Testing a Transparent Hydrophilic Copolymer as a Suitable Soil for the Observation and Study of Plant Root Growth

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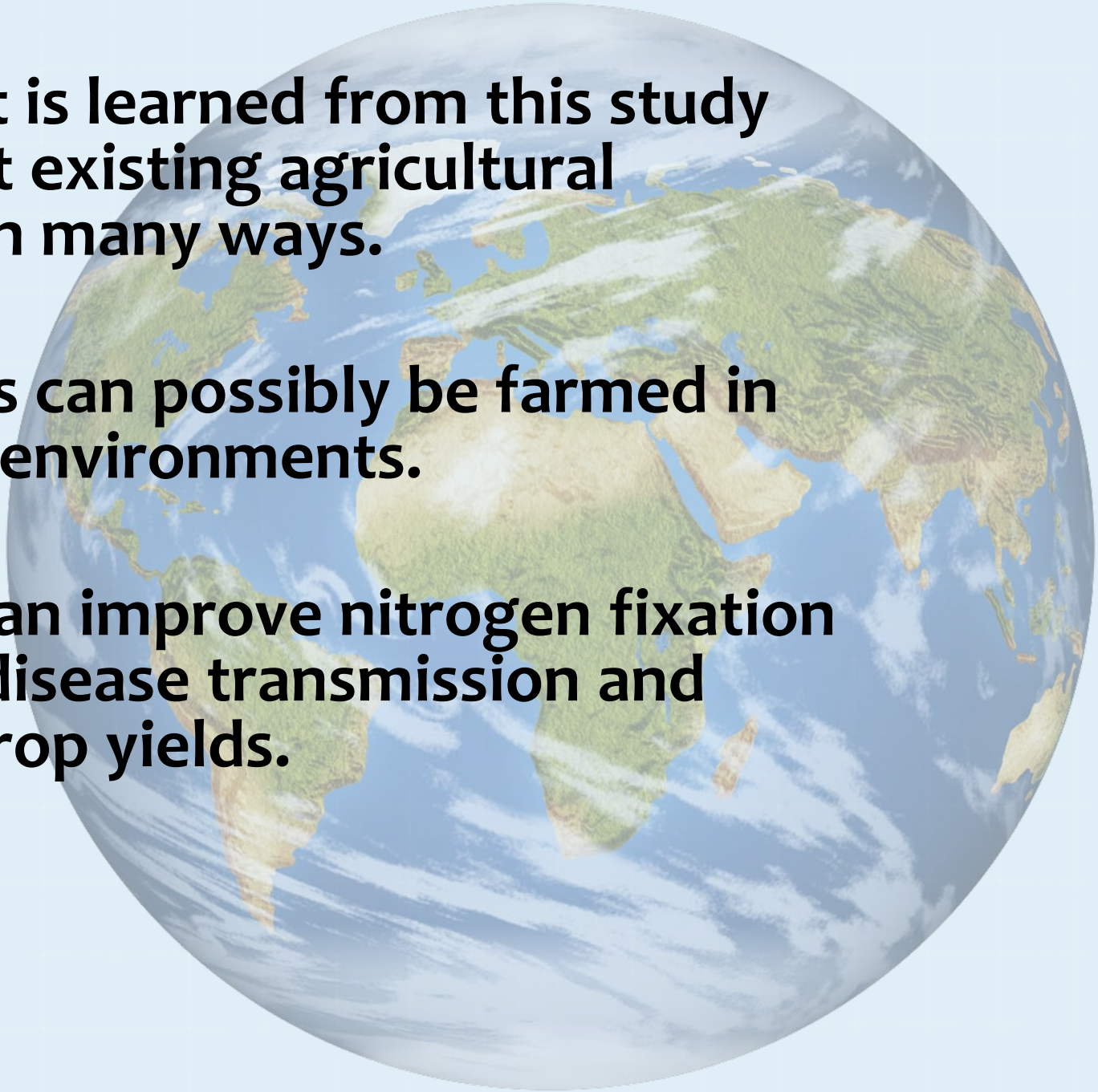
Summer 2013

Science and Mechatronics Aided Research for Teachers with an Entrepreneurship Experience

