Experiment Title: _____

Scientist: _____

**Scientific Method, Step 1:** Ask a Question

What question do you want to answer in the experiment?

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**Scientific Method, Step 2:** Propose your Hypothesis

What do you think the answer will be?

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**Scientific Method, Step 3:** Perform your experiment and record the data

See attached directions for performing the experiment

**Scientific Method, Step 4:** Conclusions

Did the results of the experiment match your hypothesis? Why or why not?

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# The Colors Hidden Inside – Photosynthesis and Paper Chromatography Version 1

Version 1: Physical extraction of plant pigments. Extraction takes less than 5 minutes, separation takes about 10 minutes.

This experiment can be done any time of year, but it's at its best in the fall, when you can get different color leaves from the same tree. Try not to use evergreens, as their leaves have a tough coating and can slow down the extraction. In the winter, hit the grocery store and buy different vegetables, spinach should give an excellent response, but try colored Swiss chard if it's available (include the stem when extracting the color).

**Credits**

A scout performing this experiment may be able to earn credit towards the activity listed below.

*Nova*

- Science Everywhere #3: Act Like a Scientist. Chose a question you would like to investigate. Use the Scientific Method to investigate and discuss your work with your counselor
    - Why and how do leaves change colors in the fall?

*Alvarez Supernova*

- Learn about the scientific method (#7)
- Participate in a Nova/STEM related Pack or Den activity (#9)

*Townes Supernova*

- Do an experiment to show how the scientific method is used (#8 – Note: this does not completely fulfill #8, the scout must still write up a lab report)
- Participate in a Nova/STEM related Pack or Den activity (#9)

*Science Belt Loop*

- Explain the Scientific Method to your adult partner
- Perform an experiment and explain the results to your adult partner

**The Science**

There's two parts to this experiment: plant biology and separations or chromatography. The plant biology is summarized in the student worksheet. The paper chromatography can be explained during the discussion of how to determine what colors are in each leaf.

*Plant Biology:* Plants make their own food by a process called photosynthesis, in which they use carbon dioxide from the air, water they obtain from the soil with the energy from light to create sugar and oxygen. This process helps to replace the oxygen we consume by breathing and also creates food for us to eat. To collect the light energy, the plants use a chemical called chlorophyll, which is contained in granules called chloroplasts. The chloroplasts are highly concentrated on the surface of the leaves, to allow the plant to collect as much light energy as possible. Chlorophyll is green because it reflects the green light to our eyes. This allows the red and blue light to be absorbed and this light energy is used to perform photosynthesis. For a good one page summary of photosynthesis, see Kids Discover Infographic here:

http://www.kidsdiscover.com/infographics/infographic-photosynthesis-for-kid/

In the fall, the leaves change colors. What happens is the plants produce less chlorophyll as the day light hours get shorter. As the chlorophyll levels in the leaves decrease, we can start seeing the other pigments in the leaves. Yellow and orange colors are due to carotenoids present in the leaves year round, but they are covered by the green from the chlorophyll. The pigment causing the bright reds, as typically seen in maple trees in the northeast, are made when there is a warm sunny day followed by a cool fall night which trapped sugar in the leaves. The red pigment anthocyanin is a way for the plant to reclaim the sugar before the leave falls and takes the food with it. The dull brown found in oak trees is made of a waste product called tannin left in the leaves. Tannin is also protection against insects such as the gypsy moth.

*Paper Chromatography:* Paper chromatography can be broken down into 3 steps: extraction, separation and measurement. Extraction is only performed if your sample (in this case, the plant pigments) isn't already in a liquid form. If you were doing paper chromatography on inks, you would skip this step. To perform the extraction, we physical manipulated the leaves by rubbing them with a coin. The paper collects the pigments. Separation is when the paper is placed into the liquid. The paper is called the "stationary phase", since it doesn't move and it carries the liquid through it. The liquid is called the "mobile phase" as it moves along the paper. As the mobile phase moves along the paper, it carries the pigments along with it. The pigments will travel slower than the mobile phase front (the leading edge of the solvent). The relative distance of the pigments can be determined by measure the distance to the mobile phase front and the distance to the pigment line. The pattern of pigments on the paper is called a chromatogram. By measure the distance the solvent travelled and the distance each of the pigments traveled, the relative distance (RD) can be determined. For example, if the solvent traveled 10 cm and a pigment traveled 8 cm, the relative distance is 8/10 or 0.8. Once these values are determined, an unknown sample can be identified by comparing the relative distances of all pigment lines seen in the unknown sample's chromatogram.

**Materials**

Coffee filters cut into 1” wide strips
Leaves of different colors (try to get 2 leaves from the same tree, each of a different color.)
Acetone based nail polish remover
Cups or bowls
Coin
Ruler
Pencils
Binder clips or other way to fasten the filter to the cups

**Methods**

*Pre-work*

- Cut coffee filters into strips about 1” wide

*Hazards*

- Acetone is flammable, keep flames away from the experiment
- Acetone can remove the finish from furniture (such as a kitchen table), nail polish and can stain clothing. Encourage kids to wear clothing that can get dirty, and cover surfaces as needed.

