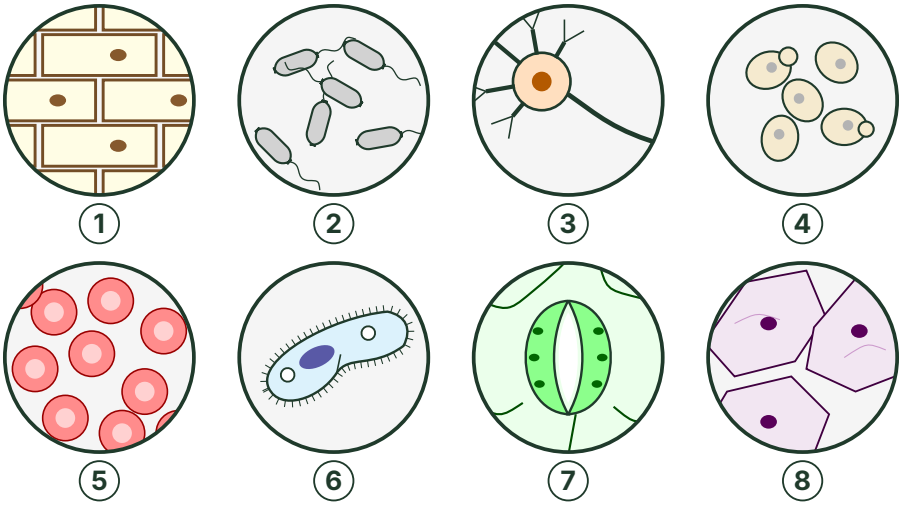
Qualification Round

Problem A: Cells under the Microscope (5 Points)

A microscope reveals a hidden world in a drop of pond water, a slice of onion or a scraping from the inside of your cheek. The drawings show eight fields of view, not drawn to the same scale.

Task: Match each field of view 1 to 8 with the correct name from the list. Each name is used once.

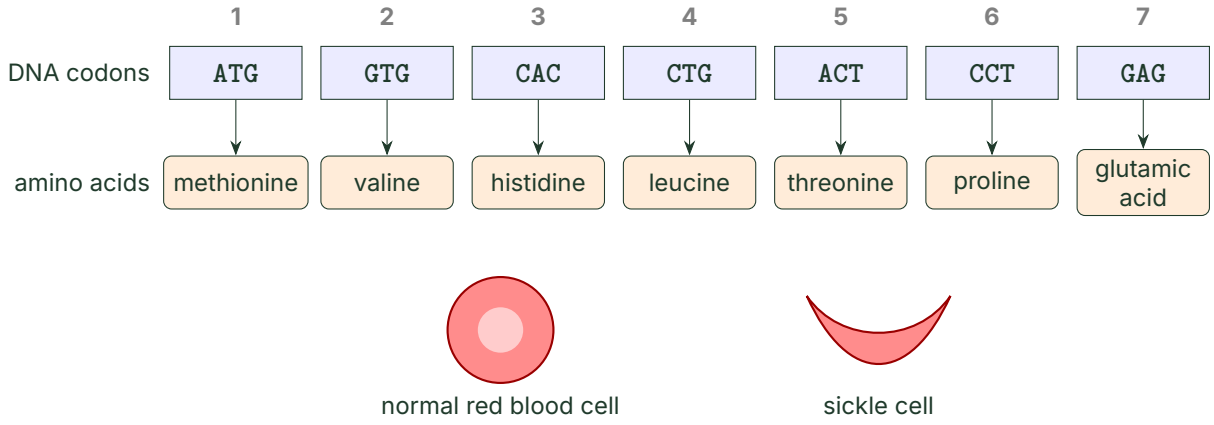
Names: bacteria, cheek cells, guard cells of a leaf, nerve cell, onion skin cells, *Paramecium*, red blood cells, yeast cells.



Problem B: A Single Letter (5 Points)

Your DNA is a cookbook. Each gene is the recipe for one protein, written with just four letters: A, T, G and C. To make the protein, the cell reads the recipe three letters at a time. Each three-letter word, a *codon*, stands for one amino acid, a building block of proteins: for example, ATG stands for methionine. The cell links the amino acids in the order of the codons, and the chain folds into the finished protein.

The figure shows the first seven codons of the recipe for haemoglobin, the protein that carries oxygen in your red blood cells.



