DNA In Agriculture TODAY

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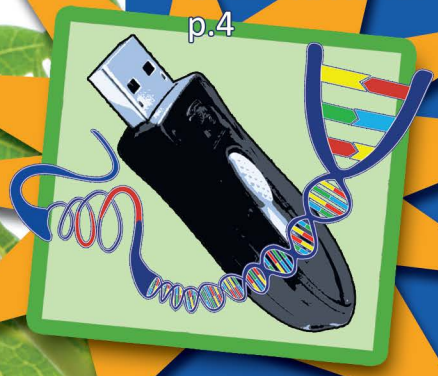
INSIDE :



Powerful Papaya Protection

Scientists help Hawaii's papaya build a strong defense. p.11

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GLOSSARY

Look here for definitions of words that are highlighted in **PURPLE** .

Adapt – The ability of an organism to survive in its environment due to evolutionary changes over time.

Agriculture - The production of plant and animal products for human well being.

Allele – One of the different versions of a gene.

Bt - (*Bacillus thuringiensis*) A soil bacterium that has been used to genetically engineer insect resistant crops.

Biofuels - Renewable fuels made from recently living plant and animal sources.

Bioplastics – Plastics that are made from renewable resources such as plants instead of fossil fuels.

Breeders – Specialists who use knowledge of plant traits and genetics to develop plant varieties.

Chromosomes – Structures in the cell nucleus that hold and organize the genetic material of an organism.

Clones – Organisms that have the same DNA.

Conventional (farming) - The most common form of agriculture, it makes use of man-made chemicals, genetic engineering, and industrial methods for higher yields and profit.

Crops – Plants grown for human and animal consumption and use.

Cross-pollination – The movement of pollen from one plant to another. Plants must be related for fertilization to occur.

DNA- (deoxyribonucleic acid) The molecule that carries the genetic information for all living things.

Fossil fuels – Products such as petroleum, coal or natural gas that were formed from the remains of plants or animals that lived long ago.

Gene – A DNA sequence that provides the instructions for a specific protein.

Gene flow – The transfer of genes from one population to another, usually through pollen.

Gene gun – A genetic engineering device used to insert genes into cells.

Gene pool – All the genes and their different alleles in a population of a species.

Genetic diversity – The amount of genetic difference between organisms.

Genetic engineering (GE) – A technology where changes are made directly to to the DNA of an organism.

Genome – The complete genetic informationof an organism.

Hybrid – The offspring from two different varieties of a plant. Hybrids of plants such as corn are stronger and more productive than the parent plants.

Molecules – A group of atoms held together by chemical bonds. DNA is a long molecule.

Mutagenesis – A process where the genetic information of an organism is changed by the use of chemicals or radiation.

Mutations – Permanent changes in the DNA of an organism.

Organic (farming) – A form of farming that promotes the use of natural chemicals and biological methods. It doesn't allow irradiation, man-made chemicals, or genetic engineering.

Organism – Any individual living thing.

Protein – A complex molecule made up of amino acids that organisms need to grow and function.

Resistance – A genetic trait that gives a plant the ability to defend itself against pests and diseases.

Sustainable agriculture – The use of farming methods that meet present human needs while protecting natural resources for future generations.

Trait – A characteristic of an organism.

Transgenes – Genes that have been moved from one organism to a different organism.

Varieties (plant) – Plant groups that belong to the same species, but can be told apart by different inherited traits. For example, Fuji and Red Delicious are different varieties of apples.

Pack your Plants

Take a look around your room. Almost everything in it is made from plants. Without plants you would not have sheets on your bed or paint on your walls. Your books would have no pages. The t-shirts and blue jeans in your closet would not be there. Even the gum you are chewing would disappear.

Most plastics are made from **fossil fuels** and have a negative impact on the environment. Scientists are now working to make plastics from corn and other plants. These **bioplastics** are better for the environment because they use less energy and generate fewer greenhouse gases. Bioplastics are being used for cell phones, plastic bottles, disposable utensils, packaging and even car parts. The goal is to make bioplastics that are recyclable and can even be composted in your backyard.

DNA: Where cells go to know how to grow!

The information for how every living thing looks, lives, and grows is found in its **DNA**. The DNA **molecule** is a long chain of smaller molecules. The order of these smaller molecules decides whether the **organism** grows into a mongoose, a mango, or a man.

1. Cells

Each **cell** holds a complete set of **DNA** for that organism. Different parts of the DNA molecule are used depending on the function of that particular cell.

4. Bases

DNA contains four smaller **molecules** called the **bases** A, T, G, and C. The order of the bases is different in each gene. A **gene** is thousands of bases long, so just these four molecules can be arranged to provide the instructions for all living things.

Find the words that are underlined on this page.

C	H	R	O	M	O	S	O	M	E
S	M	A	S	K	Z	P	S	P	O
E	R	O	D	T	R	E	O	J	R
S	H	L	L	O	N	C	H	A	G
A	O	I	T	E	S	A	U	G	A
B	D	E	G	O	C	E	L	L	N
V	I	N	R	W	J	U	A	P	I
N	C	C	A	Q	T	I	L	D	S
V	I	S	T	I	A	R	T	E	M
M	L	P	M	K	Z	G	T	D	S

2. Chromosomes

The DNA molecule in **plants** and animals is organized into long strands called **chromosomes.** The chromosomes coil up into shorter worm-like packages when the cell is about to divide. This is when they can be seen under a **microscope**.

3. Genes

Each **chromosome** has specific areas called **genes**. A gene is a single set of instructions, usually for a **protein**. The different **traits** of plants and animals may be from a single gene or a combination of many genes.

CODE VS CODE

How does the information held in a 1 GB flash drive compare to the information contained in a cell's DNA?

A **1 GB flash drive** holds 1 billion bytes. Each byte has 8 bits. A bit is either a 0 or a 1. The order of the 0s and 1s carries information.

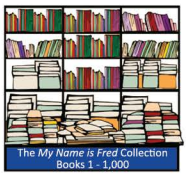
The order of the 8 bits in each byte can be translated into a number or letter.

Letters are combined to make words. To write a 5 letter word you would need 5 bytes.

Hello

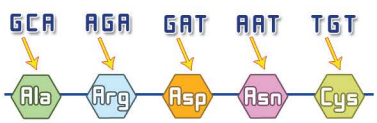
Hello, my name is Fred.

Words are combined to make sentences.



Sentences are combined to make books. A 1Gb flash drive can hold the information for a pick-up truck full of books.

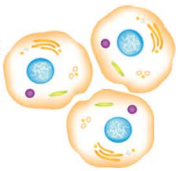
The human **genome** holds about 25,000 genes. Each gene is made up of thousands of base pairs (the molecules A, T, G, C) The order of the four bases carries information.



Genes are copied to messenger RNA (mRNA). The mRNA is read in groups of three called a codon. Each codon is a code to tell the cell which amino acid to add to a growing chain.

The long chain of amino acids folds into a protein.

Proteins combine to make cells and to control cell function.