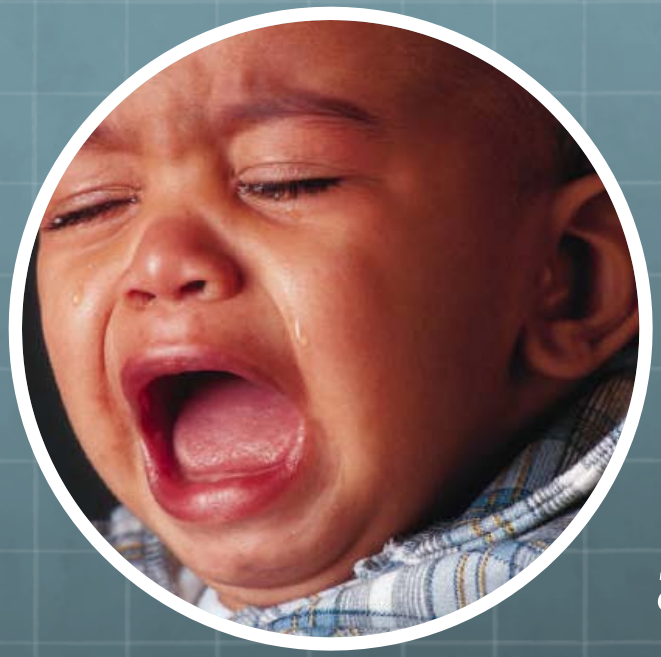
- This work is supported in part by the National Science Foundation under a Research Experience for Teachers (RET) Site grant EEC-0807286. We thank Prof. Kapila's Mechatronics Lab and Prof. Iskander's Soil Mechanics Lab personnel for hosting us during our summer research program.



What is learned from this study can impact existing agricultural methods in many ways.

Crops can possibly be farmed in more arid environments.

We can improve nitrogen fixation or retard disease transmission and improve crop yields.



Pilot Analysis of Global Ecosystems (PAGES) freshwater systems assessment (World Resources Institute, 2000)

PAGES projected substantial increases in the numbers of people living in water-stressed basins, due entirely to population growth.

Society will have to expand the areas where crops can be grown if we are going to continue feeding our rapidly growing population.

Plants

- convert solar energy into useful chemical energy
- contribute to atmospheric oxygen for aerobic organisms
- Provide food, shelter, and fuel
- make human existence possible

The three primary structures in plants

① Leaves
② Stems
③ Roots

Roots

A plant's root system is critical to its health.

To visualize through the means of a transparent soil how roots

1. anchor a plant,
2. absorb water and necessary nutrients,
3. & store food,

Soil

- Soil provides the necessary nutrients such as nitrogen, phosphorous, and potassium.
- An artificial soil must be able to hold these same nutrients.
- It also must be able to hold water

- A number of supplements were tested in order to give the plants the best chance of surviving in their new environment.
- Research goals were to optimize the soil conditions for plant growth while at the same time maintaining transparency.
- It was demonstrated that an Aquabead-based soil can visibly and quantifiably support growth of a plant or its seeds.

Aquabeads

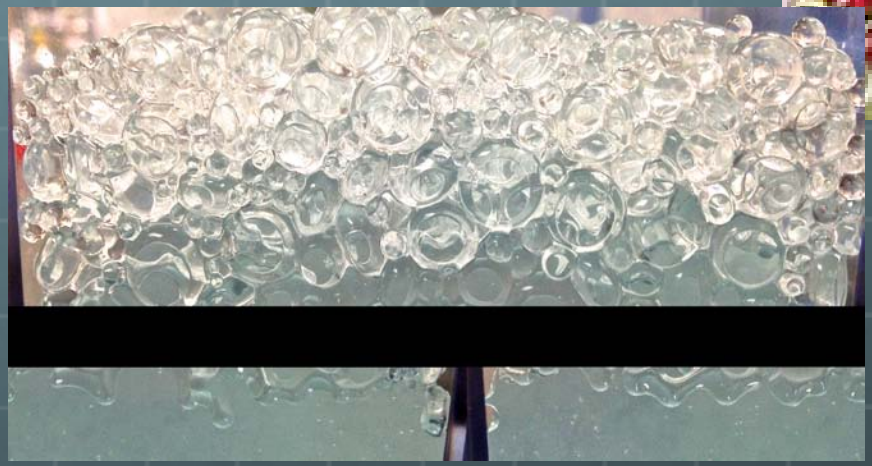
- An ionized copolymer was used to construct the transparent soil.
- When hydrated, these beads are nearly transparent with a refractive index matching water.

