Can Houseplants Impact Indoor Air Quality?

High School, Biology

Task Overview

Plants exchange gases with the surrounding environment through specialized structures on the surface of their leaves. Each leaf contains thousands of microscopic openings called stomata, which allow gases—including carbon dioxide, water vapor, oxygen, and some air pollutants—to move into and out of the plant. Stomata are controlled by guard cells, kidney-shaped cells that act like valves, changing shape to open or close the pore.

Guard cell behavior is regulated by ion channels and membrane pumps that move ions into or out of the cells in response to light, stress signals, or hormonal cues. When ions enter guard cells, water follows by osmosis, increasing pressure inside the cells and causing them to bow outward, which widens the stoma. When ions exit, water leaves, pressure decreases, and the pore closes.

Although stomata primarily regulate gases essential to photosynthesis and respiration, research shows they also enable the uptake of volatile organic compounds (VOCs), including formaldehyde. Once formaldehyde enters the plant, it can be broken down and converted into molecules used in normal cellular processes. Because gas movement is controlled by stomatal opening size, guard cell mechanisms directly influence how efficiently plants remove pollutants from the air.

Throughout the task, students will:

- Analyze pollutant-removal efficiency data to identify patterns in plant performance.
- Compare macroscopic structures, such as the number, size, and thickness of leaves.
- Examine microscopic features, including cell shape, density, and stomatal-like openings.
- Integrate information across diagrams, microscopy images, scientific excerpts, and mechanistic descriptions of guard cells.
- Construct mechanistic explanations that connect patterns in data to plant structures and processes.

By the end of the task, students should be able to explain:

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- Whether and how plants remove indoor air pollutants using evidence from real data.
- Which structural features contribute to differences in efficiency across species.
- How stomata and guard cells regulate pollutant movement through changes in pore size.
- How these structures and mechanisms can be used to make recommendations for improving indoor air quality.

Next Generation Science Standards

Three Dimensional Claim

In this task, students analyze and compare multiple data sets and visual sources to identify and interpret patterns in how plants remove indoor air pollutants. They use these patterns as evidence to construct explanations for how specialized plant structures, such as stomata and guard cells, regulate gas exchange and contribute to pollutant uptake.

This task is intended to elicit student learning of the following **NGSS elements** for each of the three dimensions:

Disciplinary Core Ideas

LS1.A-H1: Structure and Function (HS)

- Systems of specialized cells within organisms help them perform the essential functions of life

Science and Engineering Practices

Analyzing and Interpreting Data (HS)

- Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations
- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system

Obtaining and Communicating Scientific Information (HS)

- Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem

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Crosscutting Concepts

Patterns (HS)

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena

Helpful Prior Knowledge

To engage successfully in this task, students should have a foundational understanding of how plants exchange gases with their environment and how specialized structures contribute to plant function. Students should know that leaves are the primary sites of gas exchange in plants and that microscopic openings called stomata regulate the movement of gases such as carbon dioxide, oxygen, and water vapor. Students should also recognize that stomata are controlled by guard cells, whose changes in shape alter the size of the opening and influence the amount of gas that can enter or exit the leaf.

Students should be familiar with the idea that patterns in data can provide evidence for underlying mechanisms, and that structure–function relationships help explain why different organisms or different plant species perform biological processes at different levels of efficiency. Prior experience analyzing graphs, interpreting images, and integrating information across multiple source types (text, visuals, models) will support students in developing explanatory accounts of how plants influence indoor air quality.

This background knowledge prepares students to make sense of how plant structures regulate pollutant movement and how guard cell mechanisms drive daily or species-level differences in pollutant removal.

Gas Exchange Through Stomata

Plants regulate gas movement through microscopic pores called stomata, which allow carbon dioxide, oxygen, water vapor, and in some cases other gases such as formaldehyde to move into and out of leaf tissues. Each stoma is surrounded by a pair of guard cells that change shape based on ion concentrations and internal pressure. When ions flow into the guard cells, water follows, increasing pressure and causing the stomatal pore to widen. When ions flow out, water exits, pressure decreases, and the pore closes. These opening–closing cycles directly regulate how much gas the leaf can take in at different times of day.

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How Structure Influences Pollutant Uptake

The macroscopic features of leaves (such as leaf area and number of leaves) and the microscopic features (cell shape, packing density, and stomatal density) both influence how efficiently a plant can take up pollutants from the air. Plants with large surface areas, loosely packed cells, or more stomatal openings provide more pathways for gas movement. Pollutant-removal efficiency is also influenced by environmental conditions, especially light, because stomata tend to open wider under illuminated conditions. Teachers should understand that removal of pollutants like formaldehyde is a byproduct of these natural gas-exchange processes, not a separate “filtering” mechanism.

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References

Kumar, R., et al. “Mitigation of indoor air pollutants using plant-based methods.” *Air Quality, Atmosphere & Health*, 2023.

Mushahary, R., et al. “A systematic review on phytoremediation of indoor air pollution.” *Journal of Air Pollution and Health*, 2024.

Tani, A., et al. “Stomatal control of VOC uptake in plants.” *Environmental Science & Technology*, 2007.

Wolverton, B.C., et al. *Interior Landscape Plants for Indoor Air Pollution Abatement.* NASA, 1989.

Collaborations

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