DNA FOR DINNER?

Dare to Be Different

LESSON 1

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WHAT WE WILL DO

- Use the characteristics of the fruits and vegetable to try to group them into related families.
- Identify a mystery fruit or vegetable based on its characteristics.
- Search for fruit and vegetable names based on characteristics in a word search puzzle *(optional).*
- Go on a food finding field trip *(optional).*

WHAT WE WILL LEARN

- All living things, **organisms**, are made up of **cells**.
- The variation in organisms reflects their **diversity**.
- The variety comes from the different **genes** and the characteristics they encode.
- Organisms with many similar traits, and thus with similar genetic information, may be **related**.

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** optional*

Funding for this project was made available by the American Society of Plant Biologists' Education Foundation. http://aspb.org

This curriculum follows 4-H SET guidelines http://www.ca4h.org/SET

Appetizer

One of the most fascinating aspects of life on earth is the millions of different living things, called **organisms**. There are 4,500 different species of mammals, 10,000 bird species, 1 million insect species and about 350,000 plant species. And we still haven't found them all! Scientists discover 7 to 10,000 new insect species every year. Differences in all these organisms represent their **diversity**.

We can tell the difference between one organism and another by its **characteristics**, for example, its color, its shape, its size. Often organisms have similar characteristics. The more they have in common, the more likely they are to be related.

An organism's characteristics are determined by the information in its **cells**, the individual compartments that make up the organism. That information is organized into single units, called **genes**. The genes are the recipes that make up a master cookbook and are used to create the entire meal: appetizer, main dish and a dessert. Genes contain the information for **proteins**. We get protein from the foods we eat, like cheese, meat and beans. For example, when we eat beans, our bodies break down the proteins and use them to make things our bodies need. You can think of all of an organism's genes as a cookbook of recipes. For humans and certain bacteria and plants like rice, the information in all the recipes has been determined. There are 20,000 to 25,000 genes that specify a protein in a human cell. Surprisingly plants have slightly more genes than humans, around 35,000 to 50,000.

In plants these gene-recipes are responsible for the proteins that determine the **characteristics** of the plant. Traits for animals include smooth or scaly skin, gills or lungs, fins or legs. For plants, they include fuzz on a peach, sweet taste of a strawberry, tearful smell of an onion, and color of an apple.

What's in a Word?

Words

Cell • Characteristic • Diversity • Genes • Organism • Protein

Participants will find new words in this lesson. Some may be similar to words they already know and some will not be.

Cell is the small compartment that is the basic structural unit of all organisms - often called the building brick of life. The word comes from the Latin word, *cellula*, meaning "a small room".

Characteristic is a distinguishing trait or quality and comes from the original Greek word, *character*, which originally meant "sharpen or cut". The original word referred to a stamp marking one item to make it different from another.

Diversity is being made of distinct characteristics or qualities. The word is related to other words like *verse, version, vertebra*, and *divert*. The root of the word comes from a Latin word with two parts meaning "turn" and "aside". The word *divert* means "turn in new directions".

Genes are units of information that determine particular characteristics in an organism, The word comes from the old European root *gen-* meaning "to produce". Other words from "gen-" are *genetic* and *genome*. Genes have information that make individuals different. So your genes "produce" you.

Organism is an individual form of life, such as a plant, animal, or bacterium. The Greek word for *organ* means "tool or instrument"; *Ism* means "system". So an *organism*, such as the human body, is a "system of tools".

Proteins are essential components of living cells and consist of many individual chemical units called amino acids. The word comes from a Greek word meaning "of first importance", which emphasizes the important role proteins play in living organisms.

You may notice other words with these same roots. By finding the root in a word, you may be able to figure out what it means, even if you have never seen the word.

Main Course

- Lesson will introduce participants to the concept of genetic diversity.
- You will explore how this diversity occurs.
- Three activities are offered in this lesson; one is optional.
- For these activities, the fresh fruits and vegetables or pictures of them should represent whole plants, when possible, and not just their fruits. These could include vegetables with tops, like carrots, beets, green onions, or radishes. Encourage students to observe similarities in all parts of the fruits and vegetables that will lead them to think about the fact that those with similar characteristics, and thus similar genes, may be related.

ACTIVITY 1.1 Who Is Related?

In this activity participants identify different characteristics of fruits and vegetables and try to group them into families.

WHAT TO DO AHEAD OF TIME?

- Provide a variety of different produce items or ask family members to bring items.
- Provide pictures of varied produce, as an alternative.
- Encourage participants to bring different fruits or vegetables so you don't have 20 apples, although different types of apples also display diversity.
- Print copies of the fruit and vegetable Reference Guide or provide access to online version.
- Familiarize yourself with the **Reference Guide (Handout 1.1).**

WHAT IS NEEDED?

- Varied fresh produce items or pictures of them.
- Sheets of paper, pens or pencils for each participant.

HOW MUCH TIME IS NEEDED?

20 to 30 minutes

Directions

Put fruits and vegetables in the middle of the floor. In small groups, participants can pick up individual items one at a time; in larger groups the leader can pick up the items. Then ask the group the following:

- Can you identify different characteristics of the food, like its color, shape, size, smell, taste (sweet or sour), skin thickness, texture, noticeable markings or sections.?
- Does the fruit or vegetable grow above or below the ground? Based on what you know or observed about these fruits and vegetables, explain where you think they grow. On a tree, on a vine, on a plant stem? Does it grow above or below the ground?

Have each student write down the different characteristics that are identified for each food. (This list can be used in Activity 1.2 and the application activity in Dessert.) Remind the participants that the different characteristics are linked to different genes in the plant that specify what the food looks, tastes and smells like.

Once characteristics have been described, ask the participants to group the foods together that seem related, based on common characteristics. See Fruit and Vegetable Families Reference Guide, on the following page or at **http://ucbiotech.org/dnafordinner**. Even more vegetable families are at: *http://www.gardeningdata.co.uk/vegetables/vegetable_families/vegetables_families.php* or *http://vegetablesonly.com/VegFamilies.pdf*

Participants will likely group fruits and vegetables in ways different from those shown in the Reference Guide. For example, tangerines and nectarines are both orange in color; onions and carrots both grow in the ground. But neither of these groups are members of the same family.

Don't discourage participants from trying to find similarities in their fruits and vegetables even if they are not related. You can explain that, if they look at other characteristics, such as seeds, a tangerine is more like an orange than a nectarine. The way the seeds look and are arranged in the fruit is specified by genes and the similarity means that likely oranges and tangerines have some genes that are alike – but also some are different since they don't taste the same. Arrange produce according to degree of similarity based on whatever characteristics the participants choose. Then use the guide in **Handout 1.1** to show the true family relationships.

ACTIVITY 1.2 What Am I?

In the second activity, participants will be divided into two groups. Each participant will use the characteristics they discovered in Activity 1.1 to describe the fruit or vegetable in their bag. Based on the characteristics the students will guess the name of the fruit or vegetable in the bag.

WHAT TO DO AHEAD OF TIME?

- Obtain various items of produce or ask family members to bring items. Encourage them to bring unusual items so you don't have repeats.
- Alternatively provide pictures of varied produce.

WHAT IS NEEDED?

- Provide a diverse array of produce or ask family members to bring items
- Alternatively provide pictures of varied produce.
- Lunch bags, pencils, scrap paper

HOW MUCH TIME IS NEEDED?

20 to 30 minutes

Directions

Leader divides participants into two groups. Before the activity begins, leader places single piece of fruit or vegetable in a brown paper bag without others seeing what it is. Leader gives each participant a bag and asks them to make a written list of the fruit's or vegetable's characteristics based on what was learned in Activity 1.1 (or they can use the list that they wrote down in Activity 1.1). Remind participants that the different characteristics are specified by its genes. Characteristics that can be included are color, size, shape, taste (sweet or sour), skin thickness and texture, and noticeable markings or sections. Does the fruit or vegetable grow above or below the ground? Does it grow on a tree or a vine? Offer as much information as possible to help others guess what it is.

One person from each group describes a single characteristic of the food item. The second group works together to guess what the item is and names it. If the guess is incorrect, another member of the first group offers another clue to the food's identity and the second group guesses again. The clues continue until the identity of the fruit or vegetable is correct. Then a member of the second group describes a characteristic of an item in their bag and the first group works together to decide what the item is and names it. If the guess is incorrect, a second member of the group offers a clue; this continues until the identify of the fruit or vegetable is correct.

ACTIVITY 1.3 Fruit and Vegi Hunt (optional)

Use characteristics to identify food in word search.

WHAT TO DO AHEAD OF TIME?

- Make enough copies of the word search for each student or check computer access and web address, so students can play online.
- Have pens or highlighters for participants to use to identify names in the word search.

WHAT IS NEEDED?

- Copies of the fruit and vegi Word Search (**Handout 1.3**)
  -or-
  Access to internet to complete the word search online.
- Fruit or vegi snacks for participants who find the most names.

HOW MUCH TIME IS NEEDED?

Allow 20 minutes; some students can be doing this activity while others are doing other activities.

Directions

Remind participants that fruits and vegetables have different characteristics and also different names. Challenge them to find in the word search a fruit or vegetable that has the characteristics given in the hint. Some of the names in the search may be fruits or vegetables they identified in Activity 1.1.

Final Course

What You Will Need

- Examples of whole plant foods, such as carrots with tops, green onions, lettuce, radishes, and sprouts for participants to observe.
- Cookbook or recipes.

Discussion with Participants

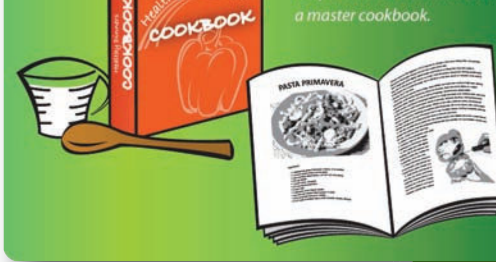
Have participants review their lists of fruit and vegetable characteristics and come up with some general conclusions about the foods we eat and their relationship with each other. Follow their lines of thinking and compare their different thoughts or views. The goal is to have participants use the new terms introduced and to come to conclusions about the concepts introduced. If needed, use the targeted questions below to stimulate discussion and bring out the important points of the lesson. Give participants time to discuss each question.

- Describe the differences you see in the various characteristics of the fruits and vegetables we have.
- Explain why some fruits and vegetables have the same shape or color but are not related.
- Explain how you think the different characteristics of the various fruits and vegetables are related to their genes.
- Explain what differences you have seen in various kinds of pets. What kinds of similarities have you seen in all dogs? All cats? What differences?
- How do you think the similarities and differences of the various kinds of pets and their characteristics are related to their genes?
- Look at the person sitting next to you. How do you think their physical features are related to their genes?

All fruits and vegetables that you saw are produced on plants or trees. Can you describe how different the plants or trees are that they grew on? Look at how different a carrot plant is from a green onion or lettuce. This variation is known as diversity. Different kinds of apples – Granny Smith, Delicious, Fuji – are members of the same family, just like your brothers and sisters, but they still have differences in taste, color and size, indicating they have differences in their genes.

- Tell me what you think it is about an apple tree that makes it produce apples and not tomatoes?
- Why do you think a tomato plant is smaller than a tree?
- Explain why cutting an onion makes you cry. Does the same thing happen when you cut a tomato?

Every organism has genetic information that dictates its characteristics – its height, its weight, its color, its smell – and it is all contained in discrete packets called genes. Genes are like recipes in a recipe box or a cookbook. In organisms, the cookbook is full of recipes called genes and you can tell how closely related two organisms are by how similar their genes are.



A genome is like many volumes containing genetic recipes that are contained in a master cookbook.

Dessert

Food Finding Field Trip

WHAT TO DO AHEAD OF TIME?

- Familiarize yourself with the Reference Guide (Handout 1.1).
- Contact produce manager of market to arrange for participants to visit..

WHAT IS NEEDED?

- Parental permission and transportation for participants to the venue

HOW MUCH TIME IS NEEDED?

Allow 20 to 30 minutes in the store or farmer's market plus travel time.

Directions

Participants take a field trip to the produce section of a supermarket or a farmer's market to examine the diversity among fruits and vegetables. Ask students to bring the lists of characteristics and families they identified in Activities 1.1 and 1.2. Ask them to use what they learned in those activities to group new foods they find in the market.

MATH MENU

1. If there are 3,500 species of mammals and 350,000 different species of plants, how many times more plant species are there?
2. Scientists discover around 10,000 new insect species every year. What percent of existing species does that represent?

See answers in Leader Supplements

Stuffed, But Hungry for More?

- Based on what you learned about characteristics, can you tell me what you noticed about oranges and lemons that make you think they might be related?
- Explain what characteristics humans have that are in common? Other animals like cows and monkeys? With plants? Based on those characteristics, ask the participants to speculate on whether insects or cows have more genes in common with humans and why.

See answers in Leader Supplements

NEXT TIME WE MEET

Information contained in genes (or recipes or folders) is recorded in a special alphabet called the genetic code. Next time we will explore how a code, like the genetic code, can be used to record information and give organisms their characteristics.

SET CONCEPTS ADDRESSED

Discovery-based research and scientific method

National Science Education Standards in Life Sciences Grades 5-8, Content Standard C: Reproduction and heredity; Diversity and adaptation of organisms

SET Process Skills Used: Categorize/order/classify; observe; compare/contrast/hypothesize; organize/order/classify

For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

Leader Supplements for Lesson 1

Key for Handout 1.3
Fruit & Vegetable Word Search

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

Characteristic List

CARROTS
CELERY
CUCUMBER
EGGPLANT
LIME
ONION
ORANGE
PEAR
POTATO
TOMATO

Answers to Math Menu

1. 100 times 3,500 X 100 = 350,000
2. 1% 10,000/1,000,000

Answer to Stuffed, But Hungry for More?

We have some genes in common with all organisms, but more with other animals than with plants. For example, all animals have eyes, most have noses, fur or hair; plants don't. All animals breathe oxygen from the air (birds, mammals) or from water (fish). The processes and the genes involved in using oxygen are the same in all animals. Plants also depend on oxygen although they don't breathe oxygen like humans and most animals do. In fact plants share ~ 40 to 60% of their genes with animals.

DNA FOR DINNER?

LESSON 1
HANDOUT 1.1

Fruit & Vegetable Families

Plants are classified into groups based on similarities in, for example, their flowers & fruits. For example, the Cucurbitaceae family, squash, cucumber, melon, gourds, pumpkin, produces male & female flowers that need bees to pollinate. But some similarities, like fruit color or shape, can mislead – like the orange color of pumpkins & tangerines.

MUSTARD

Cauliflower
Broccoli
Brussels sprout
Cabbage
Bok choy
Radish
Turnip
Red cabbage
Mustard greens

LILY

Asparagus
Onion
Garlic
Leek
Green onion

POTATO OR NIGHTSHADE

Tomato
Potato
Sweet potato
Peppers
(Green, Red, Yellow, Jalapeno, Anaheim)
Eggplant

ROSE

Peach
Apricot
Nectarine
Apple
Pear

CUCUMBER

Cucumber
Watermelon
Cantaloupe
Squash
Chayote

PALM

Coconut
Date

GRAPE

Grape

GOOSEFOOT

Swiss chard
Spinach

CARROT

Carrot
Parsnip
Celery
Cilantro
Coriander

LEGUME

Beans
Peas
Bean sprouts
Snow pea
Lentil
Jicama

SUNFLOWER

Artichoke
Lettuce
Sunflower

CITRUS

Orange
Lemon
Grapefruit
Lime
Tangerine
Tangelo

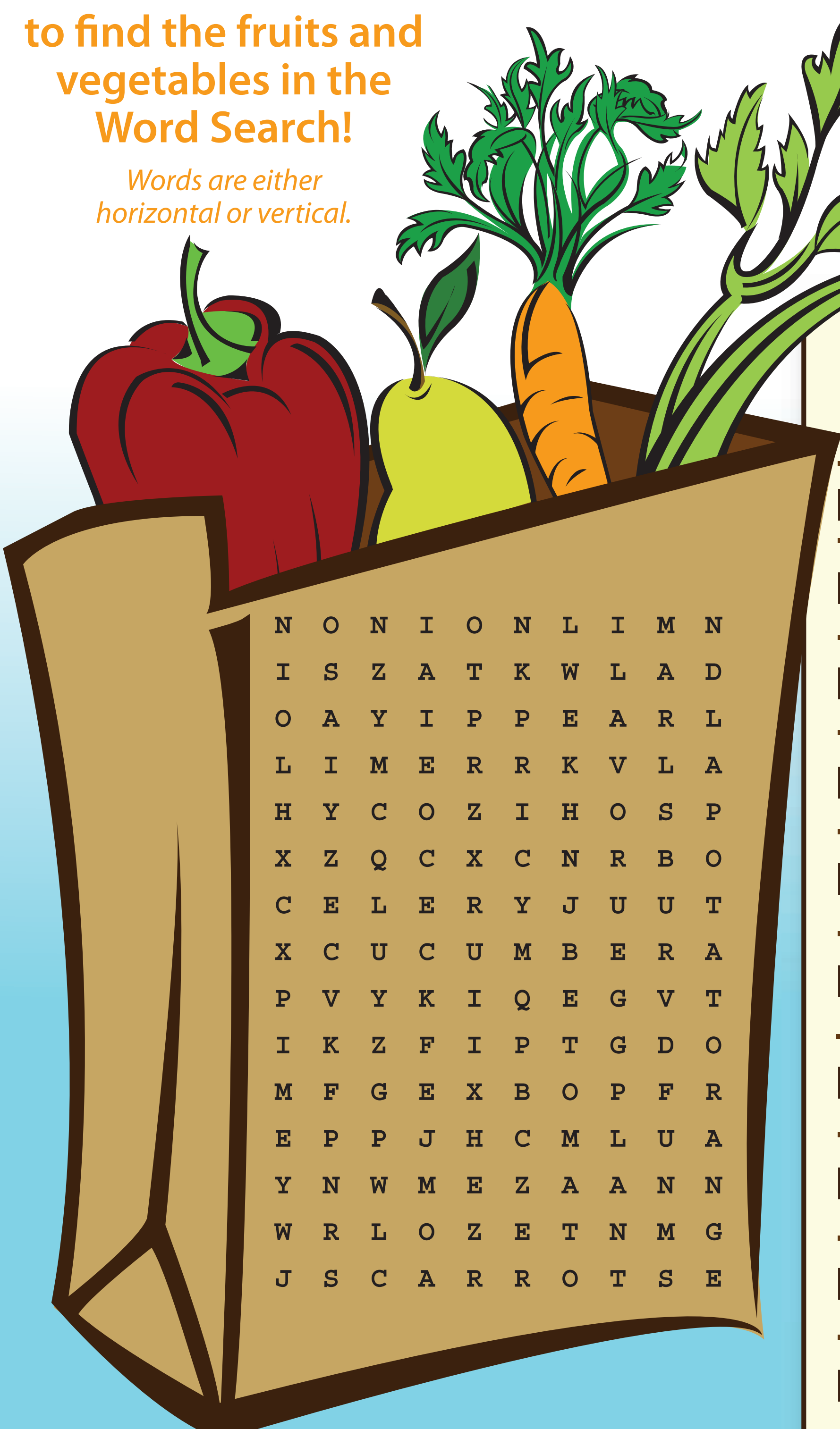
DNA FOR DINNER?

