

# Blank Lesson Template

Yellow highlight = required component

<b>Subject Area(s)</b>	AP Biology
<b>Associated Unit</b>	Plants
<b>Lesson Title</b>	Mimicking Trees: Free Energy?

## Lesson Dependency

**Time Required** 40 Minutes

## Summary

Plants use the capillary action of water through xylem and phloem to carry water from any distance of several inches to hundreds of feet above the ground. This lesson explores the physics, biology and engineering concepts behind this process and applies it to a theoretical hydroelectric generator.

## Engineering Connection

Biomimicry is the process of observing natural phenomena and attempting to duplicate it for use by humans. The fluid dynamics occurring in plants has become an exciting area for nano-engineers and microelectronics as a way to provide power and cooling to micro and nano devices. Dr. Stroock at Cornell University has developed a synthetic tree to study fluid flow through microchannels.

## Engineering Category = #1

Choose the category that best describes this lesson's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering

## Keywords

Plants, Capillary Action, Biomimicry, Fluid Dynamics, Hydroelectricity

## Educational Standards

*Science: Texas, science, 2009, The Texas Essential Knowledge and Skills, Chapter 112*

2C know scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers.

3B communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials

3D evaluate models according to their limitations in representing biological objects or events

9B compare the reactants and products of photosynthesis and cellular respiration in terms of energy and matter

## Pre-Requisite Knowledge

## Learning Objectives

After this lesson, students should be able to:

- Describe the fluid transport mechanisms in plants
- Explain what hydroelectricity is as well as pros and cons

- Understand the motivation behind microchannels in microelectronics

### Introduction / Motivation

After learning about the xylem/phloem networks in plants, students should be able to understand that water is being transported to various heights above the ground without using pumps or electricity. If that water could be collected, wouldn't it be possible to power a hydroelectric generator?

The actual power output from even millions of capillary tubes is very low and the cost to build such an apparatus is enormous. The real message for the students is about biomimicry. Biomimicry is the imitation of nature in engineering and manufacturing. By understanding how nature works at the molecular level, nanoscientists and engineers can improve products for daily life (e.g. nanofibers on clothing to make them stain resistant is an example from the lotus leaf). Capillary action is an important component in chromatography, thermometers, paper towels and even some nano-engineered structures. By using capillary action in microelectronics, engineers hope to be able to provide small amounts of energy as well as cooling to the ever-shrinking consumer electronic components.

### Lesson Background & Concepts for Teachers

Teachers should review the plant unit of the biology textbook as well as capillary action in physics textbooks. More information on hydroelectric energy can be found at:

[www1.eere.energy.gov/water/how\\_hydropower\\_works.html](http://www1.eere.energy.gov/water/how_hydropower_works.html)

More information on the Cornell microchannel studies can be found at:

[www.news.cornell.edu/stories/Sept08/stroock.trees.aj.html](http://www.news.cornell.edu/stories/Sept08/stroock.trees.aj.html)

### Vocabulary / Definitions

Word	Definition
Nanotechnology	The manipulation of matter at the atomic or nanoscale level. Often used in reference to materials or processes that involve a dimension being less than or equal to 100 nanometers.
Biomimicry	The process of examining natural mechanisms to solve human problems.
Xylem/Phloem	The transport tissues in vascular plants that carry water and nutrients throughout the plant system.
Capillary Action	The ability of a liquid to travel through a narrow space via surface tension and adhesive properties of the liquid and the surface.

### Associated Activities

Plant-Like Power Plant

### Lesson Closure

### Assessment

Students will take a short quiz on the subject matter discussed. The first portion will ask the students to describe the pros and cons of hydroelectric power. The second portion will ask the students to describe the purpose of microchannels in electronics.

### **Lesson Extension Activities**

### **Additional Multimedia Support**

### **References**

### **Attachments**

Biomimicry quiz

Perpetual Energy Presentation

Plant-Like Power Plant Activity

### **Other**

### **Redirect URL**

### **Contributors**

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### **Supporting Program**

National Science Foundation GK-12 program, University of Houston, Department of Civil and Environmental Engineering