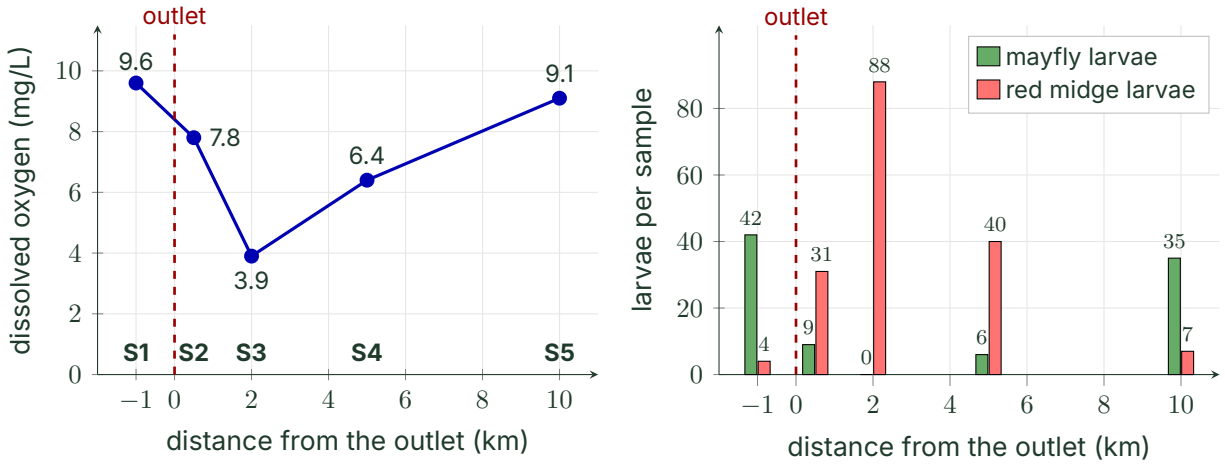
(a) Proteins are built from 20 different amino acids. Why are codons three letters long and not two?

(b) Sara has sickle cell disease. In her DNA, codon 7 reads GTG instead of GAG. What has changed in her haemoglobin? David also has a changed codon 7, GAA, but his haemoglobin is completely normal. How is that possible?

(c) In Leo, the C at the start of codon 3 is missing. Explain why his haemoglobin is far more damaged than Sara's.

Problem C: Life below the Outlet (5 Points)

Below a small town, wastewater full of food scraps and other organic matter flows into a river. A school group visits five sites, S1 to S5, from 1 km above the outlet to 10 km below it, all on the same morning. At each site they measure the dissolved oxygen and count two kinds of larvae in a one-minute sample from the river bed: mayfly larvae and red midge larvae, whose blood contains haemoglobin. The figure shows their results.



(a) Describe how the oxygen changes along the river. By what percentage is it lower at S3 than at S1?

(b) Explain why the oxygen falls below the outlet, why it is lowest at S3 rather than at the outlet, and why it recovers further on.

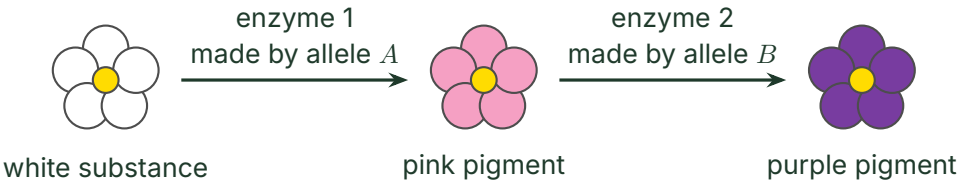
(c) Explain the numbers of the two kinds of larvae. Why can river animals reveal pollution that a single oxygen measurement might miss?

Problem D: Purple, Pink or White? (5 Points)

In a garden flower, the colour is made in two steps, each by its own enzyme (figure). The two enzymes are made by two genes on different chromosomes:

- Allele A makes enzyme 1, which turns a white substance into a pink pigment. Plants with aa have no enzyme 1.
- Allele B makes enzyme 2, which turns the pink pigment into a purple one. Plants with bb have no enzyme 2.

A is dominant over a, and B is dominant over b.



(a) Give the flower colour of plants with the genotypes $AaBb$, $AAbb$, $aaBB$ and $aabb$.

(b) Two plants with the genotype $AaBb$ are crossed. In what ratio do you expect purple, pink and white offspring?

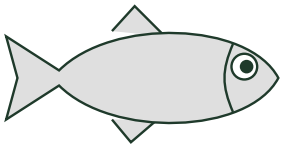
(c) A white plant crossed with a pink plant gives purple, pink and white offspring in the ratio $1:1:2$. Find the genotypes of both parents. If you sow 6 seeds from this cross, what is the probability that at least one of them grows into a purple flower?

Problem E: Fish without Eyes (5 Points)

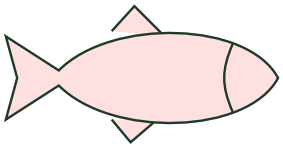
The Mexican tetra is a small fish that lives in rivers in Mexico. Some populations of the same species live in completely dark caves. These cave fish are blind: their embryos start to grow eyes, but the eyes stop growing and become covered with skin.

When blind fish from two different caves are crossed, some of their young can see.

Task: Explain both observations.



river fish: eyes, silvery skin



cave fish: no visible eyes, pale pink