LESSON 1
HANDOUT 1.3

Fruit & Vegetable Word Search

Use the characteristics to find the fruits and vegetables in the Word Search!

Words are either horizontal or vertical.



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

Characteristic List

Check off the grocery items as you find them in the Word Search. Refer to Handout 1.1.

- ☐ Orange, long slender, root-like
- ☐ Light green, watery, slender stalks, leaves on top, in carrot family
- ☐ Dark green, prickly skin, seeds inside, strong smell
- ☐ Purple, smooth-skinned, cream-colored inside, in potato family
- ☐ Green bumpy skin, sectored inside, seeds inside, strong citrusy smell
- ☐ White, yellow or purple parchment-like skin, causes tearing when cut, in lily family
- ☐ Orange bumpy skin, sectored inside, seeds inside, strong citrusy smell
- ☐ Yellow skin, small at top, bigger at bottom, seeds inside, grainy texture in rose family
- ☐ Brown skin, oblong shape, white to cream color inside, small holes on surface
- ☐ Red skin, smooth, watery and seeds inside, oval to round shape, in potato family

DNA FOR DINNER?

Language of Life

LESSON 2

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WHAT WE WILL DO

- Use code to figure out characteristics and guess the organism with those characteristics.
- Create a unique "M&M" code to describe a fruit or vegetable; let others guess the identity. *(optional).*
- Read a DNA sequencing gel to determine the order of A's, C's, G's and T's. *(optional).*

WHAT WE WILL LEARN

- All of an organism's genes are called a **genome.**
- Some genes from every organism are the same; some are different.
- The genome is written with a set of rules called the **genetic code**; that code is the same for all organisms.
- Genetic code is made up of different arrangements of four chemical units that together are arranged in a sequence called **DNA**.

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** optional*

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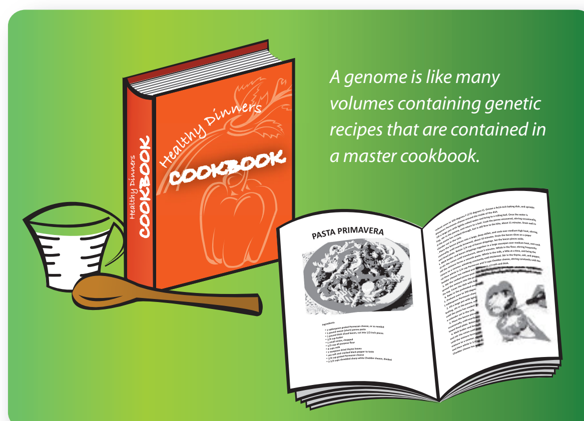
Appetizer

In Lesson 1 participants learned that diversity results from differences in the all of the genetic recipes or genes in the master cookbook of the organism, which is called the **genome.** You can think of the genome as many volumes in a master cookbook with each volume containing thousands of recipes.

The genome cookbook is written in combinations of four different chemical units that together comprise deoxyribonucleic acid, or **DNA** for short. The chemical units are arranged in a **code**, called the **genetic code**, which follows a specific set of rules. Some genomes are small; some are larger. Wheat, used to make bread and cookies, contains 32 billion chemical units; the human genome is 20% that size.



A genome is like many volumes containing genetic recipes that are contained in a master cookbook.

The genetic information specified by the code is like the recorded information in the cookbook recipes. The recipes and the DNA both serve to hold information. Just as the alphabet is used to communicate ideas in a recipe through words, the chemicals that make up DNA communicate information about the characteristics of an organism. Substituting one letter for another or inserting/deleting a letter in a word may have no effect on sentence's meaning or it can dramatically change its meaning. For example, inserting a letter in the following sentence can change its meaning. "I saw my friend eat her sandwich" is different from "I saw my friend **h**eat her sandwich". Substituting a letter in this sentence changes its meaning. "My best friend got an **A** on his math quiz" certainly differs from "My best friend got an **F** on his math quiz"! The same situation occurs with DNA. Changing a single chemical unit, referred to as causing a **mutation**, can have no effects or a profound effect depending on the change.

What's in a Word?

Words

Code • DNA • Genetic code • Genome • Mutation

Participants will find new words in this lesson. Some may be similar to words they already know and some will not be.

Code is a system of symbols, letters, or words used for transmitting messages. The word *code* comes from French and Latin words meaning "set of laws".

DNA, short for deoxyribonucleic acid, is a series of chemical units, called nucleic acids, that contains information for specific characteristics of organisms. DNA is the long-term storage unit for the organism. It is like a cookbook of instructions to construct the parts of an organism.

Genetic code is the chemical code in which DNA is written. It specifies how information in the genome is read to give proteins that determine the organism's characteristics. The code is contained in a long chain of chemical units called nucleotides. From which word is *genetic* derived? (Look in Lesson 1.)

Genome is all of the genetic information in an organism that determines its characteristics. Physically it is a coiled string of DNA that, stretched out, is over five feet long. It is from the German, *gen*, meaning "to produce" and the Greek *ome*, meaning "body".

Mutation happens when a change occurs in the series of chemical units in DNA. These changes, or mutations, play a role in evolution and contribute to the different plant varieties we saw in Lesson 1. The word is from the Latin, *mutationem*, meaning "action of changing."

You may notice other words with these same roots. By finding the root in a word, you may be able to figure out what it means, even if you have never seen the word.

Remembering Last Lesson's Important Points

Remember these words?

Cell • Characteristic • Diversity • Genes • Organism • Protein

Ask These Review Questions

- Explain what you think determines an organism's characteristics.
- Tell me what you think it is about an apple tree that makes it produce apples and not tomatoes?
- Why do you think some fruits and vegetables have the same shape or color but are not related?
- Explain why you think it might be important to have a wide diversity of plants and animals in the world?

Main Course

- Activities will introduce participants to codes, particularly the genetic code.
- You will explore how DNA and the genetic code determine characteristics of the organism and how changes in the DNA can alter the characteristics.
- Three activities are offered in this lesson; two are optional
- There are also activities associated with the Dessert
- In these activities participants will make, use and decipher codes that relate to characteristics of organisms; some are fruits and vegetables from Lesson 1.

ACTIVITY 2.1 Mystery Decoder

In this activity pairs of participants are given "genome sequences" and a code. Teams work to figure out what organism has the characteristics they find in their sequences.

WHAT TO DO AHEAD OF TIME?

- Duplicate **Handouts 2.1** and **2.2**.
- Copy lists of characteristics and families developed in Lesson 1.

WHAT IS NEEDED?

- Copies of one genome sequence (**Handout 2.1**) and one decoder sheet (**Handout 2.2**) for each group.
- Sheets of paper, pens or pencils for each participant.

HOW MUCH TIME IS NEEDED?

20 minutes.

Directions

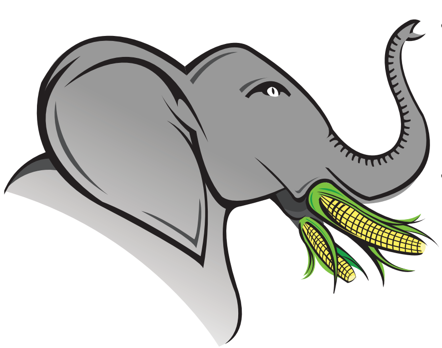
Form at least six groups of participants and have the groups form a circle. Each team receives any one of the genomes from **Handout 2.1** and any one of the Decoding Keys from **Handout 2.2**. Give teams five minutes to try to decode their genomes, write down the decoded characteristics and guess the identity of the organism. Suggest that they use the list of characteristics from Lesson 1. Then engage the group with the following.

- Can you share any difficulties you had in decoding your genome.
- Can you explain what additional information would have been helpful in figuring out the identity of your organism?

Remind participants that, to solve complex problems, scientists often share information with other scientists to find answers. If it does not come out in the discussion, point out that each team, as scientists, were given only part of the decoding key they needed.

In order to help the teams figure out the identity of their organism, ask them to trade their decoder with the next pair to their left in the circle and then try again to identify their organism. Teams continue to trade decoders with the group to their left until they can decode enough characteristics to determine their organism's identity. Then question the group.

- How did sharing decoders help you identify your organism.
- Discuss what would happen if only one team had decoders and the other did not?
- Explain why was it more difficult to identify your organism when you had only one characteristic?



- Explain what would happen if there was a mistake made in, for example, the second gene for the elephant – from 9%H!H to 5%H!H.
- Discuss why you might think that such a mutation would change the whole animal or only part of it?

ACTIVITY 2.2 M&M Codes (optional)

Using six colors of M&Ms, groups of participants will assign combinations of three colors to stand for each letter of the alphabet. Additional M&Ms will then be used to spell out characteristics of one of the vegetables or fruits from Lesson 1, using the lists of characteristics and families identified in that lesson. Groups will view coded messages from another group and, using the decoder sheet from that group, try to figure out what fruit or vegetable they are describing.

WHAT TO DO AHEAD OF TIME?

- Copy lists of characteristics and families from Lesson 1 for each group.
- Provide pictures or actual fruits and vegetables used in Lesson 1.
- Obtain ~ 250 M&Ms per group, approximately equal in color distribution.
- Obtain 3-4 sheets per group of light-colored, heavy construction paper and double-sided tape for each group.
- Obtain pens or pencils and scratch paper.

WHAT IS NEEDED?

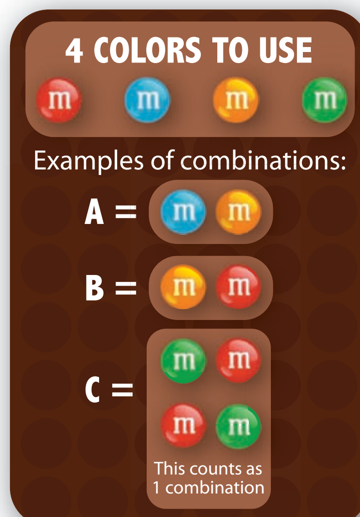
- Pens or pencils and scratch paper for each group.
- List of characteristics and families from Lesson 1.
- Pictures of or actual fruits and vegetables from Lesson 1.
- Approximately 250 M&Ms per group of approximately equal color distribution.
- Sheets of heavy construction paper and double-sided tape for each group.

HOW MUCH TIME IS NEEDED?

30 to 40 minutes.

Directions

- The code for each letter will be only made of three M&Ms but the colors for each alphabetic letter have to be unique.
- Participants in each group will work together to make their alphabet using construction paper and double-sided tape to hold the M&Ms on the paper.
- Once each group has a code, they choose a fruit or vegetable, find its characteristics from the Lesson 1 handout.
- Each group spells out in M&M code the first characteristic of their fruit or vegetable.
- Groups then trade codes and clues and see if the group with which they trade can decode the message and guess the fruit or vegetable.



- If the first clue does not lead to the right answer, the original group must describe a new trait with M&Ms and let the other group guess again.
- Continue trading clues until each group gets the right answer.

Challenge participants with these questions:

- Explain the challenges you might encounter when trying to determine genome characteristics without a decoder?
- Describe how you think keeping the decoder to yourself would affect the other group.
- Explain what would happen if your code did not use unique colors for each letter.

ACTIVITY 2.3 Sudoku Codes (optional)

In this activity participants work in pairs to solve the Sudoku puzzle and then use the code provided to discover the "genetic message" encoded in the puzzle.

WHAT TO DO AHEAD OF TIME?

- Duplicate **Handout 2.3** for each pair of participants.

WHAT IS NEEDED?

- Copies of **Handout 2.3** for each participant.
- Pencil for each pair of participants.

HOW MUCH TIME IS NEEDED?

20 minutes.

Directions

Leader asks participants to divide into groups of two and instructs participants that the Sudoku puzzle has a unique solution.

- Ask each group to read the directions on the handout.
- Explain that numbers from 1 to 9 are entered into each of the 3 X 3 squares.
- Point out to participants that each 9-box row and each 9-box column contains only one of each number. Suggest that they look at the example on the handout.
- Once the puzzle is solved, participants should use the code at the right of the puzzle to covert the numbers to letters and decode the message contained in the top line of the puzzle.

Challenge participants the following:

- Explain what you would think might happen if a mistake was made in the message while solving the puzzle?
- Describe what you think would happen if you did not have the code or had only part of it.
- Explain what you think might be the advantages of solving the Sudoku puzzle versus having the code to decode the message.

Instructions

The Soduku puzzle has a unique solution. Numbers from 1 to 9 are entered into each of the nine squares (left) in the large square.

6	5	4
8	1	3
2	7	9

Each 9-box row (below)

6	5	4	7	9	1	2	3	8

and each 9-box column (left) can contain only one of each number.

6
8
2
9
3
7
1
4
5

Final Course

What You Will Need

- Modern apple and crabapple; modern tomatoes and heirloom varieties; and colored Indian corn and yellow corn - or colored pictures of them.

Discussion with Participants

Invite participants to think about the activities they did with codes and to explain how important the codes were in these activities. How does this relate to the importance of the genetic code used for the genomes of organisms. Ask participants to talk about how their views of the importance of genomes have changed after these two lessons. Encourage them to compare differing thoughts and views. The goal is to have participants use the new terms introduced in the two lessons in their discussion and come to some conclusions about the concepts introduced. Try to bring out the important points of the lesson. If needed, use the targeted questions below to stimulate discussion. Give participants time to discuss each question.

- Can you explain how the genetic instructions in the genome are similar to and different from instructions contained in a computer folder created with a word processing system? (Encourage participants to use the terms introduced in this lesson.)
- Can you think the differences in genetic information in different organisms affect the genetic diversity that we talked about in Lesson 1?

Crabapples

Genetic diversity occurs in humans as well. Identical twins have exactly the same sets of genes and so their genomes are essentially identical. Immediate family members share most genes – about 99.5% or 199 out of 200 genes – since they were conceived from the same parents. Unrelated individuals share about 99% or 198 out of every 200 genes. Even humans and animals share many genes and, perhaps surprisingly, plants and humans share 40 to 60% of their genes.

Some diversity results from mutations in genomes. Sometimes this occurs from mistakes in decoding. Mutations can also result from, for example, radiation from the sun, which can cause changes in the chemical units in the DNA. Some different colors, tastes and shapes of apples are from mutations in the original wild apple variety, called a crabapple. Modern tomatoes also developed in part from mutations in the heirloom varieties sometimes found in the market.

Heirloom tomatoes

Indian corn

Genomes can also change because of what are called "jumping genes". These are small pieces of DNA that move around the genome. When they jump, they change the sequence of the genome and this can change characteristics. Different colors and stripes in the kernels of Indian corn are evidence of DNA jumping around in the color genes.

- Since plants and humans share 40 to 60% of their genes, can you think about any characteristics that plants might have in common with humans? Some that might be different?
- Please describe what you think might happen when the cellular machinery makes a mistake while decoding the genome?
- Explain how you think such a mistake might affect genetic diversity?