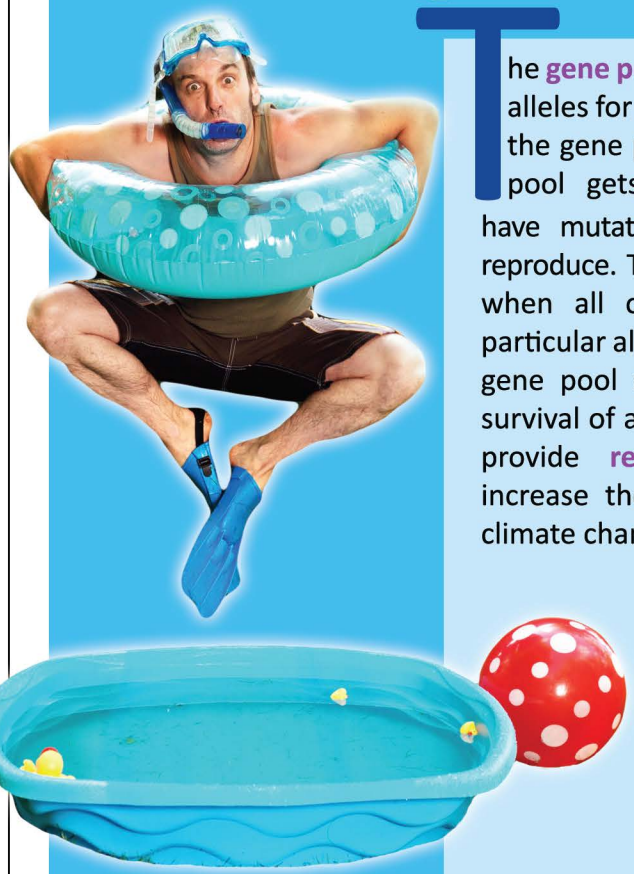
Cells combine to make people. The DNA in one cell provides the information for a person to grow from a single cell and to function throughout a lifetime.

Changes make a difference!

Mutations are permanent changes in the DNA sequence. Mutations to the order of the A, T, G, C bases can result in different versions of a particular gene. The different versions of a gene are called **alleles**. One reason individuals of the same species do not have exactly the same traits is because they have different alleles.

The color of fruits and vegetables is usually controlled by more than one gene, and there may be several alleles for each gene. The first cultivated carrots came from the area of Afghanistan and were purple or yellow. Traders carried them to Europe and the Mediterranean, where mutations occured or they were crossed with wild varieties. This resulted in the orange carrots we are familiar with. Carrots may be white, yellow, orange, red, or purple, depending on the combination of alleles that they inherit.

Jump into the Gen



The **gene pool** for a species is all of the alleles for all of the genes. The size of the gene pool can change. The gene pool gets larger when organisms have mutations and then survive to reproduce. The gene pool gets smaller when all of the organisms with a particular allele die out. The size of the gene pool can be important for the survival of a species. Some alleles may provide **resistance** to disease or increase the chances of adapting to climate change.

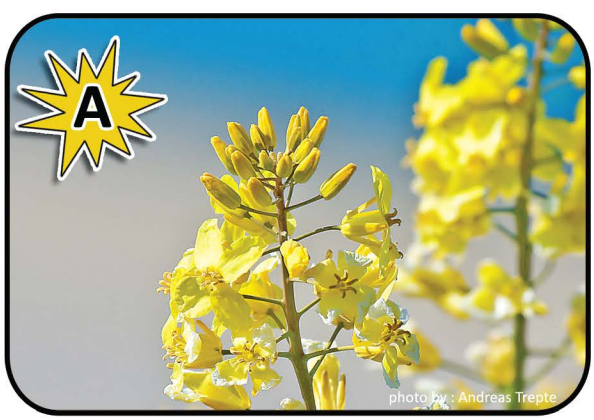
A large gene pool is important for farming. For instance, there is a fungus called stem rust that attacks and damages wheat **crops**. Spores from the fungus travel long distances by wind. It is now in Africa and the Middle East and is expected to spread into Europe and Asia. Some wheat **varieties** do not get sick from this disease. Scientists are trying to identify the genes that make these varieties resistant. Identifying these genes will help them to develop additional resistant varieties.

BACK IN THE DAY

Our food crops are very different from the original plants that were found in the wild. Over thousands of years farmers selected traits that made the plant taste better or produce more. See if you can match the food plant with the wild relative it started like.

Plant	Letter
Corn	_____
Lettuce	_____
Carrot	_____
Broccoli	_____

*Answers on pg. 7



e Pool

Unfortunately, the use of **agriculture** can shrink the gene pool of crops. Farmers may choose to grow the variety that gives them the most profit instead of a mixture of different varieties. The unique alleles of plants that are no longer grown can be lost forever. The wild relatives of our farm crops are another source of **genetic diversity**. The genes of these wild relatives can be lost when more land is cleared for farming.

The loss of genetic diversity in crops increases the risk that crops won't be able to resist diseases or **adapt** to climate change. Damage to major food crops could cause severe food shortages.

Scientists are using many tools to increase genetic diversity. Less popular varieties are being saved. Food crops are being crossed with wild relatives. **Genetic engineering (GE)** is adding genes from other organisms. These efforts will help us to have enough food to eat in the future.

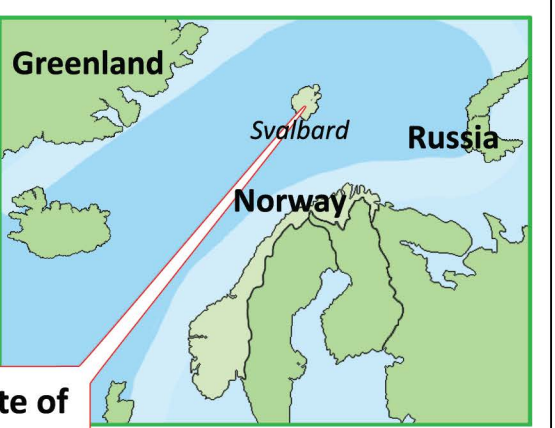
SEED VAULT

Many countries use seed banks to keep crop seeds for research and to protect the crops from extinction. The problem is that many of these seed banks are damaged because of disasters or war. The Global Seed Vault opened in Norway in 2008 as a backup for local seed banks. Countries deposit packets of seeds and can later withdraw them if all of the other sources of the seeds are destroyed.

While the Global Seed Vault focuses on seed storage in case of disaster, other seed banks have working collections. These seed banks collect thousands of seeds and keep track of the traits of each plant. The seeds can then be used as gene sources. Plants with a desired trait are grown and used to create new varieties that meet the needs of the farmers in each country.

Location, Location, Location ...

The vault is tunneled into solid rock at a location that is high above rising sea waters and deep within the permafrost. It is designed to withstand earthquakes and nuclear blasts and will hold over 3 million types of seeds when it is full.

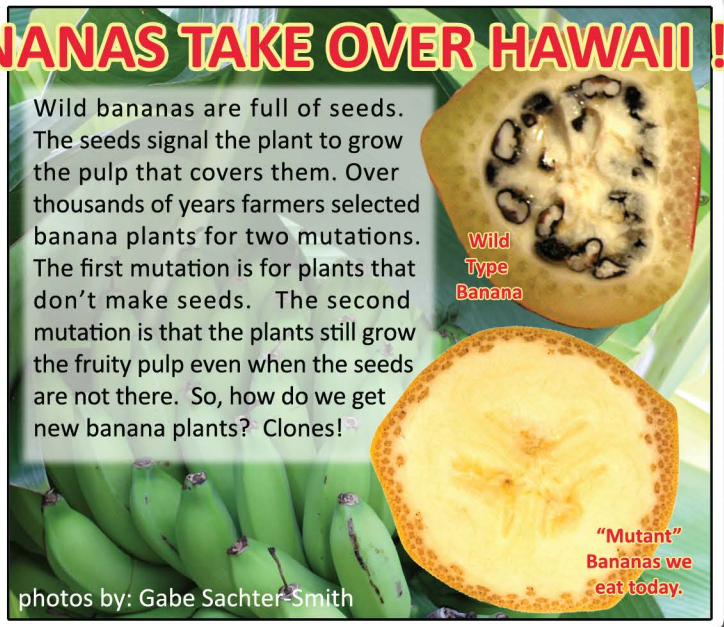


MUTANTS!