Aquabeads

Water

This is a hydrophilic polymer is made of isobutylene and maleic anhydride copolymer

Procedure



For the first week the transparent soil involved hydrating the Aquabeads.

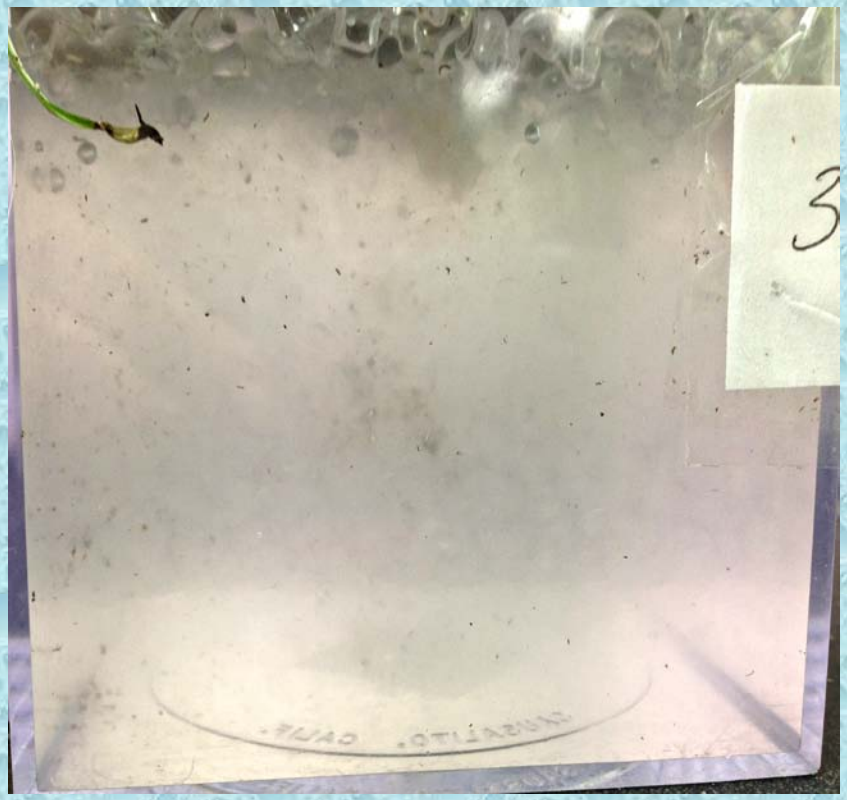
The beads were then poured into a clear plastic container.

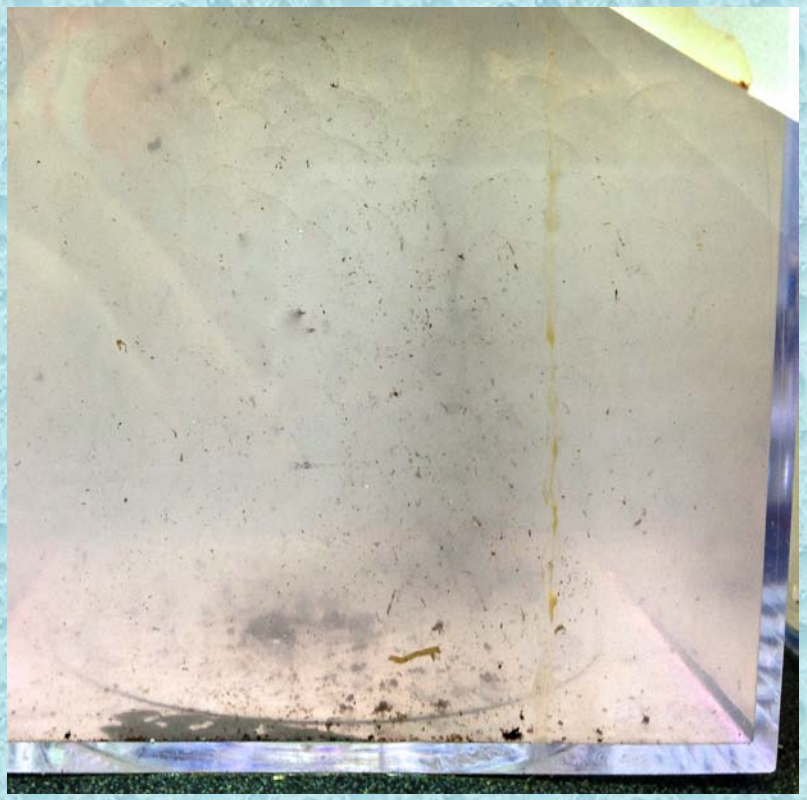
Layers: Soil atop gauze, wire mesh, fused quartz, and hydrated aquabeads.