Dessert

Reading the Language of Life

This activity builds on the other things that have been done in this lesson. Explain to participants that scientists need to determine the precise order of the four chemical letters in DNA, called A's, G's, C's and T's, in the genome. They use that information to tell what characteristics a plant will have. This exercise stresses that there are only four chemical "letters" in DNA – not 26 as in the alphabet, or the 27 that are used in Activity 1 in this lesson or the 9 that are used in Activity 2.

WHAT TO DO AHEAD OF TIME?

- Duplicate **Handout 2.4** and **2.5** for each pair of participants.

WHAT IS NEEDED?

- Copies of **Handouts 2.4** and **2.5** for each pair of participants.
- Pencils or pens and scratch paper.
- Ruler or straight-edge.
- Scissors and double-sided tape.

HOW MUCH TIME IS NEEDED?

25 to 35 minutes.

Directions

Leader asks participants to form into groups of two.

- One individual reads the gel code in Handout 2.4, starting at the arrow and using the four letters listed at the end of the gel. Note that it might be helpful for the reader to use a ruler or straight-edge to follow the gel ladder more accurately.
- Bands are read in order from left to right, just like English writing.
- The second participant writes down the letters in order as their partner reads them. Suggest to participants that reading the bands on the gels might remind them of reading a scantron they might fill out for an exam at school.
- Once all chemical letters have been read, individuals change roles and the two versions of the reads are compared to see if they are the same or have differences.

Discussion with Participants

Explain that each dark band represents one of four chemical units that make up DNA. **Handout 2.4** has photographs of "sequencing gels" that were used by scientists to determine the DNA language in genomes of living organisms. The DNA language is "written" in the four chemical units or nucleotides, represented by the four symbols, G, C, A, T. Order of the symbols determines the genes and the genes are responsible for the organism's characteristics. Ask the following.

- If sequencing gels were made that contained the genetic information in each of the different fruits and vegetables from Lesson 1, explain whether you think the gels would be the same or different.
- Explain what you think the sequencing gels might look like if they contained DNA from identical twins.
- Explain what you think sequencing gels with your DNA and that from other people in the room would look like.
- If you were responsible for copying the DNA of a cell, discuss what you think the consequences of making a mistake might be.

Since in the tomato genome, for example, there are some 950,000,000 chemical units or bases, scientists just sequence small random DNA fragments and then match overlapping base pairs. It would be like reconstructing a sentence from its parts.

IT IS LIKE CTING A SENTENCE TS PARTS.
KE RECONSTRUCT NCE FROM ITS

Try your hand using overlapping DNA fragments to reconstruct a genome (**Handout 2.5**).

- Can you discuss what would happen if a sequencing error was made in the overlapping region of one fragment?
- Can you explain how generating more fragments might help this situation?

MATH MENU

1. Family members have in common about 199 out of 200 genes. If we have 30,000 genes, how many genes do you have in common with your mother or father?
2. Wheat, used to make bread and cookies, contains 32 billion chemical units or bases. The human genome is 20% that size. How many chemical units or bases does the human genome have?
3. How many different combinations of two M&M's can you make using the six different colors of M&M's? Will it be enough to have a unique combination for all letters of the alphabet?

See answers in Leader Supplements

Stuffed, but Hungry for More?

Even though it took people a long time to understand how the genetic code worked, people have been using other codes for thousands of years. Actually all languages are codes.

Test your ability to decode. What do you think the following sentences says?

Me encanta la ciencia
(Spanish)

Ja ich liebe Wissenschaft sehr
(German)

Я люблю науку
(Russian)

मैं विज्ञान प्यार
(Hindi)

- Can you explain how a "decoder" or a dictionary for Spanish, German , Russian or Hindi could help you understand what the speaker is trying to say?

Some people make codes so they can send information without other people knowing what they are saying. In war time, some armies use codes.

- Can you explain why armies might use such codes at such a time?

If it does not come out in the discussion explain that people are oten employed to decipher codes. For example, during World War II, the American army used Navajo Indian radio operators to transmit information in the Navajo language.[1] Other armies tried to "break" the code but were never able to figure it out.

- Why do you think that even today Word Monkey (in iGoogle at http://www.google.com/language_tools?hl=en) does not allow translations of this language?

See answers in Leader Supplements

[1] *Margaret T. Bixler Winds of Freedom: The Story of the Navajo Code Talkers of World War II, Darien Conn., Two Bytes Publishing Co., 1992.*

NEXT TIME WE MEET

In this lesson we learned that information in a gene is contained in a code in DNA, but what exactly is DNA? Next time, we will learn more about DNA. We will do an activity that will allow you to see and touch DNA. Just keep this thought in mind until we meet again: DNA is in every living organism – every plant, bacteria, virus, animal and human. This means we do eat "DNA for Dinner" in fruits, vegetables, grains, eggs and meat.

SET CONCEPTS ADDRESSED

Discovery-based research and scientific method

National Science Education Standards in Life Sciences Grades 5-8, Content Standard C: Structure and function in living systems

SET Process Skills Used: Build/construct; design solutions; use numbers; problem solve; interpret/analyze/reason

For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

Leader Supplements for Lesson 2

Key for Activity 2.1
Mystery Decoder

Organism	Decoded Characteristics
#1 elephant	trunk, tusks, floppy gray ears
#2 rose bush	thorns, green leaves, fragrant flowers
#3 tiger	fangs, striped fur, claws, ears
#4 apple tree	tall, green leaves, branches, trunk, crisp fruits
#5 corn	yellow, ears, husks, silks
#6 tomato	red fruits, acidic, seeds, watery

Key for Handout 2.3
Sudoku Puzzle Solution

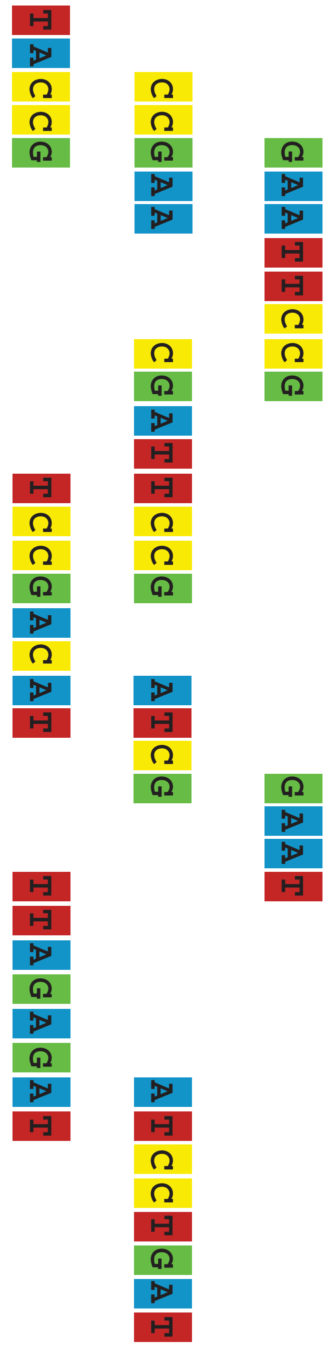
3	5	7	2	4	1	9	6	8
6	1	2	7	9	8	4	3	5
4	8	9	5	6	3	1	2	7
2	7	5	3	1	9	6	8	4
1	3	4	6	8	7	5	9	2
9	6	8	4	2	5	7	1	3
7	2	6	9	3	4	8	5	1
5	9	1	8	7	2	3	4	6
8	4	3	1	5	6	2	7	9

Message: CODES RULE

Key for Handout 2.4 DNA Sequencing Puzzle Solution

PUZZLE 1		PUZZLE 2	
1	A	1	A
2	G	2	A
3	A	3	T
4	C	4	A
5	G	5	A
6	C	6	G
7	C	7	C
8	C	8	C
9	C	9	T
10	C	10	C
11	T	11	G
12	C	12	C
13	C	13	C
14	G	14	T
15	C	15	T
16	C	16	A
17	G	17	T
18	C	18	G
19	C	19	T
20	T	20	C
21	A	21	A
22	G	22	A
23	C	23	C
24	C	24	G
25	G	25	C
26	C	26	C
27	C	27	G
28	C	28	A
29	C	29	A
30	C		

Key for Handout 2.5 Genomics Puzzle Solution



Answers to Math Menu

1. 29,850
2. 6.4 billion
3.

Answer to Stuffed, But Hungry for More?

The phrase is "I love science".

DNA FOR DINNER?

LESSON 2
HANDOUT 2.1

Genome Sequence Search

Clip out the 6 genomes and hand one out to each team.

Genome 1

9A%$!
9%H!H
T2GZZ?/WAX?/ &XAH

Genome 4

9X22/WA&&$/2&XR&H
@AX$Y5&H
9A%$!
YAQHZ/TA%Q9H

Genome 2

95GA$H
WA&&$/2&XR&H
TAXWAX$9/T2G8&AH

Genome 5

?&22G8
&XAH
5%H!H
HQ2!H

Genome 3

TX$WH
H9AQZ&K/T%A
Y2X8H
&XAH

Genome 6

A&K/TA%Q9H
XYQKQY
H&&KH
8X9&A?

DNA FOR DINNER?

LESSON 2
HANDOUT 2.2

Decoding Key

Clip out the 6 decoding keys and hand one out to each team.

X = a
@ = b
Y = c
K = d

$ = n
G = o
Z = p
7 = q

&= e
T = f
W = g
5 = h
Q = i

A = r
H = s
9 = t
% = u
R = v

V = j
! = k
2 = l
P = m

8 = w
B = x
? = y
J = z
/ = space

Soduku Puzzle

Complete the Soduku puzzle to reveal the secret message!

	5		2		1	9		
6	1	2	7	9		4	3	5
4	8	9	5	6	3	1	2	7
	7	5	3		9		8	4
1		4	6	8		5	9	2
9	6	8	4	2	5	7	1	
7	2	6		3	4	8		1
5	9			7	2	3	4	6
8		3	1	5	6		7	9

Code

1 = R
2 = E
3 = C
4 = S
5 = O
6 = L
7 = D
8 = E
9 = U

MESSAGE: _ _ _ _ _   _ _ _ _ _

Instructions

The Soduku puzzle has a unique solution. Numbers from 1 to 9 are entered into each of the nine squares (left) in the large square.

6	5	4
8	1	3
2	7	9

Each 9-box row (below)

6	5	4	7	9	1	2	3	8

and each 9-box column (left) can contain only one of each number.

6
8
2
9
3
7
1
4
5

When the puzzle is solved, participants use the code at the right to convert the numbers in the top line of the puzzle to letters and discover the hidden message.

DNA FOR DINNER?

LESSON 2
HANDOUT 2.4

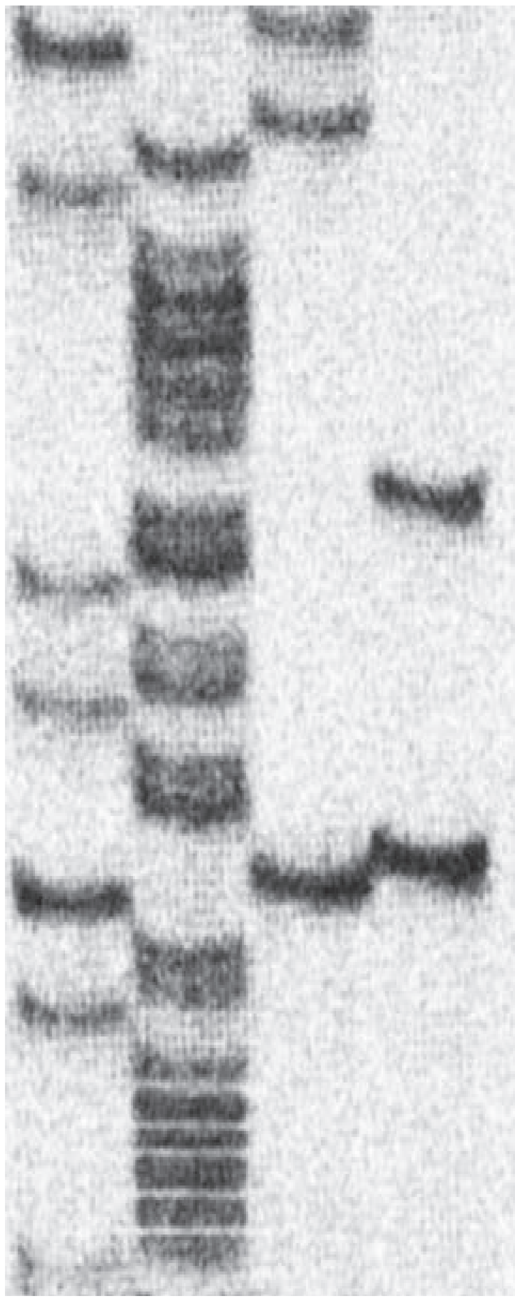
DNA Sequencing Puzzle

Start reading here

PUZZLE 1

Fill in the code letter

G C A T



1 ______
2 ______
3 ______
4 ______
5 ______
6 ______
7 ______
8 ______
9 ______
10 ______
11 ______
12 ______
13 ______
14 ______
15 ______
16 ______
17 ______
18 ______
19 ______
20 ______
21 ______
22 ______
23 ______
24 ______
25 ______
26 ______
27 ______
28 ______
29 ______
30 ______

DNA Sequencing Puzzle

PUZZLE 2

Start reading here

Fill in the code letter

G C A T

1
2
3
4
5
6
7
8
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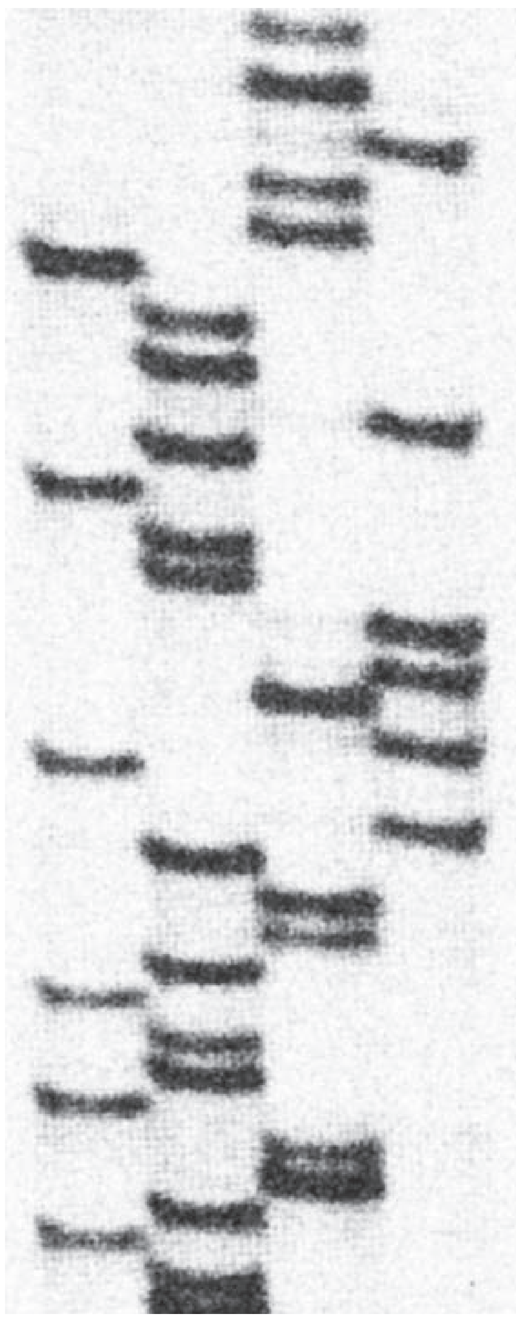

1 ______
2 ______
3 ______
4 ______
5 ______
6 ______
7 ______
8 ______
9 ______
10 ______
11 ______
12 ______
13 ______
14 ______
15 ______
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20 ______
21 ______
22 ______
23 ______
24 ______
25 ______
26 ______
27 ______
28 ______
29 ______

DNA FOR DINNER?

LESSON 2
HANDOUT 2.5

Genomics Puzzle

Special thanks to the Boyce Thompson Institute for Plant Research for providing the idea for the "Genomics Puzzle" activity.

Sequence the DNA by cutting out each DNA fragment along the dotted lines, and placing them in the correct spaces on the left alongside the chromosome.
The first fragment is already provided.

Remember that the colors and letters at the end of the fragments must match.

G A A T T C C G

C C G A A

A T C C T G A T

G A A T

T T A G A G A T

C G A T T C C G

A T C G

T C C G A C A T

For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

DNA FOR DINNER?

LESSON 3

DNA for Dinner

Prepared by Dr. Peggy G. Lemaux (Cooperative Extension Specialist)
and Barbara Alonso (Communications Specialist)
University of California, Berkeley | http://ucbiotech.org/dnafordinner

WHAT WE WILL DO

- Journey through the layers of an onion to discover cells and what's inside of a cell.
- Learn various ways people record information *(optional)*.
- Perform DNA extraction using common foods and items from the kitchen.

WHAT WE WILL LEARN

- Every organism is made up of **cells** containing a genome that has all of the genetic information that determines its characteristics.
- During reproduction, the next generation gets half of its genetic information or genes from one parent, half from the other.
- The genome and genes are written in a **chemical** language called DNA, which is made up of individual chemical units abbreviated with A, C, G and T.
- DNA is present in the cells of any organism, including foods like fruits, vegetables, cereals, meat, eggs, and fish.

