Sharper Bands, Faster Runs

Refine a gel electrophoresis method using test results

GEN.3.3 "Enrichment: Use an engineering design process to refine methodology and optimize the process of genetic transformation, protein purification, and/or gel electrophoresis.*"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the team's success criteria, circle the variable they change, and number the three measurements they use to judge each trial.

A Gel That Gives a Clear Answer

1. A student research team needs to distinguish two DNA fragments whose lengths are nearly equal. On a gel, the fragments form bands that can blur together. The team wants a method that produces two sharp bands at least 5 millimeters apart in 35 minutes or less. Their design problem has two goals: clear separation and a short run.

2. The team tests four voltages, changing only the voltage from trial to trial. They use the same DNA sample, gel concentration, buffer, and equipment each time. To make run times comparable, they stop each trial when the tracking dye reaches the same mark. They record time, distance between band centers, and whether the bands stay sharp.

GEL ELECTROPHORESIS TRIALS

Voltage (V)	Time (min)	Band spacing (mm)	Bands
70	45	3	Sharp
100	30	5	Sharp
130	23	4	Smeared
150	18	2	Smeared

3. A voltage increase can move DNA through a gel faster, but faster movement does not guarantee clearer bands. Heat during a run can make bands less distinct. The team treats any smeared result as unacceptable, even if it meets the time limit. They will select a setting from the evidence, then repeat it to check that its results are reliable.

2 ANSWER WITH EVIDENCE

Use the passage

1. Which variable did the team change, and what two conditions did they keep constant to make the trials comparable?

2. Which tested voltage meets all the team's success criteria? Use the table to justify your choice.

3. The 130 V trial finished faster than the 100 V trial. Why is it not a better choice for this design problem?

4. Choose an untested voltage between 100 V and 130 V for a follow-up trial. What would you keep constant and measure to decide whether it meets the team's goal?

3 YOUR TURN

Your own words

A second team wants to improve separation of a different pair of DNA fragments by changing gel concentration instead of voltage. Design a three-trial comparison: give the concentrations, what you would keep constant and measure, and your own measurable rule for choosing a setting.

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PART 1 · READ AND MARK

Underline the team's success criteria, circle the variable they change, and number the three measurements they use to judge each trial. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Which variable did the team change, and what two conditions did they keep constant to make the trials comparable?	**They changed voltage. They kept conditions such as the DNA sample and gel concentration constant.**
2	Which tested voltage meets all the team's success criteria? Use the table to justify your choice.	**100 V: it produced sharp bands 5 mm apart in 30 minutes.**
3	The 130 V trial finished faster than the 100 V trial. Why is it not a better choice for this design problem?	**At 130 V, the bands were smeared and only 4 mm apart, so the trial failed the clarity and spacing criteria despite finishing in 23 minutes.**
4	Choose an untested voltage between 100 V and 130 V for a follow-up trial. What would you keep constant and measure to decide whether it meets the team's goal?	**Test 110 V while keeping the DNA sample, gel, buffer, equipment, and stopping mark constant. Measure time, band spacing, and sharpness. It succeeds only with sharp bands at least 5 mm apart in 35 minutes or less.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would test gels with concentrations of 1%, 1.5%, and 2%. I would keep the DNA sample, voltage, buffer, equipment, and stopping mark the same. For each trial, I would record the run time, spacing between the two bands, and whether the bands are sharp. I would choose a concentration that produces sharp bands at least 6 mm apart within 40 minutes, then repeat that trial to check the result.

For question 4, accept any voltage strictly between 100 V and 130 V if the proposed test controls relevant conditions and checks all three criteria. For Your Turn, accept other reasonable concentrations and measurable targets if only gel concentration changes across trials.