The crops we eat look very different from their wild relatives. These changes are a result of mutations and selection. Mutations changed plants so that they had different traits. Farmers then selected and nurtured plants that produced more food, were tastier, or were easier to grow.

Plants are still changing. Farmers and **breeders** keep an eye out for plants with useful new traits. Plant breeders then cross these plants with other plants to create new varieties. Breeders love mutations because they get to work with a larger variety of plants. We love mutations because they have given us good food to eat.

MUTANT BANANAS TAKE OVER HAWAII !!!



WHAT DO CHIHUAHUAS & CHILI PEPPERS HAVE IN COMMON? MUTATION OF COURSE!

If all dogs descended from wolves, why do they look so different? Scientists have identified a section on chromosome 15 that small dogs share. They believe that this genetic mutation resulted in small dogs that were then bred and traded. Small dog breeds were developed for hunting small rodents and for living in houses with people.

Not all peppers are hot stuff. A deletion, or loss of a piece of DNA, in front of a gene on chromosome 2 makes them mild. Peppers that have the deletion cannot make capsaicin, the chemical that makes peppers hot. Wild chilies are hot to stop animals from eating them. Selecting and growing plants with the mild trait has kept the mutation in the gene pool.

Answers to **Back in the Day**: Corn = D, Lettuce = B, Carrot = C, Broccoli = A

MORE MUTATIONS PLEASE :

A radiation source at the center of this gamma field is used to force mutations in plants.

Plant breeders can make mutations happen faster with a process called **mutagenesis**. Radiation or chemicals are used to change the DNA. The goal is to cause changes in the sequence of the base pairs (A,T,G,C) so that the plant will make different proteins. These proteins may combine to make different traits. Plant breeders must grow and evaluate each plant to see if the changes give them something they want.

The main problem with mutagenesis is that there is no way to control exactly which changes will occur, and it may be difficult or impossible to get a specific trait.

Mutagenesis has been used to develop some varieties of the foods you eat, including apples, Asian pears, and pink grapefruit.

CLONES!

Once farmers get a plant that people like, they want to grow more of the same plant. Often they can grow more plants from seeds. Seeds are a product of sexual reproduction where the pollen (male part) fertilizes the ovule (female part) of the flower.

What is a CLONE?

Clones are organisms that have the same DNA.

When you eat bananas, apples, potatoes, grapes, pears, and peaches, as well as many other plants, you are eating clones.

However, plants grown from sexual reproduction have a random combination of genes from the parent plants. This means they may not end up with the traits that people want. To get exactly the same traits, growers start the next generation of plants from a piece of the parent plant. The new plant has the same DNA and the same traits. It is a **clone**!

A CLONE OF YOUR OWN

Cloning doesn't just happen in the laboratory. It's easy and fun to do. Next time you eat a pineapple, follow these simple steps:

1.) Break off the top of a pineapple, making sure there is no fruit attached.

2.) Let it dry for a few days and then strip off some of the lower leaves to bare the stalk.

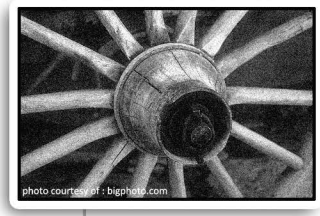
3.) Place the pineapple top in a glass of water. Change the water every few days. In 3 weeks roots should be growing .

4.) Plant your pineapple clone in potting soil.

Answer to "What Could it Be?" (Back Page): Carpeting, fireworks, batteries, chewing gum, and toothpaste all contain corn as an ingredient.

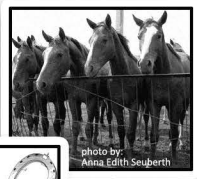
Getting There

Technology makes our lives easier and more enjoyable. You are familiar with how transportation has changed to be faster and safer. Agriculture has also had tremendous changes. These changes have allowed fewer farmers to grow more food. Check out this timeline comparing the changes in transportation to the changes in growing corn.



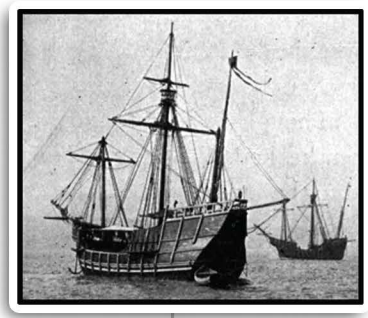
3500 B.C.

On the Move
Fixed-wheel carts were the first wheeled vehicles.



770 A.D.

GiddyUp!
Horseshoes improve travel by horse.



1492 A.D.

Off to Sea
Explorers like Christopher Columbus used Caravel ships for their long ocean voyages.

1801

Chugging Along
The steam-powered locomotive is invented.

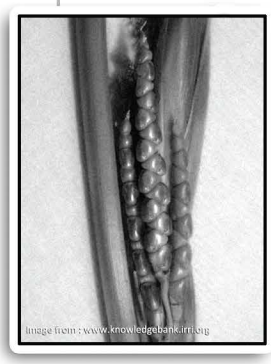
1769

On the Road
The first self-propelled road vehicle was invented-and crashed.

B.C. | A.D.

4000 B.C.

In the Begining
Natives of Mexico gather teosinte, the wild ancestor of corn.



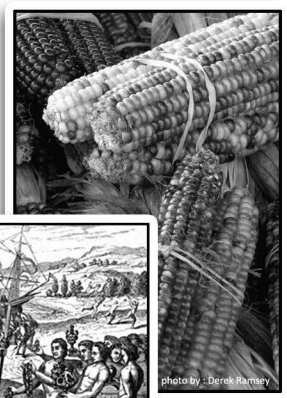
900 A.D.

Time to Grow
Tesointe becomes corn as Native Americans select for the best traits.

Corn is no longer wild. It depends on humans for survival.

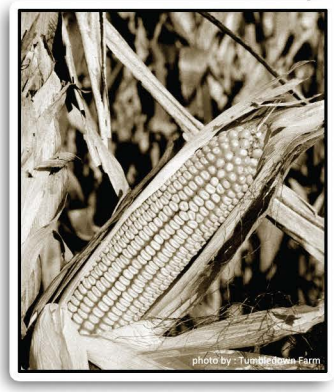
1492 A.D.

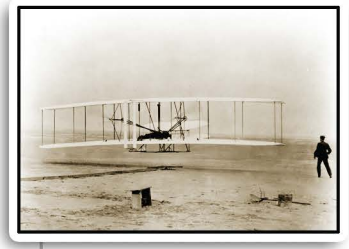
On the Move
Explorers from Spain learn about corn in the New World and send it back to Europe.



1847

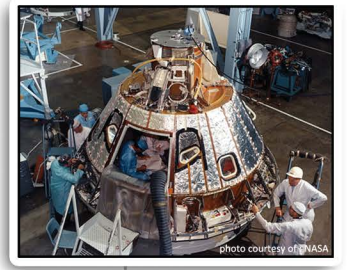
Happy Accident
Farmers acidentally discover that cross-breeding two different kinds of corn makes dent corn. This hybrid variety resists disease and grows better, so farmers can grow a lot more of it!





1903

Up, Up and Away
The Wright brothers invent the first engined airplane.



1969

A Giant Leap
Apollo 11 is the first manned mission to the moon.

Going Green
Tata Motors of India is developing the Air Car. It runs on compressed air and is emission free.