Wire mesh with hole to allow roots through to hydrated aquabeads.

On top of the transparent soil, a thin, metal netting, and dampened cloth were placed to prevent any soil particles from seeping into the beads and clouding our visibility of the roots. A hole, or passageway was created (2.5 cm diameter) to allow growing roots to eventually invade the transparent Aquabeads solution.

As the dirt slowly filtered down into the aquabeads layer, the transparency of the soil progressively decreased.





These plants roots were exposed to the beads and water solution without metal netting for support or surrounding topsoil for nutrients.

- *E. aureum* in aquabeads with fertilizer.

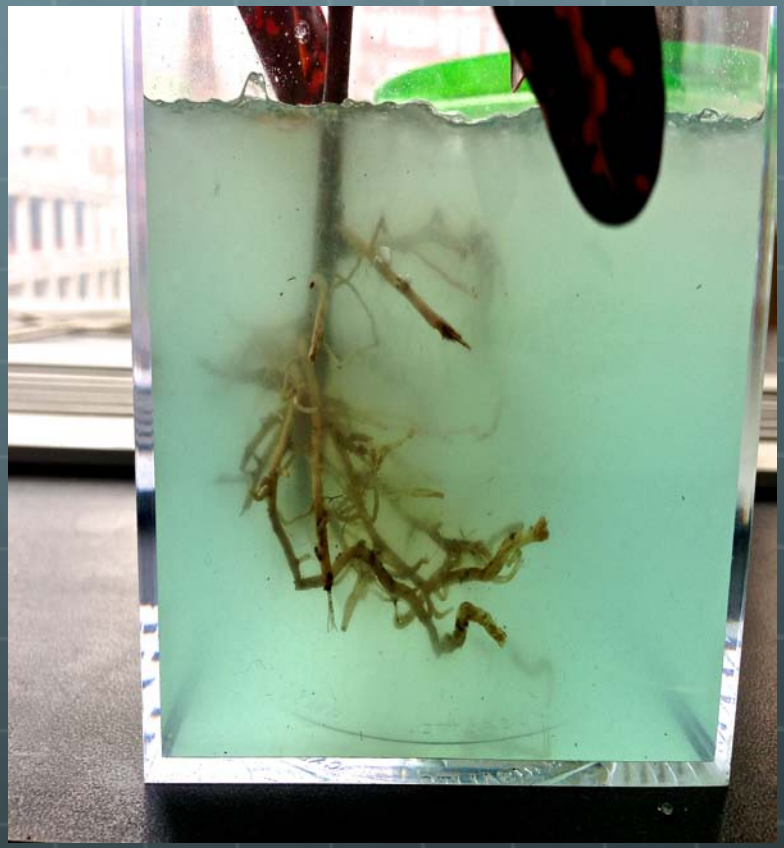
D. marginata in crushed aquabeads and aspirin.

Dracaena thrived, for the final weeks of the experiment

Sweet Potato Vine in a 10% Sucrose solution on day 1 of planting, and day 12.

Codiaeum variegatum (Croton) on day 1 and day 6 in crushed Aquabeads with 10% sucrose solution.

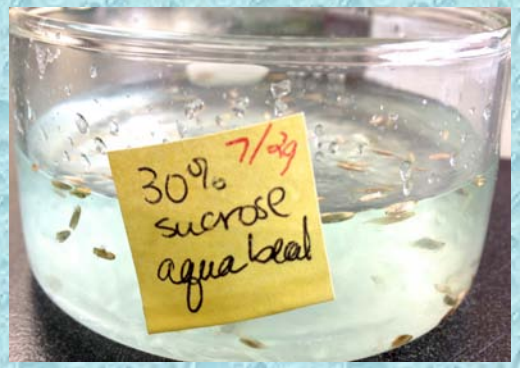
Codiaeum variegatum (Croton) in crushed Aquabeads with fertilizer and aspirin.



