omeostasi	omeyostazi	cân bằng nội môi	اتزان داخلي / توازن داخلي *ittizān dākhilī / tawāzun dākhilī*
homologous	Same origin (e.g., human arm and bat wing).	homólogo	homólogo	homologue	omologo	omològ	cơ quan tương đồng	أعضاء متماثلة *aʿḍāʾ mutamāthila*
lipid	Fat or oil.	lípido	lipídio	lipide	lipide	lipid	lipid	ليبيدات / دهون *lībīdāt / duhūn*
meiosis	Makes 4 sex cells (gametes).	meiosis	meiose	méiose	meiosi	meyoz	giảm phân	انقسام منصف / انقسام اختزالي *inqisām munaṣṣaf / inqisām ikhtizālī*
membrane	The wall around the cell.	membrana	membrana	membrane	membrana	manbràn	màng tế bào	الغشاء الخلوي *al-ghishāʾ al-khalawī*
mitochondria	Makes ATP (energy).	mitocondria	mitocôndria	mitochondrie	mitocondrio	mitokondri	ty thể	ميتوكندريا *mītūkundriyā*
mitosis	Makes 2 identical body cells.	mitosis	mitose	mitose	mitosi	mitoz	nguyên phân	انقسام متساوٍ *inqisām mutasāwin*

ENGLISH	DEFINITION	ESPAÑOL	PORTUGUÊS	FRANÇAIS	ITALIANO	KREYÒL	TIẾNG VIỆT	العربية
mutation	A change in the DNA.	mutación	mutação	mutation	mutazione	mitasyon	đột biến	طفرة *ṭafra*
mutualism	Both helped (+/+).	mutualismo	mutualismo	mutualisme	mutualismo	mityalis	hỗ sinh / cộng sinh	تبادل المنفعة / التقايض *tabādul al-manfaʿa / at-taqāyuḍ*
natural selection	The fittest survive and reproduce.	selección natural	seleção natural	sélection naturelle	selezione naturale	seleksyon natirèl	chọn lọc tự nhiên	انتقاء طبيعي / اصطفاء طبيعي *intiqāʾ ṭabīʿī / iṣṭifāʾ ṭabīʿī*
nucleic acid	DNA or RNA.	ácido nucleico	ácido nucleico	acide nucléique	acido nucleico	asid nikleyik	axit nucleic / axit nuclêic	حمض نووي *ḥamḍ nawawī*
nucleus	The control center. Holds the DNA.	núcleo	núcleo	noyau	nucleo	nwayo	nhân (tế bào)	نواة *nawāh*
organelle	A part inside the cell.	organelo	organela	organite	organello	òganèl	bào quan	عضية *ʿuḍayya*
osmosis	Diffusion of water.	ósmosis	osmose	osmose	osmosi	osmoz	thẩm thấu	تناضح / الخاصية الأسموزية *tanāḍuḥ / al-khāṣiyya al-usmūziyya*
oxygen	O_2. We breathe it in. Plants make it.	oxígeno	oxigênio	oxygène	ossigeno	oksijèn	ôxi / oxi	أكسجين *uksijīn*
parasitism	One helped, one hurt (+/−).	parasitismo	parasitismo	parasitisme	parassitismo	parazitis	ký sinh	تطفل *taṭafful*
photosynthesis	Plants make food from light.	fotosíntesis	fotossíntese	photosynthèse	fotosintesi	fotosentèz	quang hợp	البناء الضوئي / التمثيل الضوئي *al-bināʾ al-ḍawʾī / at-tamthīl al-ḍawʾī*
population	Same species, same place.	población	população	population	popolazione	popilasyon	quần thể	جماعة حيوية *jamāʿa ḥayawiyya*
producer	Plant. Makes its own food.	productor	produtor	producteur	produttore	pwodiktè	sinh vật sản xuất	كائن منتج *kāʾin muntij*
prokaryote	Cell with NO nucleus (bacteria).	procariota	procarionte	procaryote	procariote	pwokaryòt	sinh vật nhân sơ	بدائي النواة *badāʾī an-nawāh*
protein	Big molecule. Many jobs.	proteína	proteína	protéine	proteina	pwoteyin	protein / prô-tê-in	بروتين *brūtīn*
respiration	Cells make ATP from glucose. (Cellular respiration)	respiración celular	respiração celular	respiration cellulaire	respirazione cellulare	respirasyon selilè	hô hấp tế bào	تنفس خلوي *tanaffus khalawī*
ribosome	Makes proteins. In ALL cells.	ribosoma	ribossomo	ribosome	ribosoma	ribozòm	ribosome / ribôxôm	ريبوسوم *rībūsūm*
RNA / mRNA	Carries the message from DNA.	ARN	RNA / ARN	ARN	RNA	ARN	ARN / RNA	الرنا / RNA *ar-RNA / ar-rinā*
speciation	New species form.	especiación	especiação	spéciation	speciazione	espesyasyon	sự hình thành loài	انتواع / تكون الأنواع *intiwāʿ / takawwun al-anwāʿ*
transcription	DNA → mRNA.	transcripción	transcrição	transcription	trascrizione	transkripsyon	phiên mã	نسخ *naskh*
translation	mRNA → protein.	traducción	tradução	traduction	traduzione	tradiksyon	dịch mã	ترجمة *tarjama*

About this page

This is the web version of the vocabulary list (Section 1) in your paper Quick Reference. Many science words look similar across languages because they come from Greek and Latin roots — use that to help your memory.
Practice questions live in **Pear Assessment**, through Canvas. This page is for *looking up* a word you forgot.