2010

1908

America on Wheels
The Model T Ford is the first mass produced, gas powered vehicle.

1970

It's a Bird! It's a Plane!
It's : The "City of Everett," the first Jumbo jet put into service.

1968

Sweet!
Corn is used to make high fructose corn syrup, a syrupy liquid that costs less and is easier for many companies to use than sugar. More corn is grown to meet the demand for sweet treats.

1976

We Need MORE Corn!
Dent corn becomes the main food for large-scale cattle farms. People want more meat so more corn is grown to feed cows.

1995

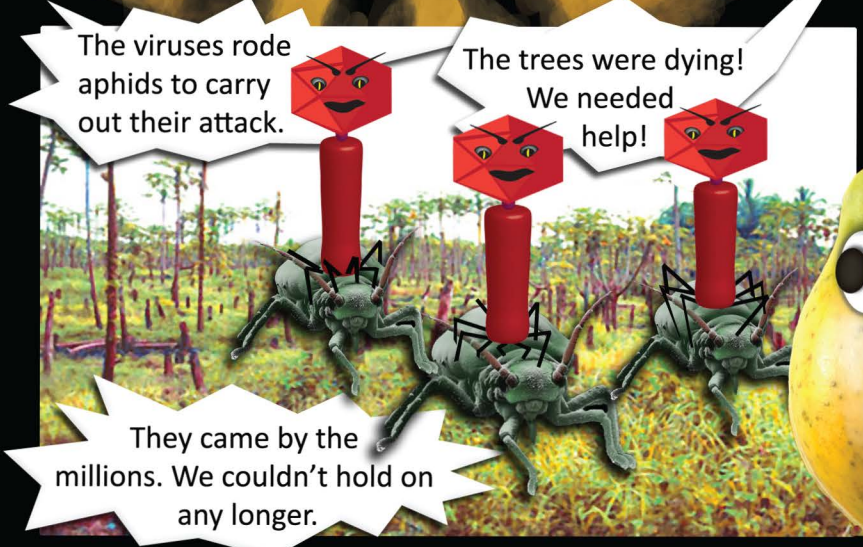
The Next Level
The EPA approves the sale of the first genetically engineered (GE) corn. A gene from Bt bacteria is transferred to the corn to make it more insect resistant. Farmers choose GE corn because it is easier to grow.

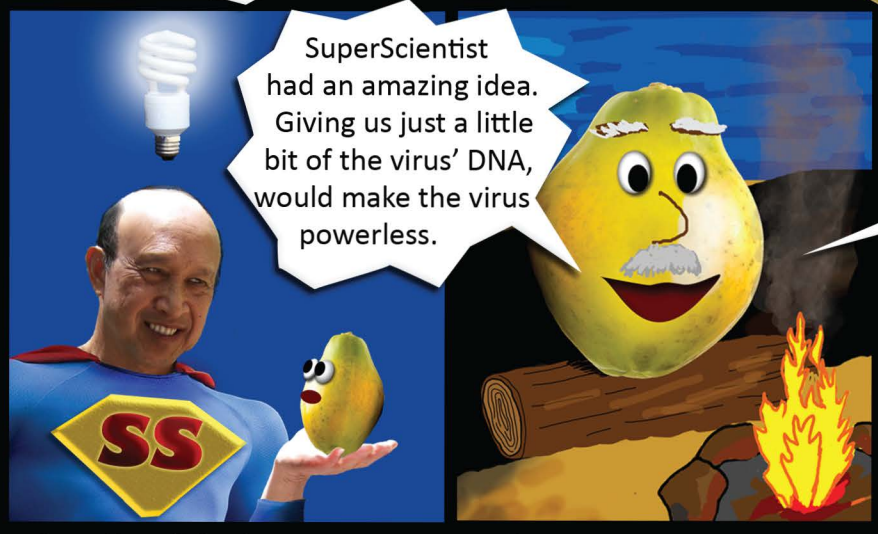
Grow for It!
Corn that is genetically engineered to need less water is in its final phase of testing.

2010

PAPAYA WARS

A long, long time ago...in 1992...the deadly ringspot virus descended upon the unsuspecting papaya of Puna. The helpless plants were being annihilated. Scientists had discovered a new technology to fight the virus. Were they able to use the powers of genetic engineering in time?





Crossword Answers (Back page) : Across - 3.organic, 7.genes, 9.sustainable, 12.genetic engineering, 14.mutagenesis, 15.bioplastics, 16.clones, 17.chromosomes, 18.genome **Down -** 1.mutations, 2.crops, 4.gene gun, 5.varieties, 6.transgenes, 8.trait, 10.agriculture, 11.DNA, 13.protein

HOW does it WORK?

What are...

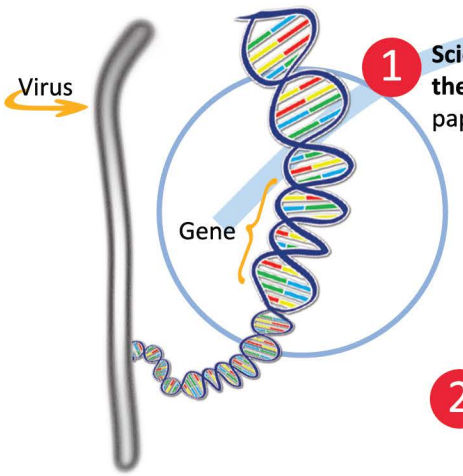
Genetic Engineering?
The process of making changes directly to the DNA of an organism.

and

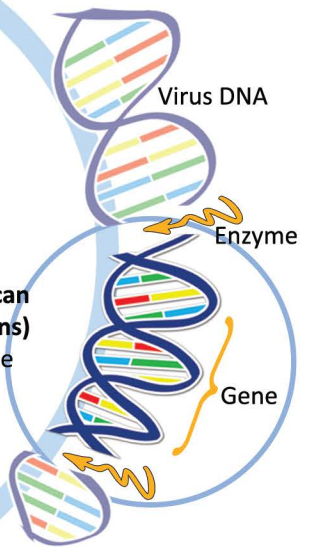
Transgenes?
Genes that have been moved from one organism to a different organism.

example:
a gene moved from a virus into the DNA of a plant.

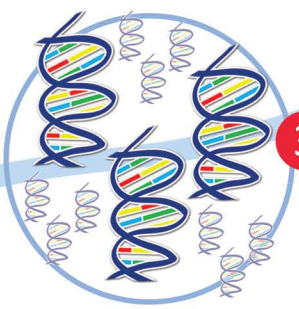
Inserting a single gene from the ringspot virus into papaya DNA made the papaya resistant to the virus. Let's take a closer look at how papaya was genetically engineered...



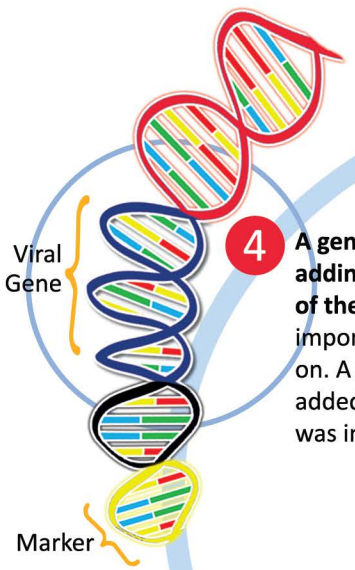
1 **Scientists identified a gene from the virus** that could give the papaya resistance.



2 **Enzymes (proteins that can control chemical reactions)** were used to cut the gene out of the virus DNA at specific ponts.

