

Experiment Guide

Amazing Maize

Objective

Corn is a significant agricultural commodity that has many uses in addition to food. This activity explores the anatomy of a corn plant and corn seed.

Introduction to Kids' Lab

Welcome to the BASF Kids' Lab. BASF is the world's largest chemical company and runs Kids' Lab programs like this all around the world. Can anyone think why? BASF wants children all over the world to understand and enjoy experimenting with chemistry!

Has anyone heard that word before: Chemistry? What do you think it means?

Chemistry is the science of matter. Have you heard the word "matter" before? What is matter? Matter is anything that takes up space and has a weight here on earth. So basically, matter is a scientific word for stuff.

Chemistry is a science that explores the composition of substances and their properties and reactions. In other words, Chemistry is a science that explores how different stuff behaves.

Matter comes in a few different forms or states: Solids, Liquids and Gases are the most common.

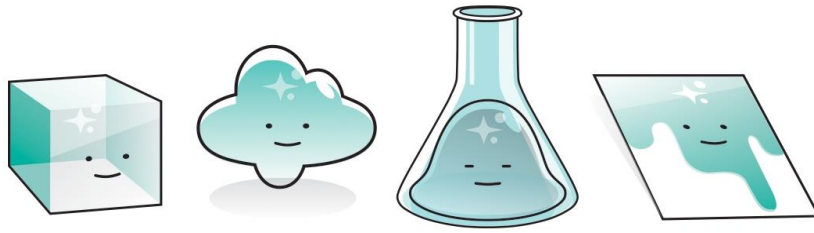
Chemistry is all around us. For example:

Who takes a vitamin? How do vitamins help you? (Grow big and strong, boost immunity) BASF makes chemicals that go into vitamins.

Raise your hand if you play a sport or ride a bike. What should you do to be safe? (Wear a helmet, pads, etc.) What materials make up the helmets that you wear? (Plastics and foam) BASF makes chemicals that go into the plastics and foams in helmets and padding.

Besides helping you grow strong and keeping you safe when you are playing your favorite sport, BASF chemistry keeps farmers' crops safe, cleans water for those in need and keeps babies clean and dry.

Let me introduce you to morpH, the face of Kids' Lab. morpH can move through the three states of matter with ease. Is there a substance that you know of, like morpH that can easily shift from solid to liquid to gas (and back again)? Water! That's right! You know that water is usually liquid but what happens when you freeze water? Water becomes a solid ice cube. When you boil water, it becomes a gas. Water is one of the most important substances on earth.



Water is essential for all living things including corn and other plants.
morph and I would like you to explore amazing maize.

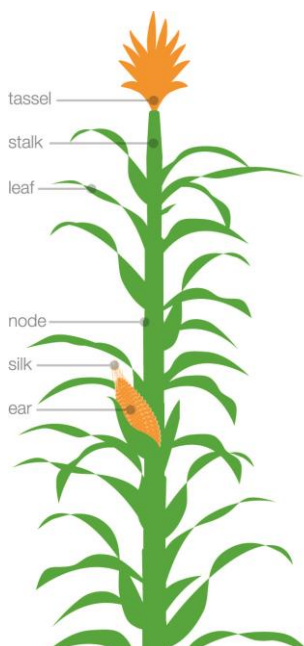
Experiment Introduction

*A poster or actual corn plant should accompany this description of the corn plant.

Corn, Maize or *Zea mays* is a member of the grass family that was first domesticated in Central America about 10 thousand years ago. The corn that existed 10 thousand years ago looks nothing like modern corn but over time was it selectively cultivated for yield and disease resistance. Since then, multiple cultures have embraced corn cultivation and the crop has migrated to other parts of the world. Now corn is a major commodity crop grown across the world.

The United States is the largest producer of corn in the world with over 90 million acres planted per year. Most of this corn (about 90%) is genetically enhanced to resist herbicides and/or insect pests. The BASF crop protection division conducts research and develops products that help grow corn and protect plants from pests. Almost all corn grown in the United States is field corn or dent corn. The dent corn variety has a dent or indentation on the outermost part of the kernel.

When you eat corn, you are actually eating a seed. All seeds contain a tiny embryo of a new plant, stored nutrients and a seed coat. When you plant a seed, and provide water and proper conditions, this tiny embryo will emerge from the seed or **germinate**. With proper care, this little seedling will grow and produce flowers. These flowers will then produce more seeds.



Within the immature corn ear are the female reproductive structures which are basically elongated stigmas called **silks**. At the base of each silk or stigma is a **carpel** or **ovule** that will become the corn kernel if properly fertilized. This ear is covered by a protective husk layer and the silks emerge from the top of the husk at maturity. The top of a corn plant has **tassels** that contain many **anthers**, which are the male reproductive structures that release pollen. In the field, corn pollen is dispersed by the wind. Sufficient corn pollination is essential to corn yield and ear filling. Every silk from the corn ear must be pollinated in order to have a full ear of corn. The silks detach from the ovules (developing kernels) following successful pollination and the kernel begins to accumulate sugars and grow in size.