“Miracle Grow” fertilizer provided the principal nutrients to ensure that the plant could synthesize the necessary macromolecules for growth.

This fertilizer was dissolved in water and then added to the dehydrated aquabeads (0.5 g / l).

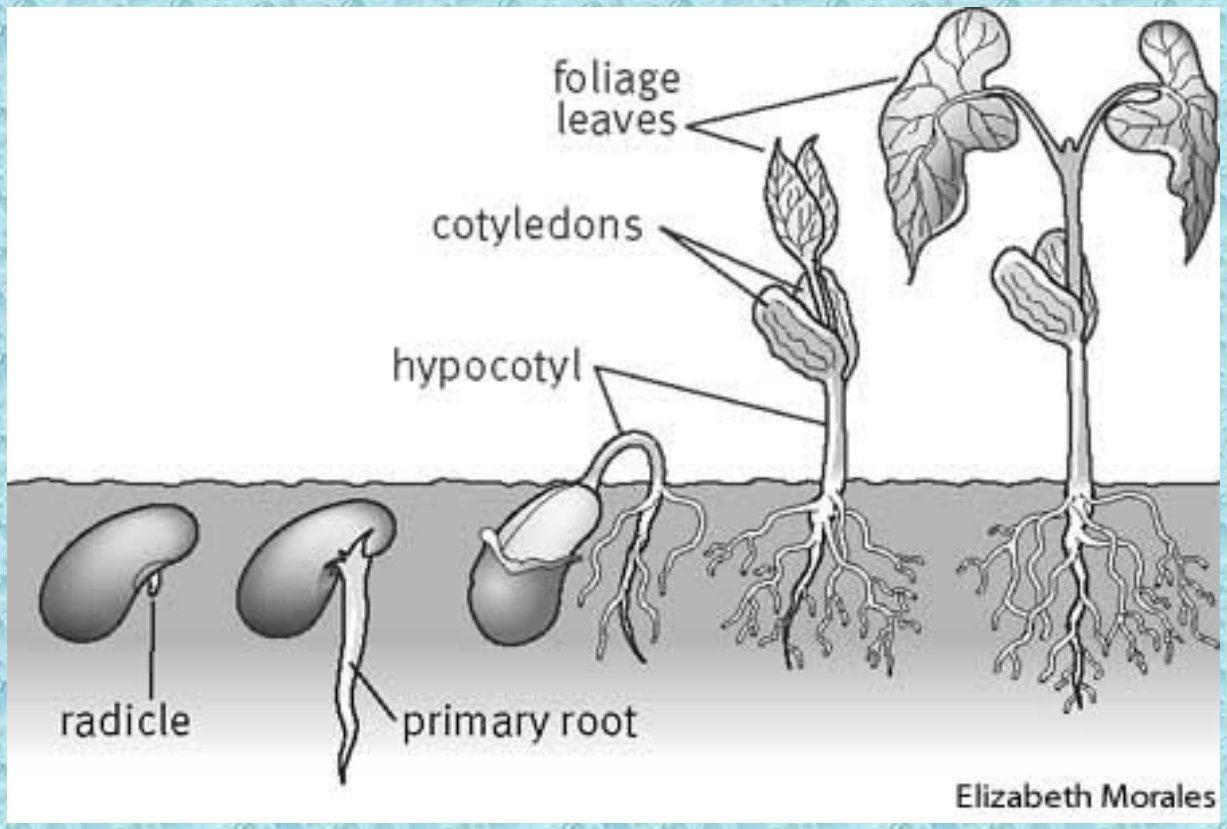
Annual Rye Grass sown on aquabeads with various solutions.



Annual Rye Grass seeds were chosen for planting in the aquabeads due to their quick germination period of 3 to 5 days.

They were planted in several aquabead solutions containing sucrose (10% & 30%), fertilizer (0.25g/L), a thin soil layer, and with no amendments .

The root is the first structure to emerge from the germinating seed.



