Repair Signals

How DNA, RNA, and proteins guide muscle cell development

BIO.2.b "Obtain and evaluate information to explore additional functions and regulatory roles of RNA, DNA, and protein, including their roles in gene expression and cellular differentiation."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Read the passage. Underline two ways a cell controls gene activity, circle the molecule involved in each, and number the evidence that supports a regulatory role.

How Muscle Cells Take Shape

1. After a muscle strain, nearby satellite cells wake from a resting state. These stem cells can make new muscle cells, while some remain stem cells for future repairs. The two groups carry essentially the same DNA, so a change in DNA sequence is not needed to explain their different roles. Instead, they use different genes. When a gene is active, a cell copies its DNA instructions into messenger RNA, or mRNA. Ribosomes use mRNA to build proteins. Some proteins become parts of a muscle fiber; other proteins control which genes are active next.

2. One control protein, MYOD, binds regulatory stretches of DNA near muscle-related genes and helps turn them on in developing muscle cells. These cells also make miR-1, a short RNA that does not code for a protein. miR-1 can bind the mRNA that carries instructions for HDAC4, reducing how much HDAC4 protein is made. HDAC4 can suppress muscle-related gene activity, so less HDAC4 removes a brake on muscle development. DNA provides both protein-coding genes and regulatory sequences, while proteins and noncoding RNA help determine which instructions a cell uses.

3. How could scientists test whether miR-1 does more than appear during muscle repair? In cultured muscle precursor cells, raising miR-1 levels lowers HDAC4 protein and increases signs of muscle differentiation. Reducing miR-1 has the opposite effects. These changes support a regulatory role for miR-1 because changing the RNA changes both a protein level and cell behavior. Still, a culture dish does not reproduce every signal in injured tissue. Scientists would need further tests in living muscle before claiming that miR-1 alone determines how many cells become muscle cells during repair.

2 ANSWER WITH EVIDENCE

Use the passage

1. Some satellite cells remain stem cells while others make muscle cells. How does the passage explain these different outcomes without a change in DNA sequence?

2. How do a DNA regulatory stretch and MYOD work together to affect gene expression?

3. Trace how miR-1 can affect muscle development, beginning with its effect on mRNA.

4. Why do the culture experiments support a regulatory role for miR-1, and what can they not establish on their own?

3 YOUR TURN

Your own words

Design a new test in cultured muscle precursor cells that changes MYOD levels instead of miR-1 levels. In four or five sentences, describe a comparison group, predict a change in gene expression and cell development, and identify one limit of your test.

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PART 1 · READ AND MARK

Read the passage. Underline two ways a cell controls gene activity, circle the molecule involved in each, and number the evidence that supports a regulatory role. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Some satellite cells remain stem cells while others make muscle cells. How does the passage explain these different outcomes without a change in DNA sequence?	**The cells carry essentially the same DNA but use different genes.**
2	How do a DNA regulatory stretch and MYOD work together to affect gene expression?	**MYOD binds regulatory DNA near muscle-related genes and helps turn those genes on.**
3	Trace how miR-1 can affect muscle development, beginning with its effect on mRNA.	**miR-1 binds HDAC4 mRNA, reducing HDAC4 protein. Because HDAC4 can suppress muscle-related genes, less of it removes a brake on muscle development.**
4	Why do the culture experiments support a regulatory role for miR-1, and what can they not establish on their own?	**Changing miR-1 changes HDAC4 protein levels and signs of differentiation. Culture experiments alone cannot establish that miR-1 has the same effects in injured muscle or determines cell fate by itself.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would raise MYOD levels in one group of muscle precursor cells. A comparison group would grow under the same conditions without added MYOD. I predict that the first group would make more mRNA from muscle-related genes. I would also predict that more cells in that group would show signs of muscle differentiation. Because the test uses cultured cells, it would not show whether MYOD has the same effect in an injured muscle.

Accept predictions that connect a change in MYOD to muscle-related gene expression and differentiation, with a comparison group that differs in MYOD level. The proposed outcome is a prediction, not a result established by the passage.