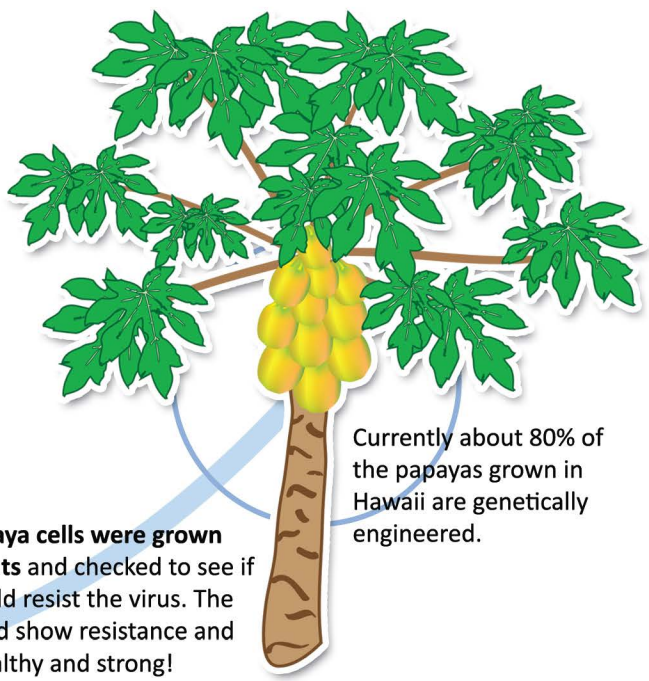


3 **The viral gene was copied.**



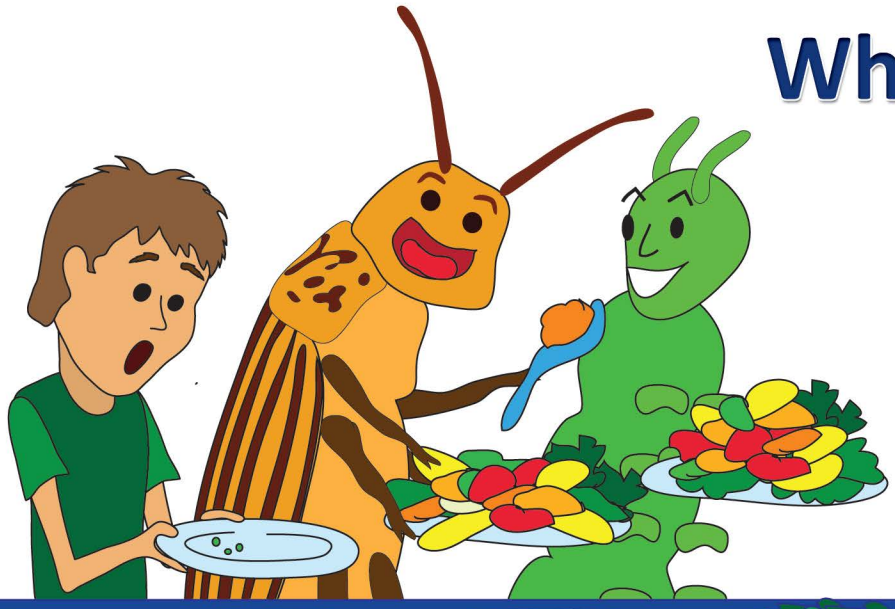
4 **A gene package was created by adding other DNA to both ends of the viral gene.** This DNA is important for turning the gene on. A marker gene was also added to show if the viral gene was inserted successfully.

5 **Microscopic gold pellets were coated** with the virus gene package and shot into papaya cells using an early version of the **gene gun** pictured here.



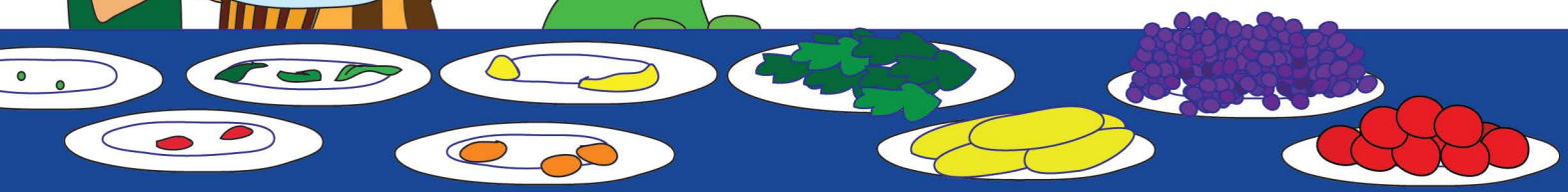
Currently about 80% of the papayas grown in Hawaii are genetically engineered.

6 **The papaya cells were grown into plants** and checked to see if they could resist the virus. The plants did show resistance and grew healthy and strong!



Who's cockroaching our dinner?!?!

Insects LOVE to grind our food! Farmers have several choices for how to control these pests. One choice is to spray insecticides, but these chemicals can be toxic to the environment and to us. Another option is to use natural controls such as other insects to eat the bad insects, but they are not always available. A third option is to genetically engineer a natural pesticide into the plant itself.



Bt Blasting Bugs since 1996

A soil bacterium called Bt (*Bacillus thuringiensis*) kills certain insects like the European corn borer caterpillar. Farmers have been spraying this bacteria on crops as a natural pesticide for over 50 years. Bt makes a protein that caterpillars can't digest. The insect's guts freeze up and it dies. Using genetic engineering, scientists moved the Bt gene that makes the toxic protein directly into the DNA of plants such as corn and cotton. Now the insect can't eat the plants.

Percentage of U.S. Corn with Bt Gene

American farmers grow approximately 250 million metric tons of corn each year. Most of this corn is grown for animal feed, food, and ethanol. Bt corn was first introduced in 1996 and has proved to be popular with farmers. The graph shows the increase in the use of Bt corn over just a decade.

What happens to me when I eat Bt corn?

Nothing. The Bt protein binds to cells found in the insect's guts. We do not have that type of cell so there is no place for the protein to stick to. Only certain insects are affected by Bt. Birds, fish, mammals, and most other insects are not harmed.

Almost all of the foods we eat contain DNA. Our bodies break the DNA down into smaller molecules during digestion. Our bodies use these smaller molecules for nourishment. The plant DNA does not change our DNA.

GE for Food and Fashion

Your favorite t-shirt is probably GE. In fact, 88% percent of all cotton grown in the U.S. in 2009 was genetically engineered to control caterpillars and/or weeds. The Bt gene makes cotton resistant to the cotton bollworm. Scientists have also added a gene that makes it easier to control weeds. This gene allows farmers to spray an herbicide on the weeds without harming the young cotton plants.

Would you like fries with that?

Potatoes have been genetically engineered to resist beetles and fungus, but nobody grows them. Why?

McDonalds was using a mix of genetically engineered and non-genetically engineered potatoes. Groups that were against genetic engineering put pressure on McDonalds to stop selling genetically engineered French fries. McDonald's did not want bad publicity so they decided to stop buying GE potatoes. McDonalds buys more than 3 billion pounds of potatoes each year (worldwide) so farmers were worried they wouldn't be able to sell GE crops. With no farmers buying the seed potatoes, GE potatoes were taken off the market.

Ooo, Controversy!

Even technologies that are great can have a bad side. Think about the inventions that you use every day. Cars take us where we want to go, but they also cause pollution. Television can entertain us, but we might get fat if we sit and watch too long. Cell phones help us keep in touch, but they can also distract drivers.

People wonder if genetically engineered (GE) foods will have negative long-term effects. They would like to see more research before the foods are grown or sold. Look at some of the questions people are asking about GE foods and see what YOU think.

