Two Kinds of Chains

Trace the atoms and steps behind proteins and rubber

HS-LS1-6 "Construct explanations and revise, as needed, based on evidence for: 1) how carbon, hydrogen, and oxygen may combine with other elements to form amino acids and/or other large carbon-based molecules..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the sentence that explains where amino-acid nitrogen comes from, circle the sentence describing how the tree joins rubber units, and box the sentence describing how the factory joins free isoprene. Use your marks to compare the evidence for each chain.

From Tree to Chain

1. At a rubber tree nursery, a student compares a seed's proteins with the stretchy material in the tree's latex. The tree takes in carbon dioxide and water, then uses sunlight to make sugars. Those sugars supply carbon, hydrogen, and oxygen for many larger molecules. Roots also absorb nitrate from soil, supplying nitrogen. Enzymes use nitrogen from nitrate to build amino acids from carbon-based starting materials. Each amino acid contains carbon, hydrogen, oxygen, and nitrogen; some also contain sulfur. When amino acids join by peptide bonds, they form a chain that can fold into a protein.

2. The same tree makes natural rubber, but its repeating rubber units do not require nitrogen. Sugars provide carbon for a series of enzyme-driven reactions that produce activated, five-carbon, isoprene-derived building blocks. In a rubber tree, an enzyme adds those activated units to a growing chain while phosphate-containing groups leave. The resulting polyisoprene chain has repeating units made of carbon and hydrogen. These units are not free isoprene molecules plucked from the latex and snapped together. Oxygen may be present in the starting materials and activated units without remaining in the repeating units of the finished rubber chain.

3. A chemist can make a similar long carbon-based chain by a different route. In a factory, free isoprene molecules, each with the formula C_5H_8, can be joined by chemical reactions to make synthetic polyisoprene. Another hydrocarbon, ethene, can also be joined into long chains called polyethylene. Both reactions connect small molecules into larger ones, but their starting molecules and processes differ from the tree's rubber-making route. A label that says 'natural rubber is made by joining free isoprene from latex' misses a crucial step: the tree builds and joins activated units instead.

2 ANSWER WITH EVIDENCE

Use the passage

1. Explain how the tree uses carbon dioxide, water, and nitrate to make a protein chain.

2. A classmate says natural rubber must contain nitrogen because the tree absorbs nitrate. Revise the claim using two details from the passage.

3. Why is it inaccurate to say that free isoprene molecules in latex join to make natural rubber? Explain the tree's route.

4. Explain how two different factory-made chains can form from hydrocarbons. Name each starting molecule and the chain it forms.

3 YOUR TURN

Your own words

A rubber tree gets sunlight, water, and carbon dioxide, but little nitrate. Predict how this shortage might affect its protein production and its rubber production differently. Explain your reasoning with atom sources, and name one reason your rubber prediction is uncertain.

ANSWER KEY

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HIGH SCHOOL · HS-LS1-6

PART 1 · READ AND MARK

Underline the sentence that explains where amino-acid nitrogen comes from, circle the sentence describing how the tree joins rubber units, and box the sentence describing how the factory joins free isoprene. Use your marks to compare the evidence for each chain. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Explain how the tree uses carbon dioxide, water, and nitrate to make a protein chain.	**Carbon dioxide and water help the tree make sugars containing carbon, hydrogen, and oxygen. Nitrogen from nitrate is added to carbon-based materials to make amino acids, which join by peptide bonds to form a protein chain.**
2	A classmate says natural rubber must contain nitrogen because the tree absorbs nitrate. Revise the claim using two details from the passage.	**Absorbing nitrate does not mean every product contains nitrogen. The tree uses nitrate's nitrogen to make amino acids, while natural rubber's repeating units contain carbon and hydrogen.**
3	Why is it inaccurate to say that free isoprene molecules in latex join to make natural rubber? Explain the tree's route.	**The tree makes activated, five-carbon, isoprene-derived units from sugar-derived materials. An enzyme adds those units to the growing rubber chain as phosphate-containing groups leave.**
4	Explain how two different factory-made chains can form from hydrocarbons. Name each starting molecule and the chain it forms.	**Chemical reactions can join free isoprene molecules into synthetic polyisoprene. They can also join ethene molecules into polyethylene.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The tree may make less protein because it needs nitrogen from nitrate to build amino acids. It may still make rubber because rubber's repeating units contain carbon and hydrogen, not nitrogen, and sugars can supply carbon. However, nitrate shortage could reduce the tree's ability to make the enzymes needed for rubber production, so its rubber output might also fall.

Accept predictions that distinguish rubber's lack of nitrogen in its repeating units from the tree's possible need for nitrogen to make enzymes. Students should not claim that rubber production will definitely stay the same.