TABLE OF CONTENTS

** optional*

Funding for this project was made available by the American Society of Plant Biologists' Education Foundation. http://aspb.org

This curriculum follows 4-H SET guidelines http://www.ca4h.org/SET

Appetizer

In the first two lessons, participants learned that information determining traits of an organism is contained in its genes. Collectively, all of the genes are like a library of cookbooks, called a genome. The genome has individual subsets of cookbooks, called **chromosomes** that exist in matching pairs. The next generation of the organism randomly receives one half of its genetic information from one parent and the other half from the other parent. That is why children do not look identical to either parent or to each other (except identical twins). Genes in the genome are like specific recipes in a cookbook and are responsible for an organism's characteristics, like its height, weight and color. Genetic information, or genes, in a genome is recorded in its DNA using the genetic code.

In this lesson we will learn that all living organisms are made of one or many tiny building blocks, called **cells** – like individual bricks in a building. The number of cells in the human body is estimated to be 10 to 100 trillion. Plants are also made up of cells and for large plants, like corn and trees, cells likely also number in the trillions. Nearly all cells in a living organism have a "control center" called a **nucleus** that contains the entire genome, arranged in chromosomes, each of which has a complementary pair of DNA strands. Individual genes can be seen using fluorescent tags, that light up like glow sticks and stick to the gene like a piece of Velcro.

The human body has many kinds of cells: heart, blood, nerve, and many others. Plants also have many different types of cells in the root, leaves and seeds. Although cells can look alike on the outside, on the inside they can look different, with many smaller structures, or **organelles**, that perform different functions. It is possible to see the small organelles inside the cell with a magnifiying glass and fluorescent dyes that stain specific organelles. You already learned about the nucleus. There are also organelles that store oils (oil body) or starch (starch granule), produce energy (mitochondrion), or convert sunlight into energy (chloroplasts).

What determines what different plants do and look like is contained in its DNA. So, information in one organism's DNA differs from that in another organism. But the four **chemical** units making up the DNA, abbreviated as A, C, G and T, are the same. The units are arranged in a code, like we learned about in Lesson 2. The code specifies the information that makes proteins. So, the content of two books or two organisms is different even though they are written in the same language. DNA is essential to life, just like other chemicals, like water, minerals, vitamins, sugars, proteins, starch and fat. Foods and drinks we consume replenish our cell's needs for these chemicals. With few exceptions, many chemicals, including DNA, are found in every living cell and thus in many foods we eat.

What's in a Word?

Words

Cell • Chemicals • Chromosome • Nucleus • Organelle

Participants will find new words in this lesson. Some may be similar to words they already know and some will not be.

Cell is the basic unit of all living organisms, sometimes referred to as the "building brick of life". The word comes from the Latin, *cellula*, meaning "a small room".

Chemicals participate in reactions that can change its characteristics or those of another chemical. The word comes from the Latin, *chimicus*, shortened from *alchimicus*, an ancient practice that attempted to change metals into gold.

Chromosome is a threadlike strand of DNA that transmits genetic information of a cell. The word comes from the Greek, *chroma*, meaning "color", because chromosomes can be stained with dyes, and *soma*, meaning "body".

Nucleus is a large, usually spherical structure containing the genetic information responsible for an organism's characteristics. The word comes from the Latin, *nucleus*, meaning "kernel" or "core", denoting its central role in the cell.

Organelle is a structure in a cell that performs a specific function. The word comes from the Greek word, *organ*, meaning "tool" and *-elle* which means "small".

You may notice other words with these same roots. By finding the root in a word, you may be able to figure out what it means, even if you have never seen the word.

Remembering Last Lesson's Important Points

Remember these words?

Code • DNA • Genetic code • Genome • Mutation

Ask These Review Questions

- Discuss why you think the genetic code used in the genome is important?
- What do you think might happen if a mistake was made when making a copy of the genetic information?
- Discuss how genetic instructions in the genome are similar to and different from instructions in a computer folder created with word processing?
- What do you think might be the consequences for others if the information to decode a message was not shared with others?

Main Course

- Activities will introduce participants to DNA and its role in recording the information that gives organisms their characteristics.
- They will learn that this "record keeping" is critical to passing that information on to the next generation of cells so the organism's characteristics stay the same.
- Three activities are offered in this lesson; two are optional. There is also an activity associated with the Dessert.
- In these activities participants explore the role of DNA for the organism and will physically isolate DNA from a strawberry, tomato or kiwi fruit.

ACTIVITY 3.1 DNA: Twisted and Bent Out of Shape?

In this activity, participants will work individually to discover how DNA becomes sufficiently compact to fit in a small cell.

WHAT TO DO AHEAD OF TIME?

- Review **Handout 3.1** for photos illustrating how to perform the activity.

WHAT IS NEEDED?

- Copies of **Handout 3.1** for each participant.
- Wide 4" long rubber bands for each participant.
- Scissors to share.
- Pen for each participant.

HOW MUCH TIME IS NEEDED?

15 minutes.

Directions

DNA strands look very small inside the nucleus of a cell. Why? Give each participant a rubber band. Explain to them that they are about to re-enact an actual, important event in the life of a cell. To learn more about this process also give each participant a pair of scissors, and a pen. These props will allow them to recreate the spectacular "supercoiling of DNA" – an event that occurs in each of the trillions of cells in their bodies as they divide.

Have participants do the following (photos illustrating the exercise can be found in **Handout 3.1**).

- Cut open the rubber band with the scissors and lay it flat on a hard surface (**Photograph 1**).
- With the pen, write their name or their email address on their "rubberband DNA".
- Squeeze the two ends of the "rubberband DNA" between the thumb and index finger of both hands (**Photograph 2**).
- Twist the band again and again – the more it is twisted the harder it is to straighten (**Photograph 3**).
- Once the band is completely twisted, slowly bring the ends of the "rubberband DNA" together until it curls on itself into a mass of tight, overlapping loops (**Photograph 4**). That is supercoiling!

Explain that twisting, or supercoiling, is what makes DNA appear so small in the picture of the nucleus. Stretched out the DNA in each cell is actually over five feet long!

Ask the participants:

- Talk about what effect you think twisting had on the rubberband?
- What effect do you think twisting might have on the ability of DNA to fit into a very tiny cell (1/200th the size of a pinhead)?
- Describe the difficulties you had in reading the information on the rubberband when it was twisted.
- What effect do you think the twisting might have on the access that cellular machinery might have to DNA when it is trying to copy it.

ACTIVITY 3.2 Tour d'Onion (optional)

In this activity, participants are divided into groups and will explore the different compartments or organelles inside the cell.

WHAT TO DO AHEAD OF TIME?

- Review **Handout 3.2.**
- Purchase an onion and experiment with removing the membrane using the tweezers.
- Prior to beginning this activity, cut the onion into ½ inch slices.

WHAT IS NEEDED?

- Copies of **Handout 3.2** or access to computer to display photos.
- Small kitchen knife.
- Cutting board.
- One clear glass baking dish (pie or cake pan).
- Water.
- One sweet onion.
- Tweezers.
- Magnifying glasses (4 to 10X), if possible, for each group or one to share. (Inexpensive magnifying glasses can be purchased).
- Plastic wrap.

HOW MUCH TIME IS NEEDED?

20 minutes.

Directions

Remind participants that all fruits and vegetables, like humans, are made of cells *(pass around an onion or several different types of onions to reinforce the diversity in onions that we learned about in Lesson 1, Activity 1.1*).

- What do you think the different onions have that would make them look different from each other?

Invite them to plug their noses and go with you on a guided tour of the onion! Have participants form several teams, depending on how many materials you have. Distribute **Handout 3.2** to each group. The leader distributes slices of the onion to each group. Starting at the center of a slice, have each group remove circular layers from the onion and place them on the bottom of a clear glass dish or plate with a thin layer of water. Ask each group to carefully remove membrane from the outside or inside of the circle using tweezers (**Photograph 1**) and place it on the water. Give each group a 6" piece of plastic wrap and ask them to touch the wrap to the membrane which will be floating on top of the water. The membrane will cling to the wrap and the group can lift the membrane out of the water. To prevent drying and to make it easier to view the membrane, fold the other side of the wrap over the exposed side of the membrane. If time is short the leader can "capture" the membrane ahead of time. Groups can then use their magnifying glasses to try to observe the outline of the cells in the membrane. Whether or not they can see the cells in the membrane, share **Photograph 2**. This is what they would see with a microscope that magnifies the image to 7 times its real size. Explain derivation of the word "cell" (see **What's in a Word**).

- Discuss why you think the "ancients" might have chosen the word, *cell*, to describe these structures?
- Can you describe what you might see inside the cell if you had a high powered microscope?

Invite them to look at **Photographs 3 through 7** in **Handout 3.2** or look at them online. In these photographs different dyes are used to bind to certain structures in the cell. In **Photograph 3** you see a slightly higher magnification of the onion cells in Photograph 2. In this image you can see dark green cell walls surrounding the outside of the stained green cells. These cells are 50-times larger than they actually are. If you enlarge the cells 200-times, shown in **Photograph 4**, you can see a smaller, bright green compartment inside the cell. That structure is considered to be the "control center" of the cell.

- Since this organelle is said to be the "control center", can you imagine what might be in this compartment?

If you further magnify the brain center and apply a red stain, you can see some red, colored strands, the chromosomes (**Photograph 5**).

- Can you speculate as to what you think the colored strands might be?

Using dyes, other organelles besides the nucleus can be stained, like the sun energy capturer, the chloroplast (**Photograph 6**). You can also link specific pieces of DNA to a fluorescent dye, like the one in glow sticks. The piece of DNA scans the entire genome until it finds its match among the tens of thousands of genes in the cell and, when it is does, it sticks to the DNA and makes bright glowing spots along the chromosomal strands – so you can see exactly where that gene is, at 1000-times larger than their actual size (**Photograph 7**).

TIPS FOR LEADERS

Chromosomes exist as duplicated copies connected in the middle. Pollen and the egg have one copy of each chromosome that combine during mating.

To learn more about the structure of a plant cell and how it is different from an animal cell, watch this.:
http://learn.genetics.utah.edu/content/begin/cells/insideacell/

- Name two things that are different between a plant cell and an animal cell.

ACTIVITY 3.3 DNA, Photos, Thumb Drives (optional)

In this activity, participants will learn about various ways people record information, such as photo albums, diaries, CDs, thumb drives, and even blogs and Facebook.

WHAT TO DO AHEAD OF TIME?

- Review **Supplement 3.3**.

WHAT IS NEEDED?

- Five books - all in one language, i.e., English, Spanish, French.
- Photo album, cell phone, thumb drive, and/or computer with access to Facebook.

HOW MUCH TIME IS NEEDED?

20 minutes.

Directions

Begin activity by posing the following questions to the group, trying to make sure that all participants contribute to the discussion.

- Name several ways that we store pictures or information so we can share them with our friends, learn from them or jog our memories?

Show participants the covers and some content from several books; let them look through the books. Then ask the following.

- Name some other languages in which these books might be written?

TIPS FOR LEADERS

Mention ways they might forget like books, photographs, cell phone text message archives or inbox messages in your computer mail server, thumb drives for your computer.

- What symbols were used to write the books and how many different symbols were needed?
- Explain what difficulties you might have if the books were written in a language you did not understand?
- Describe what would happen in a cell if a similar situation occurred.
- Describe how information in books or flash drives are the same as or different from information in a genome *(encourage participants to use terms introduced in this lesson).*

Final Course

Discussion with Participants

Have participants think about the activities they did with DNA and come up with some general conclusions about the importance of DNA in general and particularly in retaining information for the organism. Have participants talk about how their views of the importance of DNA have changed as they participate in these lessons. Encourage them to compare differing thoughts and views. The goal is to have participants use the new terms introduced in the three lessons and come to some conclusions about the concepts introduced. Try to bring out the important points of the lesson. If needed, use the targeted questions below to stimulate discussion.

- Explain why you think DNA is important for the functioning of your body? For a strawberry plant?
- What are some characteristics of a corn plant that might be influenced by its genes?

By reading the information in the genome, its A's, G's, C's and T's, it is possible to determine what different parts of the DNA are responsible for what traits.

- What happens when changes occur in DNA in a corn plant?
- How could such changes possibly affect the ways plants could survive stresses, like drought and frost?
- Speculate about how learning about DNA sequences and how to modify them could help address difficulties in energy production, and in human nutrition? (We will learn more about that in Lesson 5.)

Dessert

There's DNA in My Strawberry (Tomato, Kiwi)?

This activity expands on the other activities, and shows participants that DNA and its genes are a natural part of our every day lives. DNA is consumed every time we eat a meal, but most of it is broken down into more basic units during digestion that can be used by the body.

WHAT TO DO AHEAD OF TIME?

- Ripen fruits ahead of time because cells will be more easily broken during extraction.
- Watch video of DNA isolation procedure. http://ucbiotech.org/dnafordinner/lesson3/DNA_isolation.html
- Try the DNA extraction protocol ahead of time to make sure it works.
- Put alcohol in freezer overnight.

WHAT IS NEEDED?

- Copies of **Handout for Dessert.**

For each extraction, provide the following:

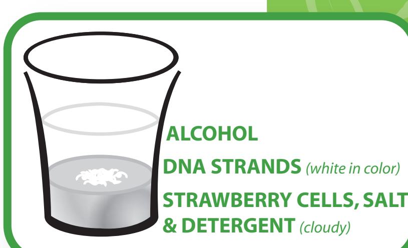
- 1 small ripe tomato, 2 kiwi fruits or 6 strawberries.
- ¼ cup water.
- ½ teaspoon salt.
- 1 blender (can be shared among groups).
- 1 tablespoon liquid dishwashing detergent (Palmolive preferred).
- Cloth or coffee filter for straining.
- Isopropyl (rubbing) alcohol.
- 1 8-ounce clear plastic glass.
- Eyedropper.
- 1 glass or clear plastic tube (½ to1" in diameter).
- 1 paper clip.

HOW MUCH TIME IS NEEDED?

60 minutes.

Directions

1. Select 2 small kiwis, 6 strawberries or a small tomato – soft fruits work better.
2. Remove leaves, stems, skin (from kiwi and tomato) and chop coarsely.
3. Put in blender and blend to achieve "pumpkin soup-like" consistency. Add water if necessary. It is okay to be slightly chunky; don't overblend.
4. Add blended fruit to 8 oz. plastic cup to ~1/3 of cup's volume.
5. Add 1 teaspoon baking soda – it will fizz, especially with acidic fruits.
6. Stir several minutes until fizzing stops.
7. Add equal volume extraction mixture; stir for several minutes.
   Extraction mixture (can be scaled for smaller volumes):
   In 1-quart container add:
   - 4 tablespoons dishwashing liquid (e.g., Palmolive)
   - 3 teaspoons iodized salt
   - Add water to 1 quart
8. Put single layer coffee filter in strainer; filter mixture into glass. Discard pulp in strainer.
9. Add ½ teaspoon (2 milliliters) of this mixture to small transparent glass or plastic tube, using "eye dropper".
10. Using "eye dropper", gently layer 1 teaspoon (4 milliliters) of cold isopropanol down side of tube to form layer on top of mixture. Try not to mix layers.
11. DNA will appear at interface between alcohol and DNA mixture.
12. Unfold a paper clip leaving one end bent into a "U". Carefully twirl it at interface of two layers to capture DNA, which appears as a "snotty glob" on the clip.



Understanding What's Happening

Each of the steps in this procedure is important to isolating DNA. Ask participants to speculate about what happened during each step of the procedure.

- What do you think happened when you mashed the fruit in the blender? *Hint for leader: It breaks the tissue into smaller pieces and even breaks some of the cells open, allowing contents of the nucleus to spill out in long strands. But be careful; if you overblend the fruit, the nuclei will break open and the long DNA strands will be torn into small pieces.*
- What effect do you think the detergent had when you added it to strained fruit mixture? *Hint for leader: Detergent is added to "dissolve" the oily membranes that surround the cell, just like detergent is used to get hamburger grease off of a picnic plate!*
- What happened when salt was added to the mixture? *Hint for leader: Salt causes proteins and starch to come out of solution.*
- Explain what affect you think adding alcohol had on the DNA in the solution? *Hint for leader: After breaking the membrane and precipitating the proteins and starch, alcohol will cause the invisible DNA to come out of solution and form a white or yellowish, snotty-looking layer between the alcohol on top and the fruit solution on the bottom.*

Remind participants that even though they isolated DNA from only one or two fruits, DNA is in all living things and therefore in meat, milk, eggs, yogurt, bread and cereals.

Stuffed, but Hungry for More?

Duckweed

Sequoia tree

If you're not a microbe and you're not an animal, chances are you might be a plant. Scientists believe there are over 260,000 different species of plants. Some are so small you can barely see them, such as some aquatic plants like duckweed. Others are taller than people or animals, like the sequoia trees in California that are almost as tall as a 30-story building. Without plants, there would be no life on Earth.

- Discuss why you think there would be no life on earth without plants.
- Explain various different ways in which humans and animals need and use plants?
- How are plants are able to use sunlight in different ways from the ways humans do?