Should we change Nature?

Some say "No"

Nature only allows closely related plants to reproduce. We don't fully understand how genes interact and turn on and off. If problems show up later, it may be impossible to undo any damage.

Some say "Yes"

People have always changed the environment to meet their needs. Genetic engineering allows us to use the gene pool of all living things to improve crops.

What about allergies?

Each gene is the code for a protein. Some people are allergic to certain proteins such as those found in peanuts, milk, and wheat. There is concern that introducing new proteins into foods will cause some people to have allergic reactions. Scientists test for allergies as part of the approval process.

Steps to allergy testing

1. Look at the source of the gene to see if it is from something that people are allergic to. If it is, the GE food needs to be tested on people who have these allergies.
2. Compare the protein that the gene makes with proteins that are known to cause allergies. If the protein is similar, more testing is needed.
3. Test how quickly the protein breaks down in artificial stomach juices. Proteins that don't break down quickly are more likely to be allergens.

Testing makes the risk of allergies low, but it is possible that some individuals could have reactions to new proteins in a GE product.

Are GE foods safe to eat?

Some say "No"

We do not know how combinations of genes will interact over a long time period. Human testing is not required before a GE food is approved.

Some say "Yes"

GE foods are compared to the non-GE version of the same food. Foods are tested for nutrition and the risk of allergies. There are no known cases of harm to humans from eating GE foods.

Label it? It bothers many people that they can buy GE foods without knowing it. They want the label to say if there are GE ingredients. The Food and Drug Administration does not think labeling GE foods is necessary because there is no evidence that these foods are unsafe. Labeling might make people think there is a problem when there isn't one. Do you think GE foods should be labeled?

Nuts!!!

Nuts are one of the most common food allergies. A big problem is that they are often mixed into other foods, making them difficult to avoid.

About 2% of people are allergic to a protein found in peanuts. For some of these people eating just one peanut can be life-threatening. Genetic engineering may one day remove the allergy-causing genes from foods like peanuts.

Should we worry that transgenes can spread?

Some say "Yes"...

Genetic changes are passed on to the next generation. This means that pollen from a GE plant can carry the transgene to non-GE varieties. This movement of DNA is called **gene flow**. Gene flow can be a problem for growers who do not want to grow GE crops. Some plants have pollen that is blown by the wind or carried by bees. Transgenes can also spread to wild plants.

Some say "No"...

First, **cross-pollination** can only happen with closely related plants. Gene flow can be controlled by spacing crops and timing when they are planted so that they can't cross-pollinate.

The United States Department of Agriculture checks to see if cross-pollinaton with wild plants is likely to cause problems before GE plants are approved.

Should GE plants be patented?

Some say "No"...

They believe it is not right to give someone ownership of a living thing. Also, farmers have traditionally been able to save seed to grow plants for the next year. Because GE plants have utility patents, the farmers must agree not to save or share the seeds they have grown. Patents may put too much control of the food supply in the hands of just a few companies.

Some say "Yes"...

A patent gives an inventor the right to stop other people from using their idea. Patents are important because they encourage people to invent new products or ways of doing things. People are more willing to invest time and money in ideas if their rights are protected. New varieties that are not genetically engineered are also patented. These patents last 20 years.

Most American farmers purchase new seeds each year in order to get highly productive hybrids. They can choose from both GE and non-GE varieties. The GE patent holders only get paid if the farmer chooses to pay the higher price for GE seed.

Plants that are developed at public universities do not have as many restrictions. The scientists who developed virus resistant papaya at the University of Hawaii gave their rights to the papaya growers.

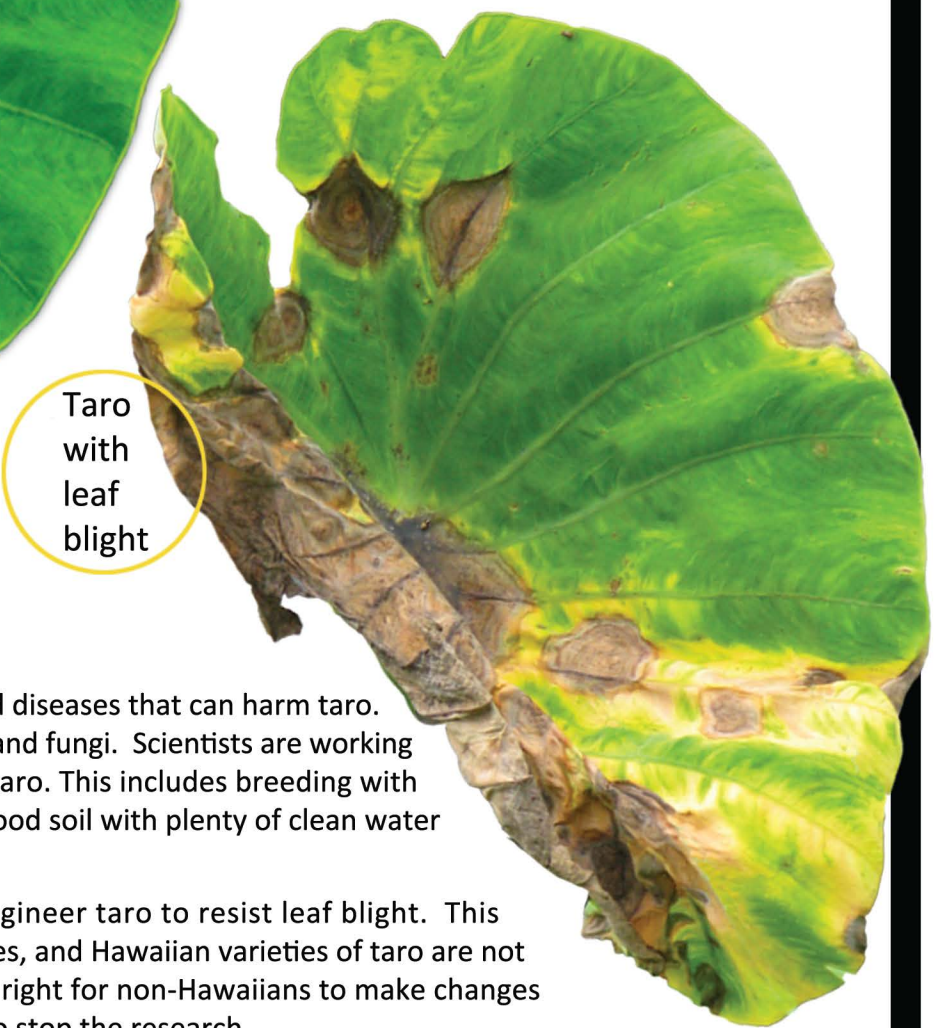
Who Owns It?

We eat a large variety of foods from all over the world. The crops we enjoy were identified, grown and improved by native farmers over many generations. Cultures developed around the protection and care of these crops. Cultural practices passed crop knowledge from generation to generation. This is why foods are tied to cultural identity.

Some people believe it is wrong to give a patent to a food crop. The holder of the patented variety has more rights than the cultural group who worked with the crop for thousands of years. There are also concerns that transgenes will spread to native or culturally important varieties. People are concerned that this could affect both the cultural identity and ownership of the crop.

No GE Taro

Kalo (Hawaiian word for taro) is an important crop for the Hawaiian people. In addition to being a major food source for early Hawaiians, it played an important role in cultural practices. The Hawaiian creation story teaches that man is supposed to respect and care for kalo.