See the Worksheet for methods.

# The Colors Hidden Inside Worksheet

During the spring and summer, leaves look green to us, but in the fall, they change to many different colors, including red, orange, yellow and even brown! Let's find out why the leaves are green, and if we can tell what color they will turn in the fall.

Leaves are green because they contain a chemical called *chlorophyll*. Chlorophyll is important because it captures the energy from the sun and uses it to make sugar out of water and carbon dioxide. Carbon dioxide is a gas that is present in the air; animals make it when we breathe out.

In the fall, the some trees get ready for winter by shedding their leaves. As part of this, the trees stop making chlorophyll, so the leaves will lose their green color. The colors you see in the fall are only visible because the chlorophyll isn't there anymore.

How do you think the plants know when it is time to get ready for winter?

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If the leaf turns orange or yellow, it means that the yellow and orange chemicals were in the leaf during the spring and summer. If the leaves turn brown, which most commonly happens with oak leaves, it means the leaf made a lot of a bitter tasting brown chemical to protect itself from insects.

Red leaves are the most interesting and don't happen every fall. If a fall day is warm and sunny, the leaves will make lots of sugar. If that night is cool, it's hard for the sugar to travel out of the leaves, which causes sugar to get trapped in the leaves. To get the trapped sugar back, the leaves make a chemical that is red in color. The more warm sunny days followed by cool nights in the fall, the more red leaves you'll see.

Now, let's do an experiment on leaves!

**Materials**

Coffee filters cut into 1" wide strips
Leaves of different colors (try to get 2 leaves from the same tree, each of a different color.)
Acetone based nail polish remover
Cups or bowls
Coin
Pencil

**Methods**

1. Draw a pencil line about 2 cm up from the bottom of a filter strip
2. Select a leaf and place it over the filter.
3. Using the coin rub the leaf approximately where the pencil line is. This is to transfer the color from the leaf to the paper. If you need to, move the leaf around until enough color has been transferred to the paper.
4. Hang a piece of filter paper a cup containing acetone for about 10 minutes to allow the liquid to travel up the paper.
5. Remove the filter paper from the cup and mark the top of the liquid line with a pencil mark. Let dry on a paper towel.
6. Measure the distance the liquid travelled on the filter and record it
7. Measure the distance each color line travelled on the filter and record it
8. For each leave, determine the "RD" of each color line by dividing the distance the color line travelled by the distance the liquid travelled. Record the RD.
9. Compare the color lines for the leaves.

**Questions to Think About**
If you had two different color leaves from the same tree, were the patterns the same or different? Why?

If you had "mystery leaves", were you able to tell which tree they were from by comparing the patterns with the other leaves?

# The Colors Hidden Inside – Photosynthesis and Paper Chromatography Version 2

Version 2: Chemical Extraction. This lab requires a 30 minute extraction followed by a 30-90 separation.

This experiment can be done any time of year, but it's at its best in the fall, when you can get different color leaves from the same tree. Try not to use evergreens, as their leaves have a tough coating and can slow down the extraction. In the winter, hit the grocery store and buy different vegetables, spinach should give an excellent response, but try colored Swiss chard if it's available (include the stem when extracting the color).

**Credits**

A scout performing this experiment may be able to earn credit towards the activity listed below.

*Nova*

- Science Everywhere #3: Act Like a Scientist. Chose a question you would like to investigate. Use the Scientific Method to investigate and discuss your work with your counselor
    - Why and how do leaves change colors in the fall?

*Alvarez Supernova*

- Learn about the scientific method (#7)
- Participate in a Nova/STEM related Pack or Den activity (#9)

*Townes Supernova*

- Do an experiment to show how the scientific method is used (#8 – Note: this does not completely fulfill #8, the scout must still write up a lab report)
- Participate in a Nova/STEM related Pack or Den activity (#9)

*Science Belt Loop*

- Explain the Scientific Method to your adult partner
- Perform an experiment and explain the results to your adult partner

**The Science**

There's two parts to this experiment: plant biology and separations or chromatography. The plant biology is summarized in the student worksheet. The paper chromatography can be explained during the discussion of how to determine what colors are in each leaf.