Note to Leader: Through photosynthesis, plants take energy from the sun, carbon dioxide from the air, and water and minerals from the soil. Leaves on the plant capture energy from sunlight and turn water and carbon dioxide into sugar and starch. This sugar and starch becomes food that provides plants with energy to grow and produce flowers and seeds.

- Can you describe what characteristics all plants have in common?
- Can you explain what differences there are between plants and animals? Any similarities? And what does this mean with respect to their genes?

MATH MENU

1. There are 10,000,000,000,000 to 100,000,000,000,000 million cells in the human body. Express the number of zeros as a power of ten.
2. If ½ teaspoon is equal to 2 milliliters (another way scientists measure volume), how many milliliters would be in a tablespoon? *(Hint to Leader: 3 tsp/tablespoon)*

See answers in Leader Supplements

Some information taken from: http://www.blueplanetbiomes.org/plants.htm

For more information about plants, visit http://www.biology4kids.com/files/plants_main.html or http://www.exploringnature.org/db/detail.php?dbID=22&detID=2290

Duckweed image courtesy of Vic Ramey, UF/IFAS CAIP
Sequoia tree image courtesy of Paul Bolstad, University of Minnesota, Bugwood.org

NEXT TIME WE MEET

The DNA you studied, saw in pictures and isolated has information written in code, which you learned about in Lesson 2. That information is contained in genes, which are like recipes that specify and organism's traits – how tall, what color and the taste. Next time we will learn more about how the information in the DNA leads to the production of the other components in the cells that are responsible for the plant's traits.

SET CONCEPTS ADDRESSED

Discovery-based research and scientific method

National Science Education Standards in Life Sciences Grades 5-8, Content Standard C: Structure and function in living organisms; heredity

SET Process Skills Used: Interpret/analyze/reason; use numbers; observe; use tools

For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

Leader Supplements for Lesson 3

Supplement for Activity 3.3

Ways to Store Information

Stored information or messages	Code, Symbols or Format	Medium
Book or encyclopedia	English language with 26 symbols called letters -or- Spanish language with 30 symbols called letters -or- Chinese language with 8000 symbols called characters	Printed on paper or as computer file
Photograph	Layers of chemicals or computer pixels	Film, photographic paper or computer printer paper
Compact Disk (CD or CD-ROM)	Standard CDs have 33,000 sectors, each with 2,352 bytes – enough to hold over 1,000 books. Each letter in the book occupies 1 byte.	1.2 mm thick, polycarbonate plastic
Flash drive	Holds up to 64 gigabytes or 64 billion bytes of information as binary code	Solid state storage device, with no moving parts; it is electronic not mechanical.
Genome	Genetic code with 4 symbols (G, C, A, T)	DNA

Answers to Math Menu

1. $1X10^{13}$ to $1X10^{14}$
2. 12

DNA: Twisted and Bent Out of Shape?

How to Supercoil!

1

Cut open the rubber band with the scissors and lay it flat on a hard surface.

2

Squeeze the ends of the "rubberband DNA" between the thumb and index finger of both hands, and begin to twist.

3

Twist the band again and again – the more it is twisted the harder it is to straighten.

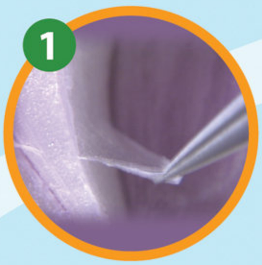
4

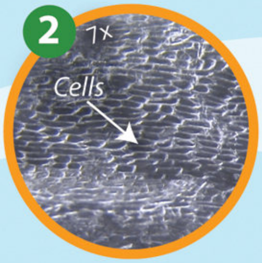
Slowly bring the ends of the "rubberband DNA" together until it curls on itself into a mass of tight, overlapping loops. That is supercoiling!

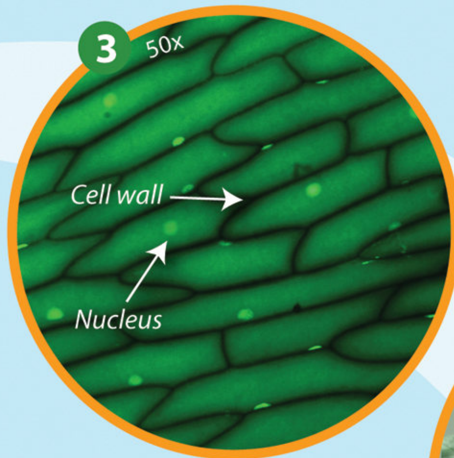
DNA FOR DINNER?

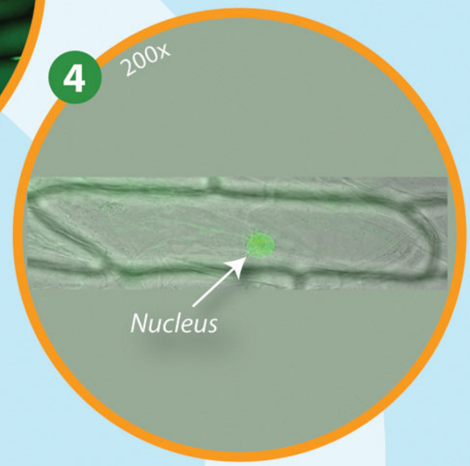
LESSON 3
HANDOUT 3.2

Tour d'Onion

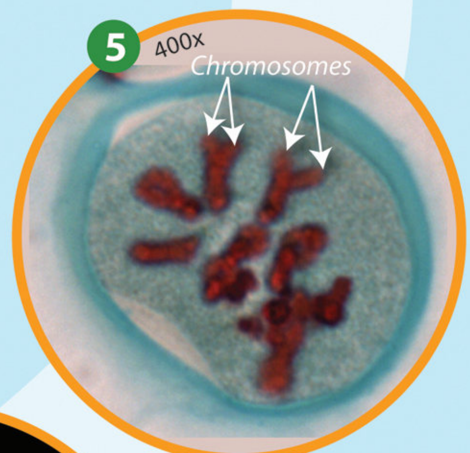


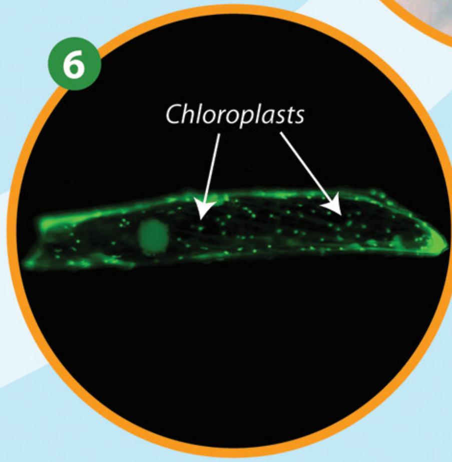






Take a trip!





For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

DNA FOR DINNER?

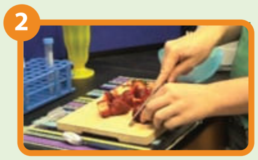
LESSON 3 HANDOUT for DESSERT

There's DNA in My Strawberry (Tomato, Kiwi)?

Extraction Protocol

1 

Select 2 small kiwis, 6 strawberries or a small tomato – soft fruits work better.

2 

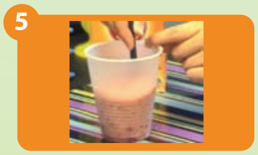
Remove leaves, stems, skin (from kiwi and tomato) and chop coarsely.

3 

Put in blender and blend to achieve "pumpkin soup-like" consistency. Add water if necessary. It is okay to be slightly chunky; don't overblend.

4 

Add blended fruit to 8 oz. plastic cup to ~1/3 of cup's volume.

5 

Add 1 teaspoon baking soda – it will fizz, especially with acidic fruits.

6 

Stir several minutes until fizzing stops.

7 

Add equal volume extraction mixture; stir for several minutes.

Extraction mixture (can be scaled for smaller volumes):

In 1-quart container add:

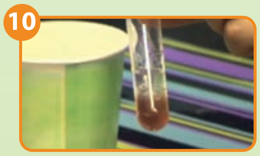
- 4 tablespoons dishwashing liquid (e.g., Palmolive)
- 3 teaspoons iodized salt
- Add water to 1 quart

8 

Put single layer coffee filter in strainer; filter mixture into glass. Discard pulp in strainer.

9 

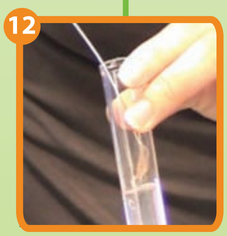
Add ½ teaspoon (2 milliliters) of this mixture to small transparent glass or plastic tube, using "eye dropper".

10 

Using "eye dropper", gently layer 1 teaspoon (4 milliliters) of cold isopropanol down side of tube to form layer on top of mixture. Try not to mix layers.

11 

DNA will appear at interface between alcohol and DNA mixture.

12 

Unfold a paper clip leaving one end bent into a "U". Carefully twirl it at interface of two layers to capture DNA, which appears as a "snotty glob" on the clip.

Congratulations!

You have seen the magic that is DNA!

For more information & additional lessons, please visit

http://ucbiotech.org/dnafordinner

LESSON 4

DNA FOR DINNER?

Building Blocks to Organisms

*Prepared by Dr. Peggy G. Lemaux (Cooperative Extension Specialist)
and Barbara Alonso (Communications Specialist)
University of California, Berkeley | http://ucbiotech.org/dnafordinner*

WHAT WE WILL DO

- Explore the function of common enzymes in food and in humans.
- Learn how DNA provides information to make RNA, from which proteins are made.
- Examine how amino acids are specified in RNA by the specific order of three bases. The order of amino acids determines the particular protein to be made.

WHAT WE WILL LEARN

- The order of A's, C's, G's and T's in the DNA sequences of genes is the code for specific **amino acids** that result in specific proteins.
- The order of amino acids determines the function of the particular protein.
- Different proteins do different jobs in the organism.
- Some proteins, called **enzymes**, have functions that speed reactions in the cell.
- Certain DNA sequences are "on" switches to start proteins; others are "off" switches to end proteins.

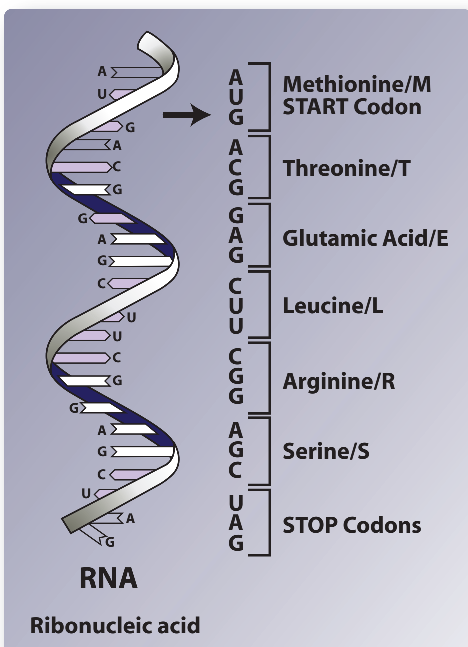
TABLE OF CONTENTS

** optional*

Funding for this project was made available by the American Society of Plant Biologists' Education Foundation. http://aspb.org

This curriculum follows 4-H SET guidelines http://www.ca4h.org/SET

Appetizer



In a previous lesson participants learned that genes contain coded information. The coded information in a single gene normally provides the organism with the "blueprint" to make a single protein. The information for proteins is contained in DNA in four chemical units or bases, termed A, C, G and T. Information in DNA is copied into the complementary bases A, C, G and U in messenger **RNA** ("U" substitutes for "T" in RNA). The bases in RNA are then read by the cell machinery in sets of three, called a **codon**, that specify one of 20 **amino acids**. Strings of amino acids make proteins and together all proteins give the organism its characteristics.

Proteins are chemicals that each accomplish a task. Certain specialized proteins, called **enzymes**, speed up reactions in the cell - sometimes making them perform a task a million times faster. Some proteins are used to give the organism its shape, while others give it energy to perform work. For example, in plants, some proteins direct the shape and size of leaves; others determine these characteristics for the fruits, flowers and seeds, like their **carbohydrate** and **starch** content. Other proteins help the plant capture energy from the sun and directly turn it into food for the plant and indirectly for humans who eat plants or parts of plants.

What's in a Word?

Words

Amino acids • Carbohydrates • Codon • Enzyme • RNA • Starch

Participants will find new words in this lesson. Some may be similar to words they already know and some may not be.

Amino acids are basic building blocks of protein. There are 20 different amino acids: alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine and valine. Each amino acid is specified by different sets of three A's, C's, G's and U's (**Handout 4.1**). The words "amino acid" relates to a 19th century German word meaning "building stones".

Carbohydrates are a group of chemicals, containing carbon, hydrogen and oxygen. They include sugars, starches, celluloses, and gums and are a major energy source in our diet. The word comes from *carbo*, meaning carbon, and *hydrate*, meaning water, which contains hydrogen and oxygen.

Codon contains three bases of either A's, G's, C's or U's, that code for a specific amino acid. Some amino acids have more than one triplet code. There are also codons that start or stop protein synthesis. Codon has the same origin as a word we learned about in **Lesson 2,** *code*.

Enzymes are specialized proteins that speed certain chemical reactions, often millions of times faster than they would occur without enzymes. Most processes in the cell require enzymes. *En* and *zyme*, originally Greek words, mean to leaven, because certain yeast enzymes cause bread to rise or be leavened.

RNA, for **r**ibo**n**ucleic **a**cid, is similar to DNA, but contains the sugar, ribose, not deoxyribose as in DNA. Unlike double-stranded DNA, RNA is single-stranded, copied from a single strand of DNA by pairing G with C; C with G; T with A; and A with U, which substitutes for T in RNA. There are three types of RNA: ribosomal, transfer and messenger.

Starch is a carbohydrate made of carbon, hydrogen and oxygen and is in the form of sugars linked together. In plants it is mainly in seeds, fruits, tubers, roots and stems. *Starch* comes from the Middle English word, *starche*, a substance used to stiffen cloth.

You may notice other words with these same roots. By finding the root in a word, you may be able to figure out what it means, even if you have never seen the word.

Remembering the Last Lesson's Important Points

Remember these words?

Cell • Chemicals • Chromosome • Nucleus • Organelle

Ask These Review Questions

- Explain how information in books or flash drives are the same as or different from information in a genome? (Encourage participants to use terms introduced in the last lesson.)
- Describe supercoiling of DNA and explain why it is necessary?
- Give each participant **Handout 4.1**, and ask them to arrange the steps in the order in which they were performed. Then talk about the various steps you performed when you isolated DNA from a tomato (strawberry, kiwi)?
- Tell me what you think might happen if cells did not have DNA.

Main Course

- Activities will introduce participants to the use of a DNA triplet code that specifies the amino acids in a protein.
- Participants will learn that specific sets of amino acids make particular proteins and that different proteins perform different functions.
- Two activities are offered in this lesson; one is optional. There is also an activity associated with Dessert.
- In these activities participants will learn about RNA and how its bases are arranged in triplets that specify particular amino acids. Amino acids are linked together to form proteins, which perform important functions in the cell.

ACTIVITY 4.1 Mellow Jell-O® and Spit 'N Crackers

In this activity, participants will learn what kinds of jobs proteins can do. Start with the gelatin and pineapple activity, so the gelatin can set while you do the Spit 'n Crackers activity. Brand names are used as examples and do not constitute product endorsement.

WHAT TO DO AHEAD OF TIME?

- Purchase fresh pineapple, 1 small can of pineapple, any gelatin flavor and unsalted or matzo crackers.
- Cut fresh pineapple into slices.
- Have boiling water ready.

WHAT IS NEEDED?

- Boxes of any gelatin flavor.
- Bowls.
- Measuring cups.
- 1 fresh pineapple.
- 1 small can of pineapple drained.
- Unsalted crackers or matzos.
- Napkins.

HOW MUCH TIME IS NEEDED?

- 15 minutes to set up Mellow Jell-O® Activity.
- 10 minutes for Spit 'N Cracker Activity.
- Additional 5 minutes to observe outcome of Mellow Jell-O® Activity.

Directions

Mellow Jell-O®
Start this activity first to allow gelatin to set up before participants end the activity. Divide participants into groups. Ask half of the groups to make gelatin with fresh pineapple; the other half with canned pineapple. Follow directions on the gelatin box for making the liquid gelatin. Divide the liquid gelatin into enough bowls so that each group has one bowl. Ask some groups to add several chunks of fresh pineapple to their bowl and the other groups to add several chunks of canned pineapple. Thoroughly stir both and refrigerate. Observe results after gelatin sets up.

Spit 'N Crackers
After gelatin activity is underway, have participants be seated and give each participant a soda cracker. Have them put it in their mouths and chew. DO NOT SWALLOW. After chewing for 30 seconds, ask participants to describe what taste the crackers have. Then ask them to continue chewing WITHOUT swallowing. After 2 minutes of chewing, ask them again to describe the flavor of the cracker. It is important to use unsalted crackers or matzo because they contain less sugar and salt and thus will have no initial salty or sweet taste.

After the Spit 'N Cracker Activity share with the group the following. Remind them that DNA contains the information that gives an organism its special characteristics, like colors, tastes and smells. The chemical bases in DNA, A,G,C,T, are used to copy another very important informational chemical, called RNA. RNA is complementary to DNA so that every G in the DNA is matched by a C in the RNA copy. Every C is matched by a G; T with an A and every A with a U. The U substitutes for T in RNA. The code in RNA is the information the cell uses to make proteins.