Unfortunately, there are many pests and diseases that can harm taro. These include non-native aphids, snails, and fungi. Scientists are working on many methods to protect Hawaiian taro. This includes breeding with varieties that have natural resistance. Good soil with plenty of clean water also helps the plants to stay healthy.

Research was started to genetically engineer taro to resist leaf blight. This disease has destroyed taro in other places, and Hawaiian varieties of taro are not resistant. Hawaiian groups felt it wasn't right for non-Hawaiians to make changes to taro. They protested and were able to stop the research.

What do you get when you cross...

Researchers are considering many sources of genes. Look at these examples of plants currently being researched.

with

You Get :

Tobacco leaves that zap bugs.

The gene for spider venom is transferred to tobacco plants.

The plant makes a venom protein that is toxic to insects.

This research may lead to new ways of fighting insects.

with

You Get :

Corn that doesn't stress out over dry weather.

One of the concerns about global warming is that there will be more dry weather. Plants make less corn if they don't have enough water, but this GE plant would still make plenty of corn in dry spells.

What do you think?

DNA is DNA, but some people are more comfortable with some uses of genetic engineering than others. What do you think about moving genes from an animal or bacteria to a plant? Do you feel the same way about moving genes from one rice plant to another rice plant? Genetically engineered plants are used for many products other than food, such as plastic and fuel. Does it make a difference to you what the plant is going to be used for?

with

You Get :

Rice that tastes good and can survive floods.

One of the problems poor farmers in Asia face is that rice may drown if there is extended flooding.

Some kinds of rice don't drown as easily, but people don't like the way they taste. Scientists selected the gene that keeps rice from drowing and put it in the popular rice.

You can make it!

Can You Taste It?

About 70% of processed foods such as crackers, cookies, and cereal, contain genetically engineered (GE) ingredients. Do this blind taste test to see if you and your friends can taste the difference between foods that contain GE products and those that don't.

Materials

8 small Cups * Marker to write on cups

*Buy cookies, chips, cereal, and cheese that are labeled Organic. Organic foods do not have GE ingredients.

*Also buy some cookies, chips, cereal, and cheese that are GE. They should look the same as the organic food, but not labeled organic or GMO-free. Read the labels. You can assume it is GE if the food contains ingredients from corn, soy or canola. Cheese that contains chymosin, an enzyme that makes the cheese hard, is GE. Chymosin is made by GE bacteria.

Directions

1. Write the letter "A" on 4 of the small cups. Then write the letter "B" on the 4 other cups.
2. Put organic cheese in an "A" cup and GE cheese in a "B" cup. Repeat with the other foods, so that the organic food is in the "A" cup sometimes and the "B" cup sometimes. Make a list to keep track of which food has what letter.
3. Explain what GE foods are to a friend. Then have them taste the food samples in sets. Ask your friend if sample "A" or sample "B" is GE. Record their answers for each food.

Results

*How many samples did your friend guess were GE?
*How many answers were right?
*Was your friend able to taste the difference between GE and non-GE foods?
*Do you think there is a taste difference?

Answer

The genes that have been moved into soy, corn, and canola help the farmer to grow the crop more easily. These genes DO NOT change the flavor of the food. Any differences you tasted were due to brands having different recipes for their products. Whole foods, like papaya, may not taste the same because you are eating different varieties of the plant.

Corn Plastic

Plastics made from fossil fuels cause damage to the environment. Scientists are working to develop bioplastics from plants such as potatoes, corn, and grass because they can potentially use less energy to produce, break down in the soil, and are less toxic to marine life. Follow these directions to make a simple plastic. Factories that produce bioplastics use more complex processes to get plastic that is harder and lasts longer.

Materials

1 Paper cup
1 Tablespoon cornstarch
2 Drops corn oil
1 Tablespoon water
2 Drops of food coloring
A Microwave oven

Directions

1. Put the cornstarch, oil, and water in the cup.
2. Stir until smooth.
3. Add 2 drops of food coloring to the mixture and stir.
4. Microwave the cup on high for about 25 seconds.
5. The mixture will be very hot. Let it cool and then remove the plastic from the cup.

Adapted from Utah Agriculture in the Classroom

The Sustainable

Farming usually depends on fossil fuels and uses water and other natural resources. As the need for food increases, there is going to be increased competition for land, water and energy. Agriculture must become more sustainable. The goal of sustainability is to meet the needs of the present generation without harming the environment or the ability of future generations to meet their needs. This page shows what a sustainable farm might look like in the future.

Plants use solar energy to convert water, CO_2, and nutrients into plant material.

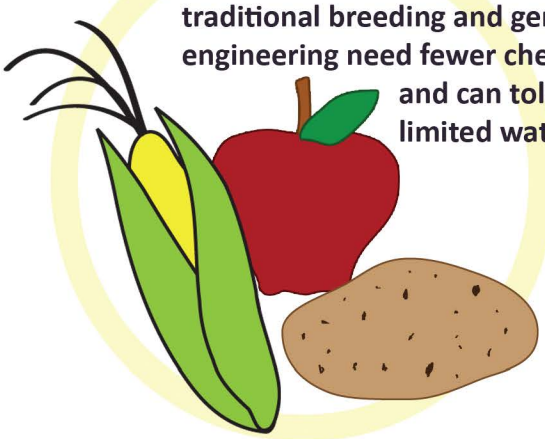
"Food production must double by 2050"

- United Nations

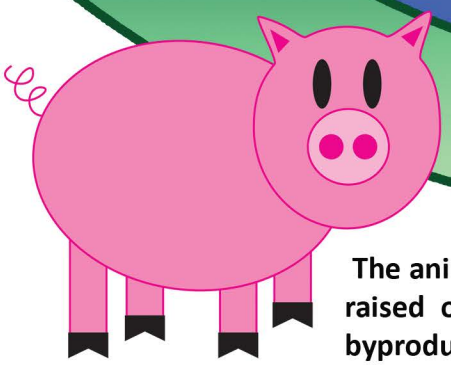
World population will increase by over 2 billion in the next 40 years. The increasing use of food crops for meat production and biofuels will result in increased prices, reducing accesses to food by the poor. At the same time, climate change is also expected to make some land less productive.

The last 100 years saw huge increases in food production per acre. While this kept millions of people from starvation, there were environmental costs. A large portion of the increased production was due to the use of man-made fertilizers and chemicals for controlling insects and weeds. These products require fossil fuels and can remain as toxins in the soil and water. Also, as more people moved into cities and food was shipped longer distances, there was less support for farming communities.

The question is whether we can meet our need for food production while reducing our dependence on oil based energy, fertilizers, and chemicals. Sustainable agriculture can offer some solutions to these challenges.



Crops developed through traditional breeding and genetic engineering need fewer chemicals and can tolerate limited water.

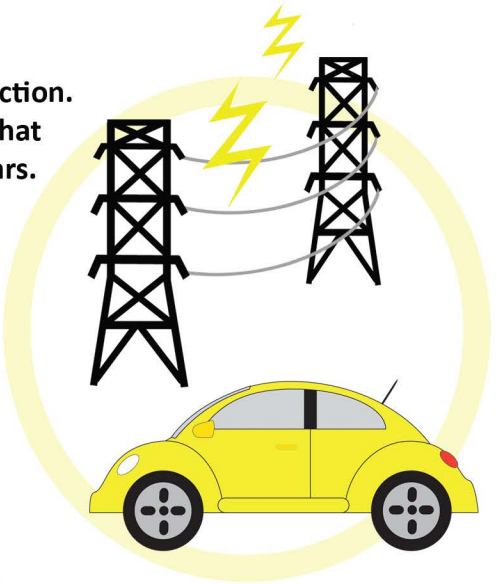


The animals are fed food that is raised on the farm as well as byproducts from growing and processing crops for human consumption.