The majority of corn in the United States is grown in the Midwest and planted around April and harvested around October after it has dried. Modern corn is harvested by a **combine** (very large tractor) which mechanically separates the ears from the stalk then removes the dried kernels from the husk and cob. This grain can then be stored until it is sold.



(https://upload.wikimedia.org/wikipedia/commons/e/e1/John_Deere_combine_and_tractor_at_work.jpg)

Most corn grown in the United States is used for animal feed or feed additives (40%). Approximately 30% of corn grown is used for the production of fuel ethanol. 12% is exported to other countries. The remainder is used to make sweeteners, starches, other foods and distillation products. By-products from corn processing also have many industrial uses.

Additional Background Information

There are six types or varieties of corn: pod corn, flour corn, flint, dent popcorn and sweet corn. Flint corn or Indian corn is mostly grown as an ornamental. Flour corn can be used to make corn flour or tortilla chips. Popcorn is a variety (*Zea mays everta*) of corn that contains more moisture which expands rapidly when heated (or pops). It also has a thicker pericarp which retains the heat until it pops.

Most people are familiar with sweet corn because humans often eat fresh sweet corn. Sweet corn is also canned or frozen. Sweet corn is harvested at a “milk stage” when the sugars have not yet converted into starch. It must be processed or consumed fresh. Less than 1% of corn grown in the United States is sweet corn used for human consumption.

Almost all corn grown in the United States is dent corn or field corn. Humans could actually consume more dent corn than sweet corn because products like corn syrup and corn meal are made from dent corn and are used in many processed foods.

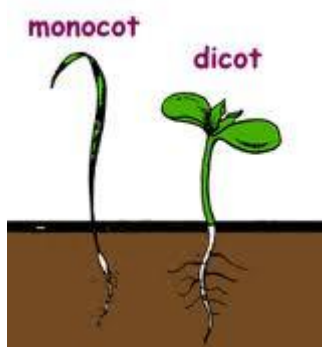
Processing corn generally begins with whole corn kernels entering a wet milling or dry milling process. Each of these processes produce byproducts or co-products that are routed

towards a final product. To produce ethanol, enzymes and water are added to milled corn and the starch from the corn kernels is converted to sugar. Then yeast and other enzymes are added and the ethanol is produced by fermentation and distillation.

Taxonomy:

Kingdom: Plantae (plants)
Subkingdom: Tracheobionta (vascular plants)
Super Division: Spermatophyta (seed plants)
Division: Magnoliophyta (flowering plants)
Class: Liliopsida (**monocotyledons**)
Subclass: Commelinidae
Order: Poales
Family: Poaceae (grasses)
Subfamily: Panicoideae
Genus: Zea
Species: mays
Subspecies: mays

Like other grasses, corn is a monocot (see the taxonomic class). Monocotyledon species have a single seed leaf or cotyledon within the seed. This is different from dicots, like soybean, which have two seed leaves or cotyledons within the seed. Generally, you can tell the difference between a monocot and dicot when the seed germinates. A monocot, like corn will have a single leaf emerging from the seed whereas a dicot will have two leaves. There are other observable differences in the leaves, stem and flowers of these two plant classes as a plant matures.



(<https://radicalbotany.files.wordpress.com/2012/03/moncot-vs-dicot.jpg>)

Safety Guidelines

Lab safety is a must! In order to safely explore Chemistry, we need to follow proper lab safety. How do you think we are going to do this? Biologists follow very strict procedures to protect themselves and they include:

- Gloves
- Safety glasses
- Lab aprons or lab coats

Before we get started:

- Be sure everyone including instructors and helpers are wearing safety glasses and gloves. An apron or lab coat are also recommended for this activity.

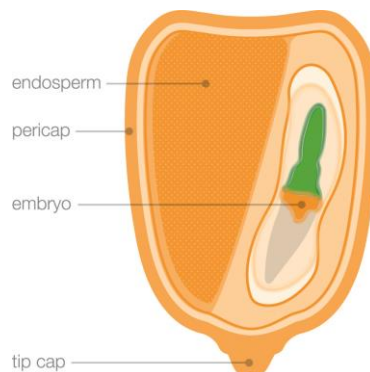
- Point out any safety features in the classroom (ie. Eyewash or emergency shower; emergency exits).
- Mention housekeeping rules – NO EATING OR DRINKING.
- Mention location of bathrooms.

The Experiment: Dissection of a corn seed

A corn seed or kernel is a good example to demonstrate the anatomy of any seed. Corn seed is made up of 62% Starch, 19% protein and fiber, 15% moisture and 4% oil. What other foods do you eat that are a seed? (soybean, beans, peas, nuts, quinoa, chia, rice, wheat, barley, millet, sunflower seeds, coffee bean, poppy seed, oats, etc.)