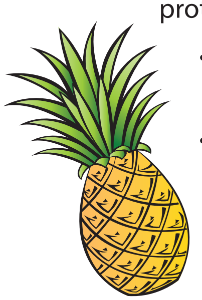
- Describe what kinds of functions proteins might perform?
- Explain why the taste of the cracker changed after you chewed on a cracker for several minute?

  Hint to Leader: Amylase, an enzyme which degrades starch into sugars, is present in our saliva and changes cracker starch into sugar. Sugars taste sweet; starch doesn't. Breaking down starches to sugars is necessary for the body to use the starch for energy.

• How do you think the cell is able to make so many different proteins of different functions?

Hint to Leader: The number and sequence in which amino acids are hooked together determine a protein's size and its function. Cells hook amino acids together, just like cars in a train are hooked together; the result is called a protein.

After completing the Spit 'N Cracker activity, have participants check the results from their Mellow Jell-O® Activity. When considering the Mellow Jell-O® Activity, share the following. The ingredient in Jell-O® that makes it wobbly is actually a protein, called gelatin. When it is dissolved in hot water and allowed to cool, the proteins link together like strings in a net to make the mixture solid.



• Explain why you think the gelatin did not solidify when you added fresh pineapple?

• Why do you think canned pineapple did not give the same result?

Hint to Leader: The gelatin didn't become wobbly when fresh pineapple was added because there is an enzyme in fresh pineapple that breaks the long protein chains that makes the gelatin strings break into shorter pieces. The heat used to can pineapple destroys the enzyme that breaks down the gelatin.

ACTIVITY 4.2 Genetically Modified Hopscotch (optional)

WHAT TO DO AHEAD OF TIME?

- Choose one of the diagrams in the Leader Supplement for Activity 4.2 to use as your hopscotch court.
- Draw it out with chalk to speed up the game.
- Let the participants add the A's, G's, C's and U's to reinforce learning the chemical units in RNA.
- Copies of **Handout 4.2**.

WHAT IS NEEDED?

- Cement surface, driveway or sidewalk.
- Sidewalk chalk.
- Unique small markers for each player (stones, plastic yogurt lids, buttons).
- **Handout 4.2** containing the triplet code.
- Paper, pencil to write down amino acid sequences generated.

HOW MUCH TIME IS NEEDED?

30 - 40 minutes.

Directions

Remind participants that DNA is written in the chemical bases, A, G, C and T that is translated into RNA. RNA is complementary to the DNA.

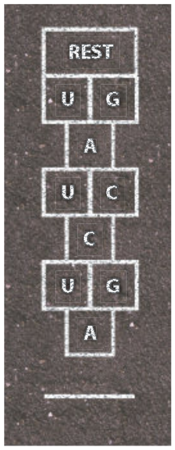
• Explain what it means that RNA is complementary to DNA?

Note to leader: Participants will learn more about this in the Dessert activity).

• Can you discuss why you think it is important that RNA is copied exactly as the DNA is?

The protein synthesizing machinery reads the chemical bases in groups of three, inserting a specific amino acid for each triplet in the RNA using the genetic code (**Handout 4.2**). The amino acids are strung together to make a protein and that protein has a specific function in the cell, just like the enzyme in your spit that broke down the starch in the cracker to make sugar. Today we will create a genetic code with hopscotch and then translate that code into a protein.

How to Play



Find a level cement surface and draw two identical hopscotch courts with sidewalk chalk following the hopscotch court diagrams shown in the Leader Supplement for Activity 4.2. Each box should be about 18 inches square. Have participants put either an A, G, C or U in each box, as shown. This will help familiarize them with the chemical makeup of RNA. Draw a two-foot line a few feet from the bottom of the diagram where players will stand to toss their markers.

Divide participants into two teams and start each team at the line for one of the hopscotch courts. One player from each team throws their marker. To start their protein, they must get their marker first on an "A". If they do not, the second player tries to land on the "A". Once they get the marker on the "A", they hop on one foot when there is a single square (without a marker) and on two feet when there are two squares across the court. Participants must miss jumping in the square with the marker. They lose their turn if they step on the square with the marker or step on a line. Once the individual reaches the final square, marked REST, he/she turns around and comes back, retracing their steps and stopping at the square with the marker. The participant must then bend down, pick up the marker and return to the beginning line. After the "A", the next player must get a "U" and finally the third player a "G".

Once the team has "AUG", which is the starting codon for almost all proteins, they continue throwing their markers on any square to make a protein of 5 amino acids using sets of 3 bases (for a total of 15 bases). One participant keeps track of each base on the sheet of paper. Each team must end their five-amino acid protein by landing their markers on a stop codon, "UAA, UGA or UAG". If a team gets a stop codon before they have 5 amino acids, they must toss their marker again to get a triplet for an amino acid. Once they have 15 bases, they separate the bases out in the order in which they were generated, into triplets. They then construct their protein by converting the base sequence into an amino acid sequence using **Handout 4.2**.

Once both teams finish, they should check the sequence of the other team to make sure they read the amino acids correctly.

Challenge the players with the following:

- Why do you think you had to land first on the "AUG" before you could start building your protein?
- Explain what you think would happen if you landed on "UAA, UGA or UAG" before the entire protein sequence was completed.

Final Course

Discussion with Participants

Proteins are chemicals and our bodies and many foods we eat are made up of proteins. Most proteins are not harmful to our bodies, but some are. Poisonous snakes have many proteins in their saliva. Some are toxic and are called venom. Snake venom is only poisonous when a snake bites you and releases its poisons into your bloodstream. If you drank snake venom or sucked it from a snake bite on your arm, it wouldn't be poisonous.

- Why do you think venom would not be poisonous if you sucked it from a snake bite or drank it?
  Note to Leader: Humans have enzymes in their digestive systems that break down the venom protein before gets to the bloodstream.
- How is what happens to venom in your digestive track similar to what happened in the **Spit 'N Cracker Activity**?

Dessert

Live and Play DNA

This activity builds on other information that participants has been learned in this lesson. Explain to participants that each of them is going to be one base in a DNA strand that they will form. They will then pair with their complementary base in another DNA strand. They will live and play as DNA!

WHAT TO DO AHEAD OF TIME?

- Make enough 8.5" x 11" sheets of paper for all participants with equal numbers of A's, C's, G's and T's written in large letters on each sheet.
- Pin or tape paper to attach letters to front of participants' coats or shirts.
- Two 2' long pieces of string or yarn for half of the participants.

WHAT IS NEEDED?

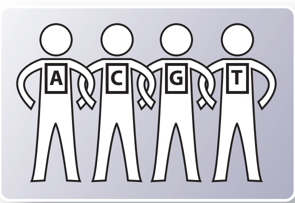
- One sheet of paper with a letter for each participant. Enough sheets of paper so each participant has one.

HOW MUCH TIME IS NEEDED?

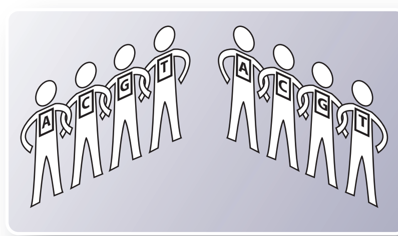
25 - 35 minutes.

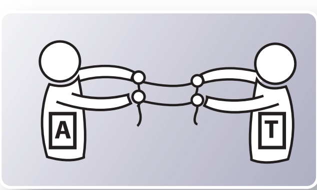
Directions

Ask each participant to take one letter and either pin or tape it to the front of their coat or shirt. Make sure that there are equal numbers of complimentary bases. That is, the same number of A's and T's and the same numbers of G's and C's so that all participants will be able to pair with their "compliment".



Have participants stand in a long line. The two lines must have equal numbers of A's to match with T's in the other line, G's to match with C's, etc. The leader reminds participants that chromosomes have two complementary strands. The bases in the DNA, A's, T's, G's and C's, link to each other in one strand and then pair with their complementary base in the other strand. Ask half of the participants to line up randomly in a straight line, making sure that there are equal numbers of A's in the first line to match with the same number of T's in the second line; the same number of G's in the first line to match with equal numbers of C's in the second line, etc. To simulate that the bases in each strand link to each other, ask participants in the first line to link elbows tightly with the other "bases" in their line. Once the line is linked, ask the second set of participants to find their complementary base in the first line: "A" finds a "T" and "G" finds a "C". When they find their complementary base, ask them to stand directly across from the base and also link elbows with the other "bases" in their line.





In the two complementary strands that form DNA in an organism, the two complementary bases in the opposite strands pair with each other. To simulate that, hand each participant in the first line 2 pieces of string, one for each hand. Ask participants with complementary bases, standing across from each other, to grab the ends of the two strings being held by their complementary base. Each line should continue to lock elbows.

- Speculate as to which bond in the DNA you think might be stronger – the one linking the backbone (locking elbows) or the pairing between bases (holding the strings)?
- If only one strand of DNA is copied to make RNA, can you guess what must happen to the base pairing in order for copying to occur?

Special thanks to Jenne Stonaker for providing the idea for the "Live and Play DNA" activity.

Have everyone take a step to their right. Instruct participants to grasp hands of the person in front of them only if that person is a complementary base.

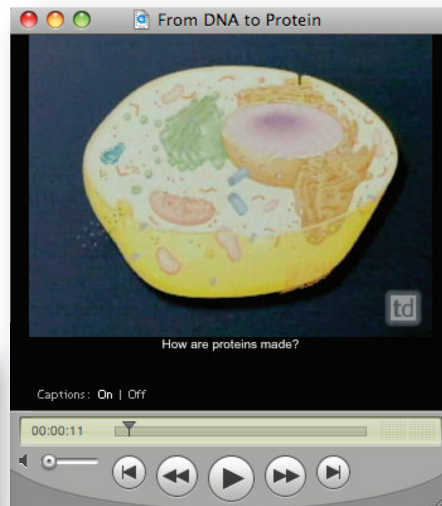
- Describe what you think happened to the strength of the bonding in the backbone when you moved to the right?
- Describe what you think happened to the bonding of the complimentary bases when you moved to the right?

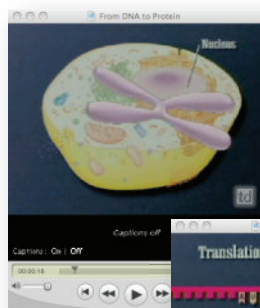
Tip to Leader: The bonds between the bases in the backbone (elbows linked) are covalent bonds that are stronger than the hydrogen bonding (strings held) that takes place between complimentary bases. Those bases must come apart when DNA is replicated but the bonds in the backbone do not.

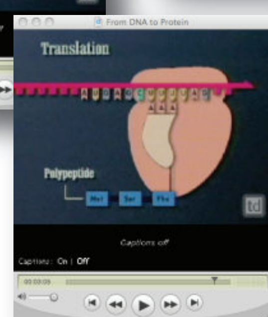
Stuffed, but Hungry for More?

Watch the animated video, adapted from NOVA's "Secret of Life" http://ucbiotech.org/dnafordinner/lesson4/DNA.html.

This video illustrates the process of protein synthesis, starting with chromosomal DNA inside the cell's nucleus. A gene is transcribed into messenger RNA (mRNA), which leaves the nucleus and binds to the protein synthesizing machinery, called ribosomes, in the cytoplasm. There, other RNAs, called transfer RNAs or tRNAs that attach to the mRNA and build a chain that will fold into a functional protein.







"From DNA to Protein" video ©1995, 2002 WGBH Educational Foundation. All rights reserved. Adapted from NOVA: "Secret of Life".

MATH MENU

1. If there are four different nucleotides and they are used as triplets in the genome to encode amino acids, how many different combinations of triplets can there be?
2. The smallest protein known is believed to be only 20 amino acids long; one of the largest is believed to be 27,000 amino acids. How many times larger is the largest protein?

See answers in Leader Supplement

NEXT TIME WE MEET

In this lesson we learned that genes are coded for in DNA that is made into RNA. The triplet codes in RNA specify amino acids that are linked together to form proteins that serve important functions in the cell. Next time we meet we will see how researchers perform genetic modification of plants by crossing two plants using classical breeding to change traits or by using genetic engineering to locate and move specific genes into other genomes to change traits of the organism that receives the new gene.

SET CONCEPTS ADDRESSED

Discovery-based research and scientific method

National Science Education Standards in Life Sciences Grades 5-8, addressed: Content Standard C, Structure and function in living organisms; regulation and behavior

SET Process Skills Used: Interpret/analyze/reason/observe; predict; problem solve; question

For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

Leader Supplement for Lesson 4

Supplement for Activity 4.2

DIAGRAM 1

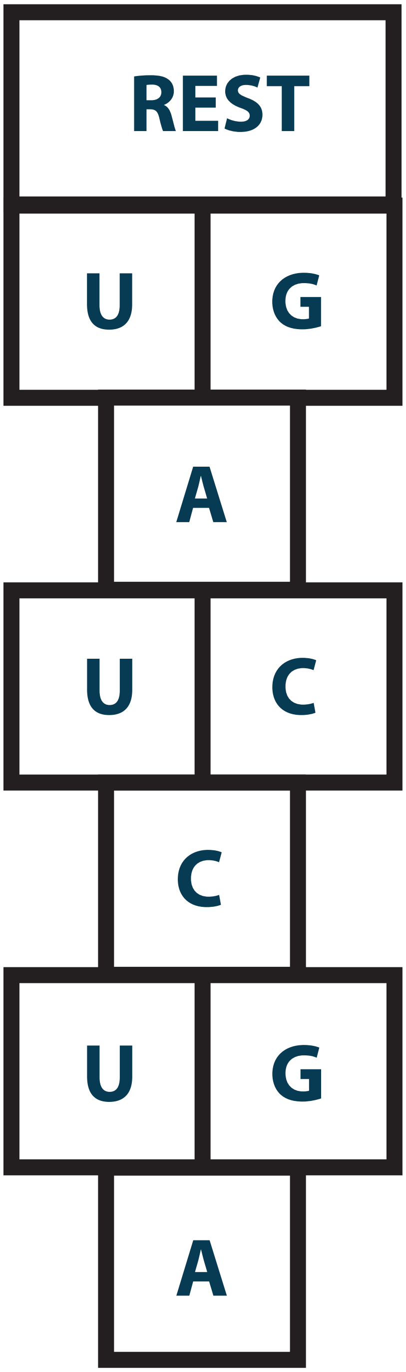
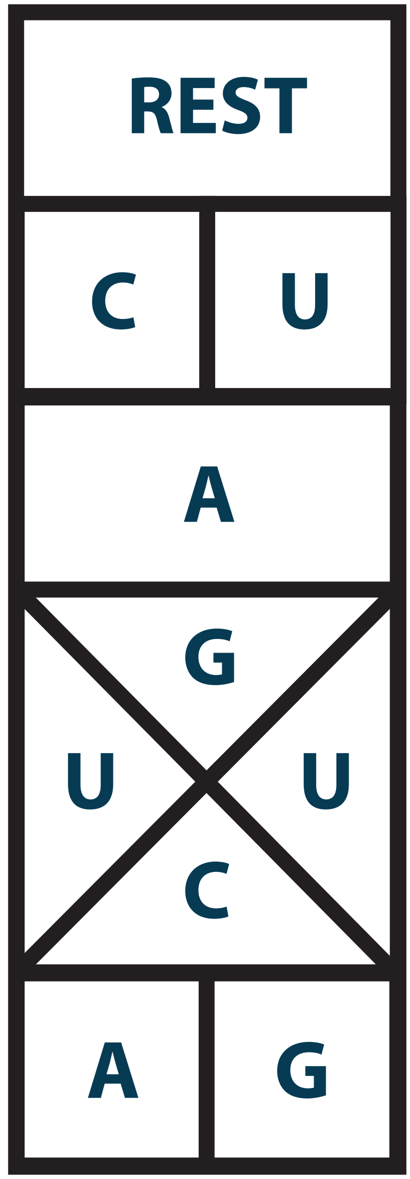


DIAGRAM 2



Answers to Math Menu

1. 64
2. 1350 times

DNA FOR DINNER?

LESSON 4
HANDOUT 4.1

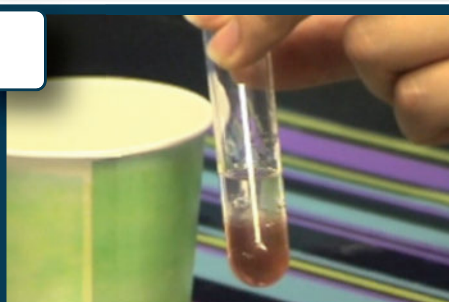
Juice Bar Jumble

Instructions

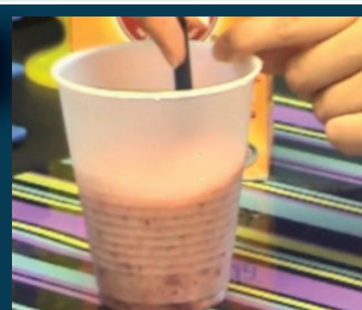
Some of the steps from the DNA isolation activity are pictured. The first and last steps are already numbered and the challenge is to fill in the rest of the numbers in the top left-hand box to create the right sequence of steps. Read the captions to help guide you in the right direction.