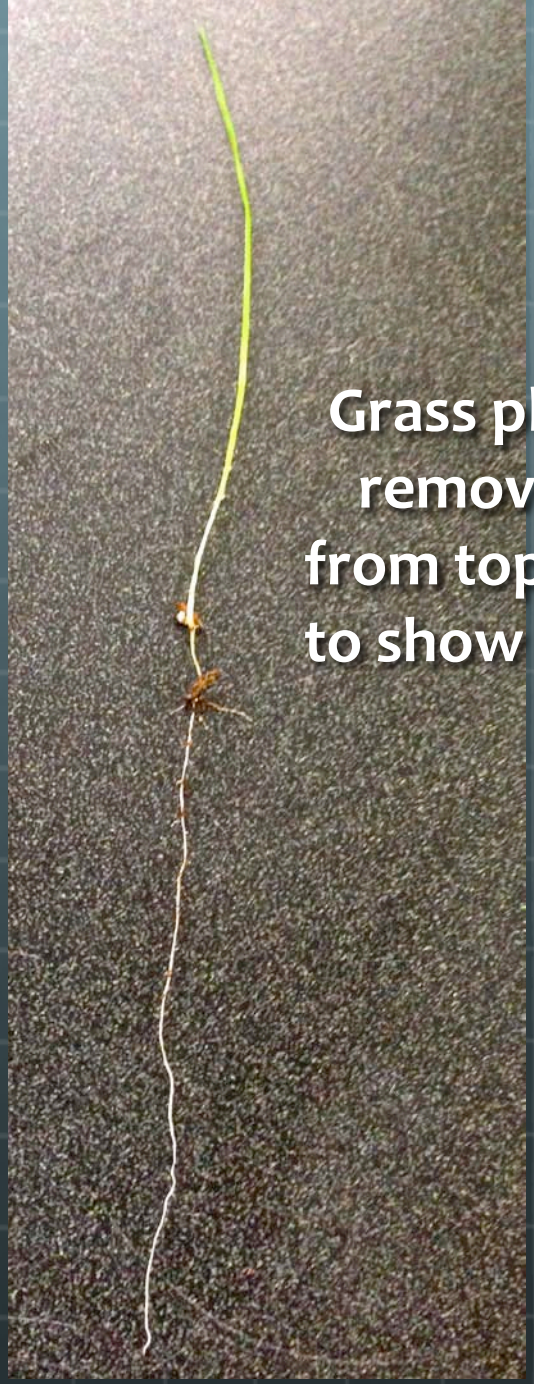
In order to constantly supply the necessary nutrients, water, and support to the leaves and stem of the plant, the root system persistently grows into the surrounding soil.

Grass Shoots and Roots

- Aquabeads mixed with soil

The only seeds to germinate were the ones sown in aquabeads with the layer of soil

Healthy Roots and Shoots



Grass plant removed from top soil to show root

Activity

- ✓ This study offers the unique advantage of using a transparent soil to actually visualize how a plant's roots respond to varying temperature.
- ✓ Students will calibrate and use a thermal sensor with an Arduino to monitor soil temperature.
- ✓ Students will collect data over a six week period.
- ✓ Students will present their findings to the class