In dissecting a corn seed, students can observe the four main parts of a seed:

- The **tip cap**: is the part of the corn seed that attaches to the cob;
- **Seed coat or pericarp**: a thin layer that covers the entire seed and protects it from insects, disease and drying out;
- **Endosperm**: this tissue surrounds the embryo and provides nutrition to the maturing embryo during germination. It is primarily composed of starches (62%) but also contains proteins and moisture. This starch can be extracted and used for all kinds of products including the production of ethanol;
- **Embryo**: this part of the seed contains all of the genetic material for the plant and is often used in plant biotech research to introduce genes into a corn plant. This embryo contains tiny root and shoot tissue that will grow and become a plant. This is the part of the seed from which corn oil is extracted.



Materials required:

- Corn seed: 1 Tablespoon (approximately 50 seeds). Try to get large kernels of dent corn which you may be able to find at a seed retailer. Alternatively, use dried whole corn seed that is intended to feed squirrels, deer or livestock.
- Paper plate or tray

For the instructor: Soak dried corn seeds in advance

Typical dried corn seed should be soaked in water for 24-48 hours beforehand so that the seed tissue will soften and be easier to dissect. Keep moistened until you are ready to dissect. Give each student three or four seeds to dissect.

For the Student:

Step 1: Remove the tip cap and pericarp

Over your paper plate or tray, use your fingernail to pull off the tip cap of the seed (this is where the kernel was attached to the cob). As you pull off the tip cap, you may notice a thin

layer of the translucent seed coat or pericarp. Peel off as much of this seed coat as you can and observe how it covers the entire seed.



Endosperm
and embryo

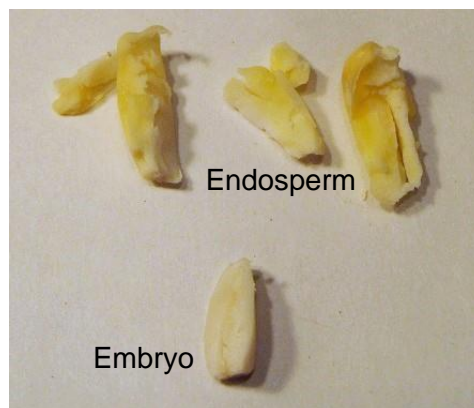
Pericarp

Tip cap

Step 2: Remove the endosperm and isolate the embryo

On one side of the seed, you may observe the area where the embryo is located. This may look like a lighter colored triangle or oval shape. The objective is to isolate this embryo. Use your fingernails and fingers to remove as much of the endosperm of the seed until you are left with the small embryo. The embryo may only be the size of the tip of a pen.

If you were to examine this corn embryo closer, you may observe tiny root and shoot tissue. These embryos can be isolated and used in plant research. In fact, you can grow an entire full sized corn plant from just this tiny portion of the seed but you will have to grow it in media that will replace the starch and other molecules that were present in the endosperm.



Supplemental Activity: Corn Products

For the instructor:

This activity demonstrates the variety of products that are made from corn. These items could be part of display or passed around to students. Ask the students to try and identify the ingredient that is made from corn by reading the ingredient list on the label. Ask the students to list the corn ingredients on a flip chart or bulletin board.

Here is a list of suggested products (from easiest to identify to more difficult):

- Popcorn
- Corn oil
- Corn Meal
- Grits
- Doritos ®: corn, corn oil, maltodextrin, dextrose, corn flour, MSG can be made from corn
- Trix Cereal® or other breakfast cereal: Whole grain corn, Corn meal, Corn Syrup, (many sweeteners are derived from corn)
- Cat food or dog food: corn gluten meal (citric acid and tocopherol). Most pet food and animal food contain corn meal and other corn based ingredients. (40% of corn grown in the US is used in animal feed-pigs, cows, chickens, etc.)
- Coke® or other cola: High fructose corn syrup, caramel color
- Toothpaste: sorbitol
- Splenda® and Equal®: dextrose, maltodextrin
- Bubble Yum® or other chewing gums: corn syrup, high fructose corn syrup, caramel color
- Lotion: may contain lots of plant based ingredients (like oils, extracts and scents), cellulose, sorbic acid and propylene glycol can be made from corn
- Shampoo: citric acid and propylene glycol can be made from corn
- Lip balm: lots of plant based ingredients, tocopherol can be made from corn
- Cosmetics/eye shadow: magnesium stearate and glycerin can be made from corn, sometimes talc includes corn starch although not listed in the ingredients

Did you Know?

- Corn can also be used to make PLA, polylactic acid which is a type of bioplastic that is biodegradable. BASF makes a ecoFlex® -a polymer that is mixed with PLA to make biodegradable plastics.
- Also mention that 30% of corn grown is used for ethanol production. Ethanol is an alternative fuel that can reduce greenhouse gas emissions. The primary bi-product from making ethanol goes into animal feed. Starches from corn seed are used in all kinds of industrial applications and may be part of the paper you are using.

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| Summary: |
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Corn is a staple crop across the world. Not only does it provide food for humans and animals but has a multitude of other uses. The embryo or germ is used to make vegetable oil. The starch from the endosperm is used in the production of ethanol and other distillation products. It can also be used to make sweeteners and other food additives. Milled corn is also used to make ingredients in paper, building materials, medicines, cosmetics and many other items. There is a good chance that you have encountered an item made from corn every day.