1

Choose the fruit, put in blender and blend to achieve "pumpkin soup-like" consistency. Add water if necessary; don't overblend.

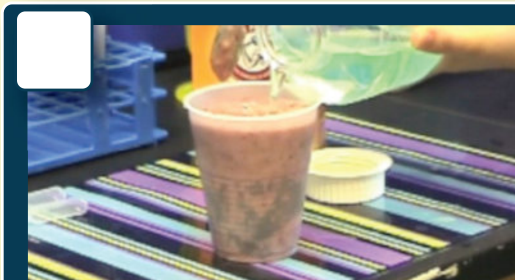


Add ½ teaspoon (2 milliliters) of mixture to small transparent glass or plastic tube and then add one teaspoon (4 milliliters) of 95% ethanol gently down the side on top of the mixture.



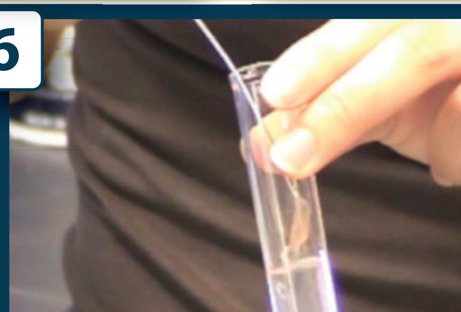
Add blended fruit to plastic cup and add 1 teaspoon baking soda – it will fizz.

Put single layer coffee filter in strainer; filter mixture into glass.



Stir few minutes until fizzing stops. Add equal volume extraction mixture and stir.

6



DNA will appear at the interface. Use a paperclip to pull the gummy mass of DNA out of the solution!

DNA FOR DINNER?

LESSON 4
HANDOUT 4.2

Genetically Modified Hopscotch

Amino Acid/Abbreviation	Triplet Code in RNA
Alanine/A	GCU, GCC, GCA, GCG
Arginine/R	CGU, CGC, CGA, CGG, AGA, AGG
Asparagine/N	AAU, AAC
Aspartic Acid/D	GAU, GAC
Cysteine/C	UGU, UGC
Glutamine/Q	CAA, CAG
Glutamic Acid/E	GAA, GAG
Glycine/G	GGU, GGC, GGA, GGG
Histidine/H	CAU, CAC
Isoleucine/I	AUU, AUC, AUA
STOP Codons	UAA, UGA, UAG
Leucine/L	UUA, UUG, CUU, CUC, CUA, CUG
Lysine/K	AAA, AAG
Methionine/M START Codon	AUG
Phenylalanine/F	UUU, UUC
Proline/P	CCU, CCC, CCA, CCG
Serine/S	UCU, UCC, UCA, UCG, AGU, AGC
Threonine/T	ACU, ACC, ACA, ACG
Tryptophan/W	UGG
Tyrosine/Y	UAU, UAC
Valine/V	GUU, GUC, GUA, GUG

LESSON 5

DNA FOR DINNER?

From Bread to Biotech

Prepared by Dr. Peggy G. Lemaux (Cooperative Extension Specialist)
and Barbara Alonso (Communications Specialist)
University of California, Berkeley | http://ucbiotech.org/dnafordinner

WHAT WE WILL DO

- Learn how yeast uses sugar to make holes in your loaf of bread.
- See how male and female corn cells come together to form the grain on an ear of corn.
- Create a recombinant story using cutting and pasting methods similar to those used for DNA manipulation.
- Find out how PCR can be used to multiply gene fragments.

WHAT WE WILL LEARN

- Literally **biotechnology** means using organisms to do a job, like using yeast to make bread.
- Modern biotechnology uses new genetic tools to modify genomes and speed crop development.
- In the past humans modified genomes by crossing plants with different traits and selecting ones with improved traits.
- A part of modern biotechnology, called **genetic engineering**, involves isolating genes, linking them to on and off switches and introducing them into the same or different organisms.
- Special enzymes are used to cut (restriction enzymes) and paste (ligase) DNA, in a process called **recombinant DNA**.

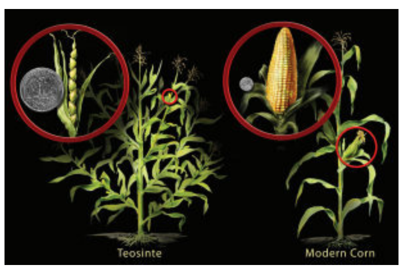
TABLE OF CONTENTS

** optional*

Funding for this project was made available by the American Society of Plant Biologists' Education Foundation. http://aspb.org

This curriculum follows 4-H SET guidelines http://www.ca4h.org/SET

Appetizer



Teosinte (left), ancestor of modern corn (right)

Most all food comes from plants – either directly by eating them or indirectly from animals that eat them. Plants we eat haven't always looked the way they do today. See on the left how modern corn has changed from its ancestor. This is because people have selected plants for thousands of years that are sweeter, bigger, tastier and able to fight off pests and survive harsh environments.

One way people have done this uses **selective breeding**. Male cells, or pollen, from one plant is crossed with female cells, or eggs, of another related plant. Plants from that cross are observed and ones with the best traits are selected. For example, if we cross one tomato variety with deeper color and more vitamins with another that is sweeter, we look through resulting plants for one with sweeter, darker red, more nutritious tomatoes.

About half of the genes in each parent's genome end up in offspring, but the choice of which genes is random. This is why two brothers look different from each other. Results with plant breeding are the same. Breeders can't control what genes end up in a given plant. They can just choose plants with desired traits.

Today new tools speed breeders' jobs. By developing road maps for the genome showing locations with valuable traits, breeders perform **marker assisted breeding**. Using this tool breeders can identify plants with specific traits using molecular markers. Think of this in terms using a word processing system to find particular words in a document.

Although selective breeding results in genetic modification, it can't be used to move traits from different kinds of organisms, like from apples to tomatoes. This kind of modification is possible using new genetic tools, called by some **biotechnology**, but by others **genetic engineering** or **recombinant DNA**.

What's in a Word?

Words

Biotechnology • Genetic engineering • Genomics
Marker assisted breeding • Recombinant DNA • Selective breeding

Participants will find new words in this lesson. Some may be similar to words they already know and some may not be.

Biotechnology involves the use or manipulation of living organisms to produce useful products. This includes using microbes to produce bread or yogurt or applying genetic engineering to make pest-resistant plants. It comes from the Greek root, *bios*, which means life, and *technē* meaning craft or skill.

Genetic engineering is a new method of genetic modification that involves the scientific alteration of the genome of a living organism, using the tools of recombinant DNA.

Genomics is the study of the genome, which contains most all of the genetic information in an organism that determines its traits. The word is from the German, *gen*, meaning to produce, and the Greek, *ome*, meaning body.

Marker assisted breeding is a process by which a visible, chemical or RNA/DNA-based marker is used to select indirectly plants that have traits of interest.

Recombinant DNA means joining DNA together from two sources, using enzymes that can cut and paste DNA. It is the process used to genetically engineer plants.

Selective breeding is a classical means of genetic modification that involves crossing two different, but compatible, organisms to get offspring that have the desirable traits of both parents.

You may notice other words with these same roots. By finding the root in a word, you may be able to figure out what it means, even if you have never seen the word.

Remembering the Last Lesson's Important Points

Remember these words?

Amino acids • Carbohydrates • Codon • Enzyme • RNA • Starch

Ask These Review Questions

- Describe what an enzyme is and what functions it might have in your body. (Encourage participants to use terms introduced in the last lesson).
- Explain the relationship of RNA to DNA and the importance of RNA in making protein.
- Describe the manner in which the A's, C's, G's and T's in DNA bond to each other within a single strand and between strands.

Main Course

- Activities will introduce participants to the consequences of genetic modification using classical breeding techniques and recombinant DNA technology.
- Three activities are offered in this lesson; two are optional. There is also an activity associated with Dessert.
- In these activities participants will find out how genetic modification has been accomplished in the past and what new tools are used today to study and modify DNA.

ACTIVITY 5.1 Balloons, Bottles and Bread

In this activity we will see the process of yeast producing carbon dioxide after being fed sugar – the same activity that occurs when making bread.

WHAT TO DO AHEAD OF TIME?

- Purchase yeast, sugar and a large rubber balloon.
- Find an empty, heavy glass/plastic beverage bottle.
- Make copy of **Handout 5.1** for each participant.

WHAT IS NEEDED?

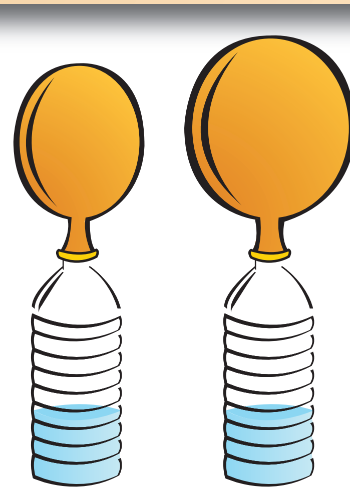
- One package of rapid active dry yeast.
- 1 cup very warm water (105º F to 115º F).
- Two tablespoons of sugar.
- Copy of **Handout 5.1** for each participant.

HOW MUCH TIME IS NEEDED?

20 - 25 minutes.

Directions

1. Before beginning the activity, stretch the balloon out by blowing it up several times and then releasing the air.
2. Add entire packet of yeast and sugar to cup of warm water and stir until sugar is dissolved.
3. Pour mixture into bottle.
4. Attach balloon to top of bottle, making sure bottle is sealed tightly.
5. After several minutes, observe the balloon. If nothing happens right away, wait longer.



Discussion

Nearly 10,000 years ago, humans began using one-celled organisms to make bread. In bread-making the organisms, yeast, are provided with sugars which they can break down. As they consume the sugar, they produce alcohol, which contributes to the aroma of baking bread, and carbon dioxide, which makes the dough rise and form a honeycomb texture.

In this activity the yeast feeds on sugar and produces carbon dioxide. With no place to go but up, this gas slowly fills the balloon. A very similar process happens as bread rises. Carbon dioxide made by the yeast has no place to go and expands the network made by the proteins in the wheat flour to form thousands of balloon-like bubbles. Bubbles gives the bread its "holey" texture texture.

- What do you think would happen if we substituted salt for the sugar?
- Describe what might happen if you used cold water instead of warm water.

When participants finish discussion, ask them to complete **Handout 5.1**.

ACTIVITY 5.2 Birth of Baby Corn (optional)

WHAT TO DO AHEAD OF TIME?

- Purchase ear of fresh sweet corn (preferably with husk and silks).
- Review **Handout 5.2.**

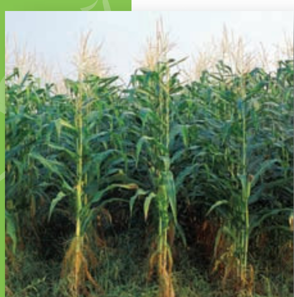
WHAT IS NEEDED?

- Copies of **Handout 5.2** for each participant.
- Ear of sweet corn.
- Table knife.
- Tweezers.
- Disposable plates.
- Magnifying glasses (10X), if possible.

HOW MUCH TIME IS NEEDED?

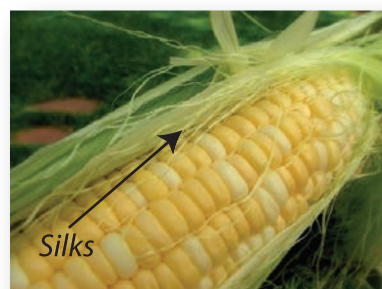
15 minutes.

Directions



Provide participants with **Handout 5.2** and the following explanation. A mature corn plant has a tassle at the top and one or two ears half-way down the plant (**Photograph 1**). The female corn cell (the egg) resides in the ear of the corn (**Photograph 2**), and the male corn cell (the pollen, **Photograph 3**) comes from the tassel on the top of the plant. When the pollen lands on the corn silk (the hairy part on the top of the ear, **Photograph 4**), the male cell travels down the silk until it mates with the egg inthe ear. When the mating occurs each cell donates half of its genetic information to the fertilized egg. That way the final fertilized egg has exactly the same amount of genetic information as the original corn cells. Once fertilized, the egg develops into a small embryo surrounded by a starchy layer (**Photograph 5**) that provides food for the embryo when it is exposed to water and soil and germinates. One end of the embryo forms leaves and the other the roots. Sometimes when the pollen does not reach the egg to fertilize it, the ear has gaps with no developing grain (**Photograph 6**).

Ask participants to remove husks from ear of corn and pass it around to the other participants. Try to leave the silks attached to the ear. Ask participants to look at the ear and try to identify individual seeds and where the silks attach to the seeds. Once everyone has seen the ear, use a knife and the cutting board to cut off seeds as close to the cob as possible. Place one or two seeds on a disposable plate for each participant. Ask them to use tweezers to open the seed to look inside. Most of what they see is starch but, at the cut end of the seed, they should see a small, firm 1/8-1/4" oval structure, the embryo, embedded in the softer, starchy tissue. Instruct participants to use the tweezers to remove the embryo, placing it on the disposable plate. Tell them to use the magnifying glass to look at the embryo.



- When using the magnifying glass to look at the embryo, describe what you see?
- Speculate about what you think any structures you see might be.
- Why do you think they might be important to the developing seed?

ACTIVITY 5.3 Gene Hunt (optional)

WHAT TO DO AHEAD OF TIME?

- Make copies of **Handouts 5.3** and **5.4** for each participant, as appropriate.
- Secure access to the internet, if possible.

WHAT IS NEEDED?

- Copies of **Handouts 5.3** and **5.4**, as needed.
- Pencils for each participant.

HOW MUCH TIME IS NEEDED?

30 - 40 minutes, as appropriate.

Directions

If you want to engineer a gene and reintroduce it into a plant cell, you have to first find the gene and get enough of it to manipulate it in the laboratory. One way to do this is using PCR, or polymerase chain reaction. Participants will first be introduced to the principles of PCR in **Handout 5.3** and **5.4**.

Before participants begin the activity, share the following. PCR is used to amplify certain fragments of DNA. This is quite similar to activities that you can do with a word processing system. Both handouts cover the principles of PCR. Participants can perform the exercises on **Handout 5.3**, **Handout 5.4** or both, depending upon interest. Give each participant a copy of the appropriate handout and give them time to complete this exercise.

If participants are going to complete the exercises in both handouts, wait until the participants finish Handout 5.3 before giving them Handout 5.4. The activity in Handout 5.4 will allow them to perform the process of PCR on DNA on paper - just like it occurs in a test tube in the laboratory.

After participants complete **Handouts 5.3**, **5.4** or both, challenge them with the following.

- Describe ways in which PCR is similar to actions that are performed with a word processing system.
- Explain what the meaning of the acronym Pick, Copy, Repeat means with regard to the process of PCR.

If participants completed Handout 5.4, ask them the following questions.

- How does the sequence of the complementary strand, Copy-C1, in Step 4 cycle differ from that of C-1 made in Step 3?

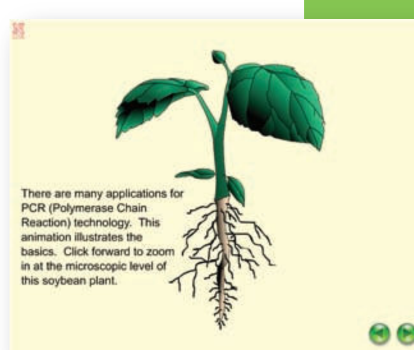
  Hint to Leader: If participants have difficulty answering this question, ask them to write out the two sequences, one right under the other.

- Why does this difference occur?
- Describe what you think will happen when you repeat these cycles over and over.

  Hint to Leader: During each cycle after the 2nd cycle, the proportion of Copy-C1 and Copy-C2 fragments will increase, resulting in thousands of copies of Copy-C-1 and Copy-C-2. The number of original strands (S-1 and S-2) will not increase. This results in a large amount of the Copy-C1 and Copy-C2 fragments.

If participants have access to the internet, the URL provided gives a brief tutorial on the principles of PCR.

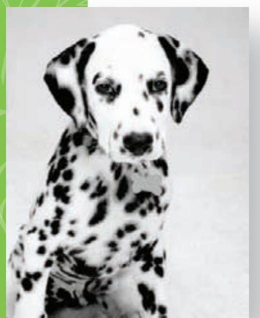
http://plantandsoil.unl.edu/croptechnology2005/pages/animationOut.cgi?anim_name=PCR.swf



University of Nebraska, Institute of Agriculture and Natural Resources

Final Course

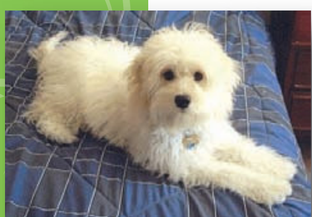
Discussion with Participants



Read or paraphrase:

- Ask participants who have dogs as pets to describe their pet. What color is its coat? How big is it? How long is their coat?