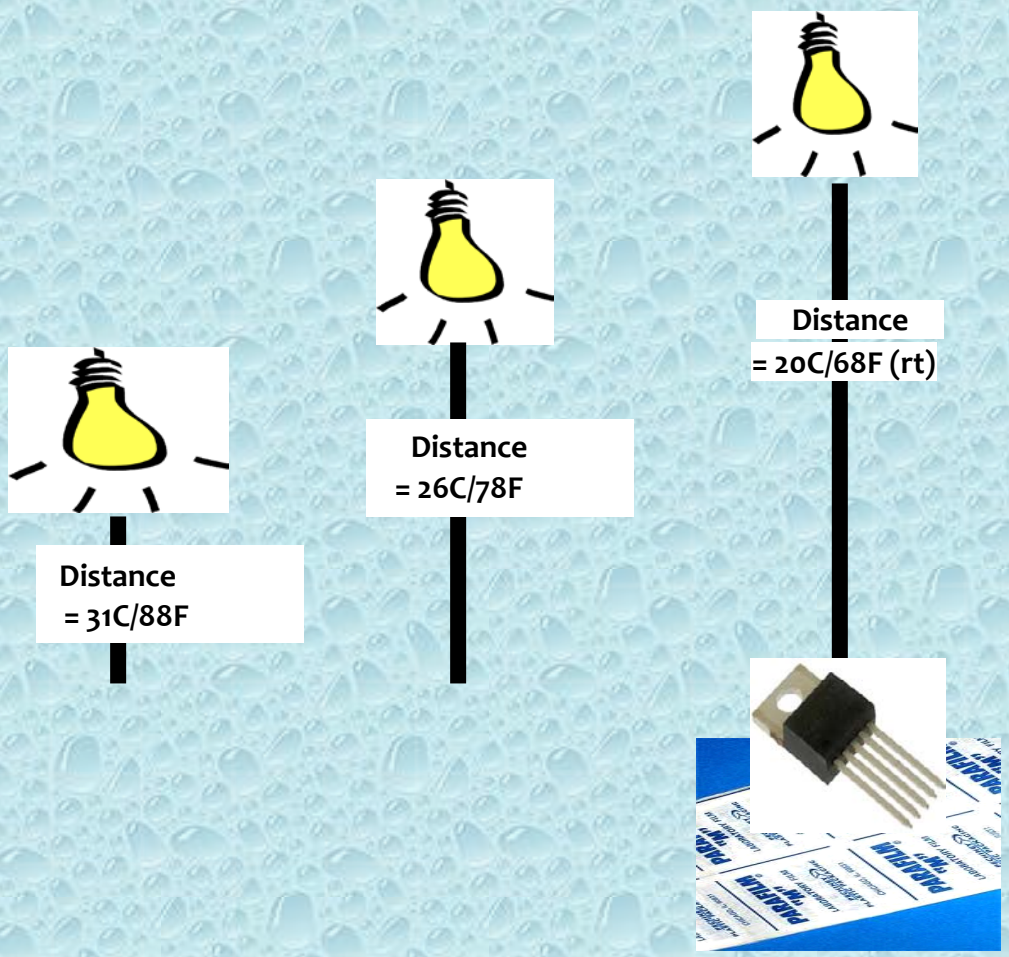
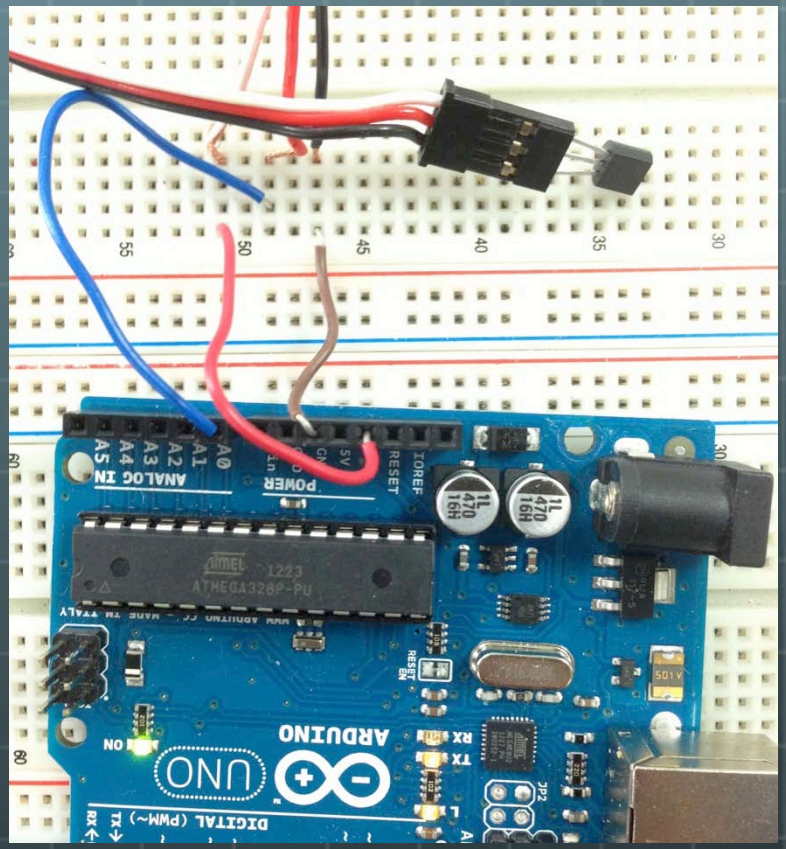


