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Concepts of Biotechnology 8

DESIGNER TREES: A WAY TO COUNTERACT THE GREENHOUSE EFFECT

Earth's climate has been relatively stable for the last several thousand years. However, there is a new threat to Earth's climate: air pollution. Global air pollution has steadily increased in recent decades. The ecological, economic, and societal costs of air pollution are increasing daily.

Greenhouse Effect The release of carbon dioxide, or CO_2, is associated with increasing air pollution. The burning of fossil fuels and wood and the cutting down of forests have released much carbon dioxide into the air. Since the start of industrial times there has been a 25 percent increase in the amount of atmospheric carbon dioxide. During the same period of time, global temperatures have increased by 0.5°C. Scientists think that the temperature increase is caused by the release of more carbon dioxide into the air. Because carbon dioxide molecules in the air help to trap heat, they act like the glass roof of a greenhouse. Consequently, the heat-trapping action of carbon dioxide in the atmosphere has been called the *greenhouse effect*.

Current computer models of the global atmosphere and climate give conflicting information about the world's future climate. Nevertheless, in the next 100 years, the amount of atmospheric carbon dioxide will probably double. Although atmospheric carbon dioxide levels have changed in the past, they have never doubled in just 100 years! Concerned people think it is important to find techniques and propose policies to reduce air pollution.

Storing Carbon The cultivation of more woody plants is one possible way to reduce atmospheric carbon dioxide. Plants need carbon dioxide for photosynthesis. During photosynthesis, plants change carbon dioxide into sugar, which the plants use for energy. Woody plants convert much of their sugar into wood. Consequently, woody plants can also store carbon for many years in their woody stems and roots.

Because they can store carbon, woody plants can be considered a kind of carbon bank. The longer a woody plant lives, the longer it can store atmospheric carbon. So, long-lived trees are excellent for storing carbon. The faster trees grow and the more forests that are planted, the greater the effect trees could have on slowing the increase of atmospheric carbon dioxide. But, because forests are being cut down rapidly, more carbon dioxide is being released into the atmosphere, and the amount of potential carbon storage is being reduced.

Speeding up the Process Besides growing more trees, another possible way for humans to reduce the amount of carbon dioxide in the atmosphere is by enabling plants to use more carbon dioxide. Normally there is enough carbon dioxide in the air so that the rate of photosynthesis is not slowed. Usually during photosynthesis, other steps than the ones of the Calvin cycle limit the rate at which plants can use carbon dioxide. In theory, by finding a way to speed up the slowest steps, the rate of carbon dioxide uptake should be increased. Making the sugar-transfer enzymes of a plant work more effectively would be one way to speed up the process of using sugars. As a result, plants would move sugars faster and produce more cellulose. Consequently more carbon would be stored.

Enhancing Sugar Transport One of the most important enzymes involved in moving sugars in plants is called *sucrose phosphate synthetase*. This enzyme catalyzes the reaction between fructose-6-phosphate and UDP glucose. UDP glucose, or uridine diphosphate glucose, is an activated form of glucose. When the enzyme links fructose and glucose together, they form sucrose-6-phosphate. Sucrose is the sugar that is usually transported in the sap of woody plants.

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In theory, plants that have more-active sucrose-forming enzymes should grow faster than plants with less-active enzymes. Actually, researchers have found that certain plants with more-active sucrose phosphate synthetase enzymes do grow faster. Consequently researchers can screen plants for more-active sucrose phosphate synthetase enzymes by studying the seedlings that grow fastest.

Researchers have to consider a second factor when selecting plants to counteract the greenhouse effect. The chosen plants should be able to grow faster when the carbon dioxide concentration in the air is higher than normal. So after screening plants for more-active sucrose phosphate synthetase enzymes, researchers also need to screen the plants for the ability to grow fast in the presence of higher levels of carbon dioxide.

After researchers have identified plants with more-active sucrose phosphate synthetase enzymes, there are still more steps in the process of genetic engineering. Scientists must locate and remove the gene for the sucrose phosphate synthetase enzyme from the faster-growing plants. Then the genetic engineers must duplicate the gene many times and insert copies of the gene into seedling plants so that the plants will grow faster. Through this process, eventually it may be possible to create trees that grow faster and remove more carbon dioxide from the air.

REVIEW *In the space provided, answer the following questions.*

1. Why are some people concerned about the increase in the amount of carbon dioxide in the air?

2. How might trees be used to reduce the amount of carbon dioxide in the atmosphere?

3a. What does the enzyme sucrose phosphate synthetase do?

b. Why is this enzyme important to plants?

4. What might be done to make trees more effective in storing carbon?

5. List some steps in the process of genetically engineering trees with the enzyme sucrose phosphate synthetase.