Farm

BIOFUELS

Corn is used for ethanol production. Ethanol is a gasoline additive that decreases air pollution from cars. The grain that remains after ethanol production can be used to feed cattle.



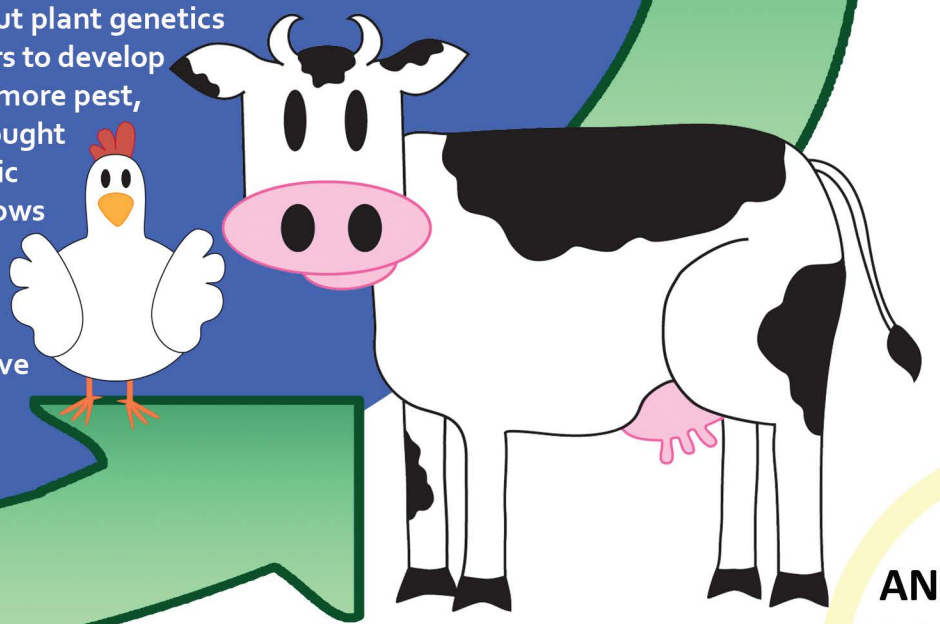
Sustainable Agriculture

Sustainable agriculture uses a wide range of methods to meet the needs of consumers for healthy food while providing farmers and their communities with an income and a safe environment to live and work in.

Sustainable agriculture integrates methods from conventional, organic and traditional farming. These methods include crop rotation, composting, and biocontrols to decrease the need for man-made chemicals.

Meeting the needs of a growing population requires continued improvement of plant varieties. To reach this goal, sustainable agriculture makes use of new technologies. Knowledge about plant genetics will help breeders to develop plants that are more pest, disease, and drought resistant. Genetic engineering allows scientists to select from a wide range of genes and to have greater control over their use.

Manure produces methane gas which can be used to power the farm and ethanol distiller. Processing manure decreases water pollution and greenhouse gases. It also turns manure into fertilzer and compost for the crops.



ANIMAL PRODUCTS

Having a local food source for the animals decreases pollution caused by transporting animal feed. It also helps the farm have more control over the quality of the feed. The result is that we get higher quality food with less environmental impact.

What Could it Be?

What is one ingredient that all these things have in common?

Hint:
It's an agricultural crop.

* Answer on Page 8

To learn more, make sure to check out our website!
www.ctahr.hawaii.edu/biotech

What's the Word?

Across

3.) This kind of farming doesn't allow man-made chemicals.

7.) One set of instructions in DNA.

9.) Agriculture must become more _____.

12.) What "GE" stands for.

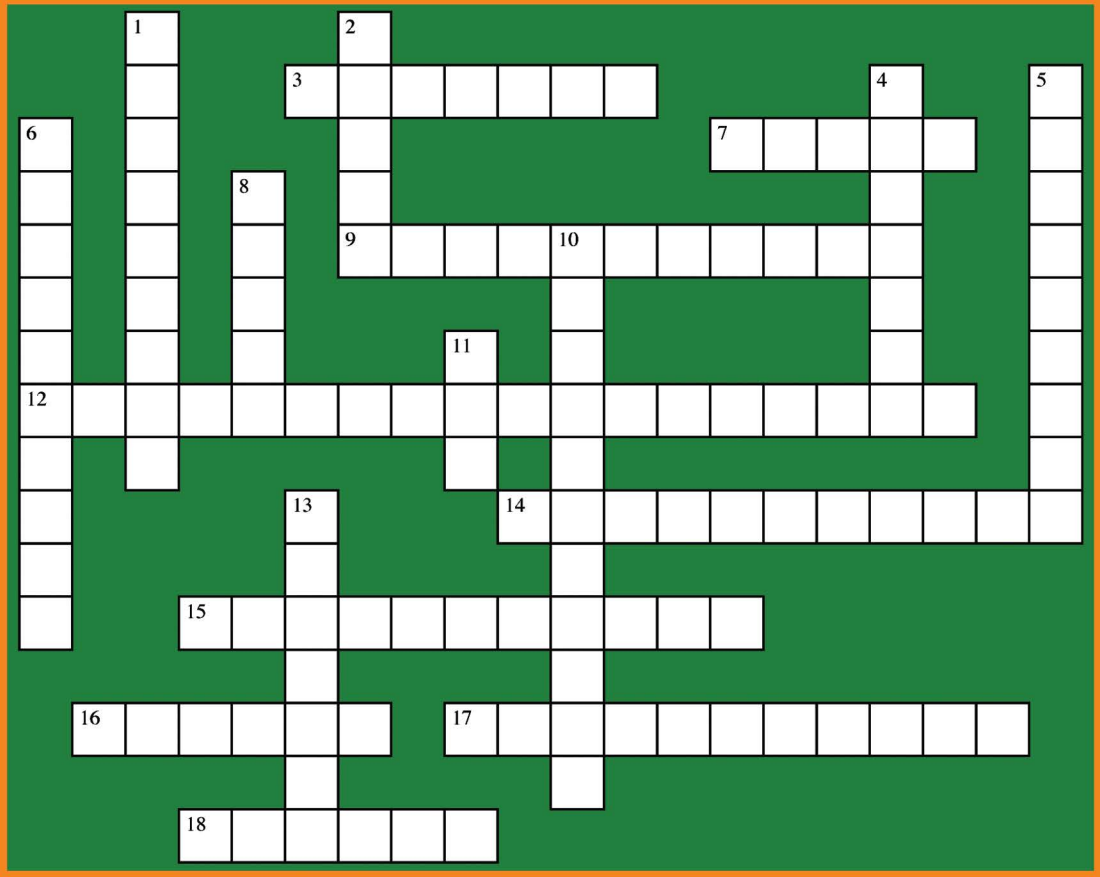
14.) Used to develop Asian pears.

15.) Castor oil is in the _____ used to make some laptops.

16.) Organisms that have the same DNA.

17.) DNA structures in the nucleus.

18.) The complete genetic info of an organism.



Down

1.) Permanent changes in the DNA of an organism.

2.) Plants farmers grow for us to eat.

4.) Used to shoot a gene into papaya cells.

5.) Fuji and Golden Delicious are different _____of apples.

6.) Genes moved from one organism to another.

8.) A _____ of bananas is that they are yellow when ripe.

10.) Production of plant and animal products for human well being.

11.) Deoxyribonucleic acid

13.) A gene is a set of instructions for a _____ .

* Answers on Page 11