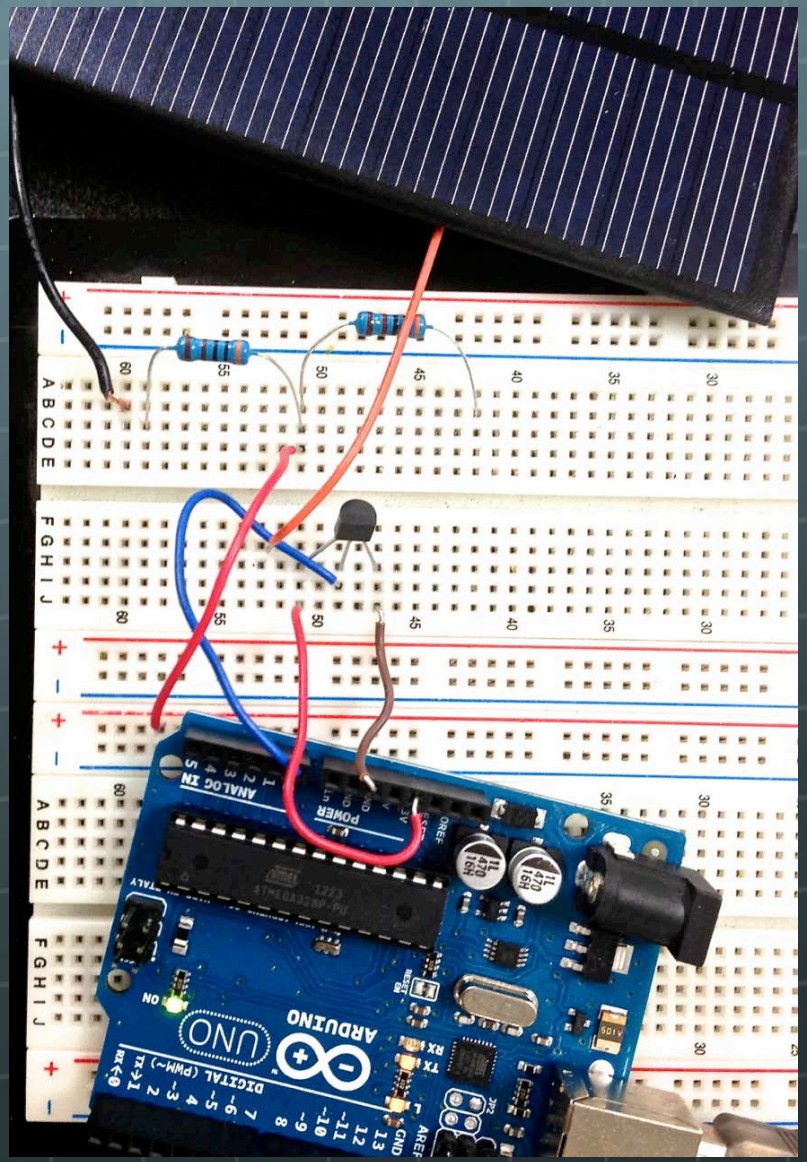
Image 3

ADA Description: A parafilm sheet-wrapped thermal sensor (wired into breadboard, Arduino powerboard and computer) is positioned at varying distances from the 100W lamp.

Caption: Students determine the distance between the thermal sensor and 100W lamp in order to achieve the desired temperature.

Thermal and Solar Panel Sensors





Arduino Code for thermal and light sensors

```
int temperaturePin = A0;
int lightPin = A1;
int sensorValueT;
double sensorValueL;
double lightVoltage;
int temperature;

void setup() {
  Serial.begin(9600);
}

void loop() {
        sensorValueT = analogRead(temperaturePin);
        sensorValueL= analogRead(lightPin);
        Serial.print("The temperature analog value is ");
        Serial.print(sensorValueT);

        //temperature= sensorValue1^2+2*sensorValue1+3;
        //Serial.print(" which corresponds to : ");
        //Serial.print(temperature);
        //Serial.print("*C");

        Serial.print("\n");
        Serial.print("------------------------\n");

        lightVoltage=5*sensorValueL/1024;

        Serial.print("The solar panel voltage value is ");
        Serial.print(lightVoltage);
        Serial.print("\n");
        delay(1000);
```

Activity

After this activity, students should be able to:

- ✓ **Understand the roles water, light and, most importantly, temperature play in fueling photosynthesis.**
- ✓ **Design an experiment including a negative control and dependent/independent variables**
- ✓ **Describe necessary substrates and products of photosynthesis**
- ✓ **Construct and analyze graphed data**