*Plant Biology:* Plants make their own food by a process called photosynthesis, in which they use carbon dioxide from the air, water they obtain from the soil with the energy from light to create sugar and oxygen. This process helps to replace the oxygen we consume by breathing and also creates food for us

to eat. To collect the light energy, the plants use a chemical called chlorophyll, which is contained in granules called chloroplasts. The chloroplasts are highly concentrated on the surface of the leaves, to allow the plant to collect as much light energy as possible. Chlorophyll is green because it reflects the green light to our eyes. This allows the red and blue light to be absorbed and this light energy is used to perform photosynthesis. For a good one page summary of photosynthesis, see Kids Discover Infographic here: http://www.kidsdiscover.com/infographics/infographic-photosynthesis-for-kid/

In the fall, the leaves change colors. What happens is the plants produce less chlorophyll as the day light hours get shorter. As the chlorophyll levels in the leaves decrease, we can start seeing the other pigments in the leaves. Yellow and orange colors are due to carotenoids present in the leaves year round, but they are covered by the green from the chlorophyll. The pigment causing the bright reds, as typically seen in maple trees in the northeast, are made when there is a warm sunny day followed by a cool fall night which trapped sugar in the leaves. The red pigment anthocyanin is a way for the plant to reclaim the sugar before the leave falls and takes the food with it. The dull brown found in oak trees is made of a waste product called tannin left in the leaves. Tannin is also protection against insects such as the gypsy moth.

*Paper Chromatography:* Paper chromatography can be broken down into 3 steps: extraction, separation and measurement. Extraction is only performed if your sample (in this case, the plant pigments) isn't already in a liquid form. If you were doing paper chromatography on inks, you would skip this step. To perform the extraction, we physical and chemically manipulated the leaves. First, they are torn to release the pigments, then they soaked in a solvent. The mashing of the leaves in the solvent helps to release additional pigment as well. Two different solvents are used to allow the scouts to compare the relative effectiveness. Separation is when the paper is placed into the liquid. The paper is called the "stationary phase", since it doesn't move and it carries the liquid through it. The liquid is called the "mobile phase" as it moves along the paper. As the mobile phase moves along the paper, it carries the pigments along with it. The pigments will travel slower than the mobile phase front (the leading edge of the solvent). The relative distance of the pigments can be determined by measure the distance to the mobile phase front and the distance to the pigment line. The pattern of pigments on the paper is called a chromatogram. By measure the distance the solvent travelled and the distance each of the pigments traveled, the relative distance (RD) can be determined. For example, if the solvent traveled 10 cm and a pigment traveled 8 cm, the relative distance is 8/10 or 0.8. Once these values are determined, an unknown sample can be identified by comparing the relative distances of all pigment lines seen in the unknown sample's chromatogram.

**Materials**

Coffee filters cut into 1" wide strips
Leaves of different colors (try to get 2 leaves from the same tree, each of a different color.)
Rubbing alcohol
Acetone based nail polish remover
Cups or bowls
Wooden spoon
Ruler
Binder clips or other way to fasten the filter to the cups

**Methods**

*Pre-work*

- Cut coffee filters into strips about 1” wide and 6-8” long

*Hazards*

- Acetone and rubbing alcohol are flammable, keep flames away from the experiment
- Acetone can remove the finish from furniture (such as a kitchen table), nail polish and can stain clothing. Encourage kids to wear clothing that can get dirty, and cover surfaces as needed.

See the Worksheet for methods. For a more challenging experiment, combine pieces from 2 or more leaves into a single cup and have the kids determine which leaves were combined by comparing the RD of the colors on the chromatogram.

# The Colors Hidden Inside Worksheet

During the spring and summer, leaves look green to us, but in the fall, they change to many different colors, including red, orange, yellow and even brown! Let's find out why the leaves are green, and if we can tell what color they will turn in the fall.

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How do you think the plants know when it is time to get ready for winter?

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If the leaf turns orange or yellow, it means that the yellow and orange chemicals were in the leaf during the spring and summer. If the leaves turn brown, which most commonly happens with oak leaves, it means the leaf made a lot of a bitter tasting brown chemical to protect itself from insects.

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Now, let's do an experiment on leaves!

**Materials**

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Cups or bowls
Wooden spoon
Ruler

**Methods**

10. Separate leaves by color and type.
11. Tear leaves into small pieces and place about 1 tablespoon of torn leaves into a cup. Label the cup.
12. Add about 1-2 tablespoons of either rubbing alcohol or acetone to the cup
13. Using a wooden spoon, smash the leaves into the liquid and let sit in warm water for 30 minutes.
14. Hang a piece of filter paper into each cup for about 60-90 minutes to allow the liquid to travel up the paper.
15. Remove the filter paper from the cup and label. Let dry on a paper towel
16. Measure the distance the liquid travelled on the filter and record it
17. Measure the distance each color line travelled on the filter and record it
18. For each leave, determine the "RD" of each color line by divided the distance the color line travelled by the distance the liquid travelled. Record the RD.
19. Compare the color lines for the leaves.

**Questions to Think About**
Did the solvent change the patterns?

If you had two different color leaves from the same tree, were the patterns the same or different? Why?

If you had "mystery leaves", were you able to tell which tree they were from by comparing the patterns with the other leaves?