People have developed dog breeds as different from one another as a spotted, short-haired dalmatian and the solid-colored, long-haired collie. The many different breeds of dogs we have today are due to **selective breeding**. People decide which dogs to breed - that is, which dogs they want to have puppies. But, when you breed two dogs together, you don't have control over exactly what the puppies will look like because you can't control which genes are kept and which are lost.



Breeding allows genomes of parents to mix together and offspring obtain genes from both parents. This is especially noticeable when you breed two very different dogs, like a poodle and a cocker spaniel. Then you get a Cockapoo.

- Describe what you think the puppies from such a mating would look like.
- Explain what you believe would happen if you tried to mate a dog with a cat?

And you can only breed between organisms that are closely related – dogs with dogs, not dogs with cats. The same is true with plants. One apple variety can be crossed with another apple variety, but not with a tomato. With genetic engineering, it is possible to cut out a single gene from the genome of one organism, like a tomato, and paste it back into a tomato or into the genome of another organism, like apple. This process is called recombinant DNA because it involves chemically recombining DNA.

- Describe why you think it is possible to move a gene from a tomato into an apple.
- Explain why you think moving a single gene from a tomato into apple would or would not make the apple red and seedy like a tomato.

Dessert

Recombinant Folk Tale

This activity builds on the information contained in this and earlier lessons. Participants will construct recombinant folk tales by exchanging phrases between the two stories. But phrases can only be exchanged if the "target sites", on both ends of the text that is exchanged is the same. This is the same process that in principle is used when performing genetic engineering in plants.

WHAT TO DO AHEAD OF TIME?

- Determine access to word processing system on computers to demonstrate the process of cutting and pasting folk tales.

- or -

- Make copies of **Handouts 5.5** and **5.6** for each participant.

WHAT IS NEEDED?

- Computer with word processing system

-or-

- Pencils.
- Scissors.
- Clear tape.
- Paper copies of **Handouts 5.5** and **5.6** for each participant.

HOW MUCH TIME IS NEEDED?

25 - 30 minutes.

Directions

Request that each participant read the two folk tales and then ask them to describe the solution to each folk tale.

*Note to leader. Answer to folktale in **Handout 5.5**: Frog's swimming around began to churn the cream into soft fresh butter. Answer to folktale in **Handout 5.6**: Frog saw the sunlight reflecting off the sides of the mountain in the west while Deer was watching the plain in the east. Mountains, being higher, always catch the suns rays first as the earth turns to face the sun.*

After they describe the solutions, read or paraphrase the following.

Now you are going to create recombinant folktales from the two folktales in the handouts. You will do that by cutting out text from both stories and recombining them into new stories. But you can't choose just any text to exchange - only text that begins and ends with the same words.

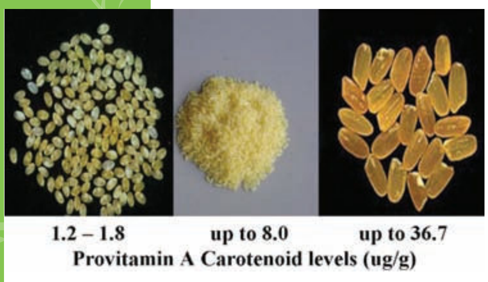
Look at the two handouts with the folktales,"The Frog" and "Sunrise" and find the following phrases, "the sides of the" and "hours and hours". These are the *target sites*. Use scissors and tape to remove the text between the target sites in the two stories and switch them. The new story is called a "recombinant" story.

After participants finish the exchange, ask them to look at their recombinant stories.

- Explain why you think the new fairytale is considered a recombinant story.
- Describe what happened to the story when the exchanges were made.
- Explain what effects might occur if the target site was only one word, like "frog", instead of several words.
- What would be the consequences if the replaced text was only one word instead of full sentences?

Stuffed, but Hungry for More?

Genetic engineering has been used to modify and put into commercial production some of the major agricultural crops in the world, canola, corn, cotton, soybeans and sugarbeet. But these are not the crops that are of the most importance to agriculture in developing countries. Different crops are important for human consumption in countries, like India, the Congo, Malaysia, Zimbabwe. Some of these foods might be familiar to us, like banana, rice and eggplant, but others we might never have heard of, like cassava and sorghum.



Golden Rice

Golden rice is a variety of rice that was engineered using recombinant DNA to produce provitamin A or beta-carotene, which can be converted to vitamin A in the human body. While in developed countries we get adequate vitamin A in our diet, in developing countries people suffer from vitamin A deficiencies, which can cause night blindness. In South-east Asia, it is estimated that a quarter million children go blind each year because of nutritional deficiencies. Also lack of vitamin A makes certain other diseases more severe. Since rice is a staple, and sometimes the only, food for many of the world's poor and because rice lacks the provitamin, scientists in Switzerland and Germany engineered rice with two plant genes and one bacterial gene to produce provitamin A in the grain.

For more information on Golden Rice, see http://cls.casa.colostate.edu/transgenicCrops/hotrice.html

MATH MENU

1. If one gram of dry yeast contains 25 billion cells, how many cells would be in one milligram of dry yeast? Hint: 1 milligram is 1 one-thousandth of a gram.
2. If an ear of corn has 15 rows of kernels and each row contains on average 18 kernels, approximately how many kernels are on the ear? Express your answer in a power of ten.

See answers in Leader Supplement

NEXT TIME WE MEET

Now we know genetic engineering can be used to cut genes that code for a protein out of the genome of one organism and paste it into the genome of another organism. We also know there are approximately 30,000 to 40,000 genes in plant genomes. Next time we will discuss the concept of relative risk and we will explore the potential risks and benefits involved in genetically engineered crops, particularly Golden Rice.

SET CONCEPTS ADDRESSED

Discovery-based research and scientific method

National Science Education Standards in Life Sciences Grades 5-8, addressed: Content Standard C, Reproduction and heredity; structure and function in living systems

SET Process Skills Used: Hypothesize; interpret/analyze/reason; use numbers; use tools

For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

Leader Supplement for Lesson 5

Answers to Math Menu

1. 25 million cells.
2. 270 or 2.7×10^2

DNA FOR DINNER?

LESSON 5
HANDOUT 5.1

Balloons, Bottles and Bread

Draw a line to match the ingredient on the left with its role in bread-making on the right.

Sugar	Provides texture for the bread
Flour	Prevents the dough from drying out
Oil	Consumes sugar and creates bubbles in bread
Yeast	Provides food for the yeast to eat

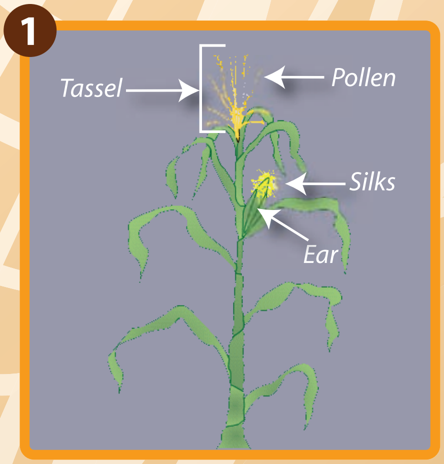
DNA FOR DINNER?

LESSON 5
HANDOUT 5.2

Birth of Baby Corn

How a Corn Plant Grows

1



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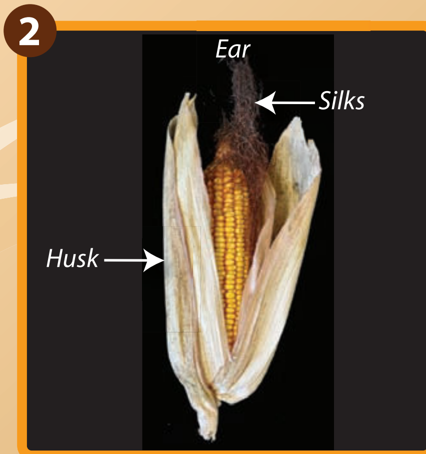

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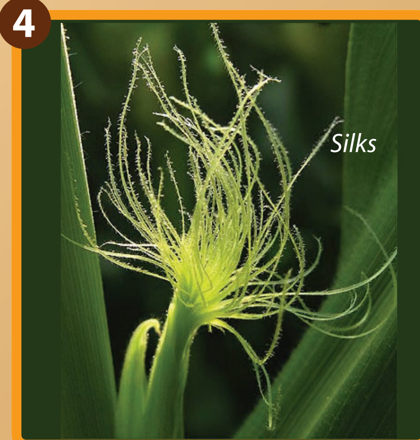

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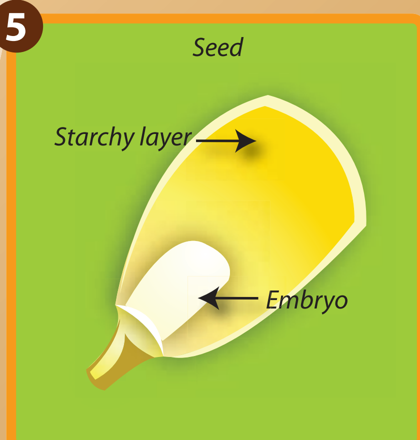

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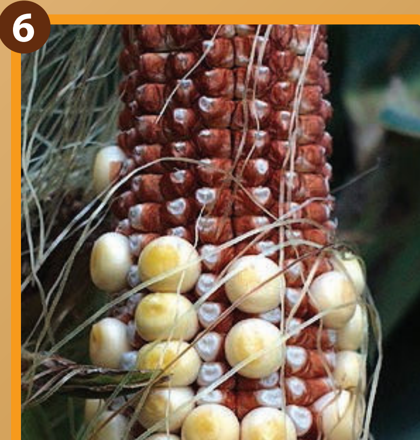


Image credit:
(1) Plant and Soil Science eLibrary, University of Nebraska;
(2) Joshua Wong, University of California, Berkeley;
(3 , 4 & 6) Bob Nielsen, Purdue University;
(5) Barbara Alonso, University of California, Berkeley.

For more information & additional lessons, please visit
http://ucbiotech.org/dnafordinner

DNA FOR DINNER?

LESSON 5
HANDOUT 5.3

Pick Copy Repeat 1

Instructions

Read through the text below and follow the instructions on the right.

In a previous lesson participants learned that genes contain coded information. The coded information in a single gene normally provides the organism with the blueprint to make a single protein. The information for proteins is contained in DNA in four chemical units or bases, termed A, C, G and T. Information in DNA is copied into the bases A, C, G and U in messenger RNA ("U" substitutes for "T" in RNA). The bases in RNA are then read by the cell machinery in sets of three, called a codon, which specifies one of 20 amino acids. Strings of amino acids make proteins. The sum of all proteins gives the organism its characteristics.

- Use your own eyes or a word processing system FIND command to identify the word, "provides" in the text on the left. Underline its location on the page.
- Next find the word, "blueprint" and underline it.
- Select the text starting with "provides" and ending with "blueprint" and copy it below, or use the copy command with the word processing system.

____

- In word processing open a new document and paste the text.
- Write the text over and over again below. Or in word processing, paste the text again, and again, and again!

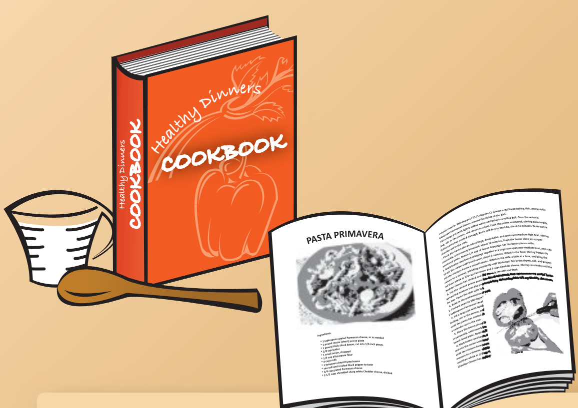
____

____

____

____

- In principle, this is the process of PCR, which results in amplification of the information between the two key words, which are termed primers in PCR.



Comparing Word Processing to PCR

Word Processing	PCR Technology
Series of electronic cookbooks	Entire genome
Page from one cookbook	Specific DNA fragment
Words at beginning and end of a sentence on page	Primers that recognize beginning and end of fragment
Copy command	Enzyme that copies DNA (polymerase)

Pick Copy Repeat 2

Instructions

In this exercise, you will use your pencil in a step-by-step process to perform PCR. It is just like the copying that would occur in a test tube.

STEP 1

During PCR, copies of a DNA segment of interest in the genome are made. In this exercise, the first complementary DNA strand is called **Strand-1 (S-1)**.

- *Write the nucleotide sequence of the complementary strand, **Strand-2 (S-2)**.*

Segment of interest

```
S-1   3' T C G G C T A C A G C A G C A G A T G G T A C  5'

S-2   5' _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _  3'
```

STEP 2

Small DNA pieces, called primers because they prime or initiate the PCR process, are made that have A's, C's, G's and T's complementary to those in the DNA segment of interest. Remember an A is complementary to a T and a G is complementary to a C. One of the primers matches one end of the fragment (5') and one matches bases on the other end (3').

- *Write the four complementary bases for the **5' Primer**.*
- *Fill in **S-2** bases written down in Step 1.*
- *Write the four complementary bases for the **3' Primer**.*

Segment of interest

```
S-1   3' T C G G C T A C A G C A G C A G A T G G T A C  5'

      5'    _ _ _ _
                          (5' Primer)
S-2   5' _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _  3'

      3'                                  _ _ _ _    5'
                                              (3' Primer)
```

Activity obtained from Iowa State University
http://www.biotech.iastate.edu/lab_protocols/PCR_Activity.html

Pick Copy Repeat 2

STEP 3

Every time the PCR cycle is repeated, a copy of each of the two original strands (**S-1**, **S-2**) will be made. Copying begins at the 3' end of the primer and continues to the 5' end of the original strand.

- *Write the sequence of the copies (**C-1**, **C-2**) made from the **S-1** and **S-2** strands.*

Segment of interest

```
S-1    3' T C G G C T A C A G C A G C A G A T G G T A C  5'

C-1    5'     C C G A _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _  3'

S-2    5' A G C C G A T G T C G T C G T C T A C C A T G  3'

C-2    3' _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ A T G G        5'
```

STEP 4

During the 2nd PCR cycle, copies are made from **S-1** and **S-2** and from **C-1** and **C-2**, obtained in cycle 1.

- *Write the sequence of **C-1** formed during the replication of **S-1** in cycle 2. Also write the copy of the sequence formed from priming off of the copy **C-1** made from the original sequence, **S-1**.*

Segment of interest

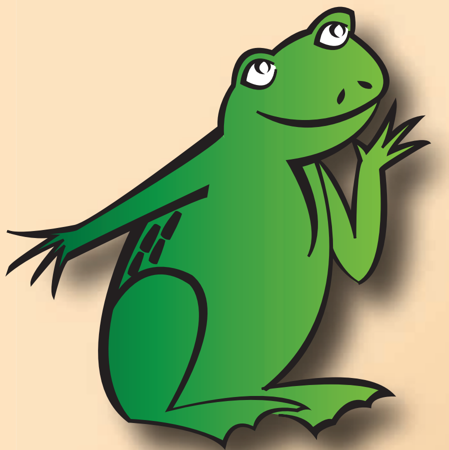
```
S-1      3' T C G G C T A C A G C A G C A G A T G G T A C  5'

C-1      5'     C C G A T _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _  3'


C-1      5'     C C G A T G T C G T C G T C T A C C A T G  3'

Copy-C1  3'     _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _      5'
```

Activity obtained from Iowa State University
http://www.biotech.iastate.edu/lab_protocols/PCR_Activity.html

DNA FOR DINNER?

LESSON 5 HANDOUT for DESSERT Page 1

The Frog



Once long ago on a summer day, a frog, who was hot from the sun, was out looking for adventure. He found a wooden bucket filled with fresh cream, smiled to himself and jumped right in! "This feels wonderful, all cool and silky against my skin," said Frog. He played and splashed and swam from left to right.

After a while he was ready to go home and tell everyone about what he had done. He was ready to go, but he couldn't get out. The bucket was too deep for him to touch the bottom and push out through the cream. There were no rocks or logs like the ones in his pond, and the sides of the bucket were too slippery to climb. He was trapped. He knew his only choice was to keep swimming or drown.

Frog couldn't bear the thought of drowning, especially in cream. He swam around and around for hours and hours till his arms and legs were too tired to move.

It's no use, he told himself. This is the end. I might as well get it over with.

He swam to the center of the bucket and began to sink, but as soon as the cream covered his mouth, he sputtered out, "No," and started swimming again.

After a while his arms and legs again grew too tired to move. Again he swam to the center and began to sink. And once again, when the cream began to cover his face, he sputtered out, "No," and started swimming.

But the fifth time this happened he sank only a little bit before he felt something beneath his feet. It was soft and slippery, but still solid enough to hold him.

Frog pushed down and hopped out of the bucket and back to his friends as fast as he could go. When he told them what happened, they all wanted to know how he finally got out, but the frog didn't know. Do you know how?

A Russian Folktale, adapted from "Lazies: Tales of the Peoples of Russia"

Sunrise

One night long ago in Mexico, a frog and a deer had an argument at frog's home. They decided to settle their differences with a bet.

"Twenty-five flies for the one who can see the first rays of the sun," said Frog.

Deer laughed and quickly agreed. "I will look to the east." He knew that the sun
always rises in the east. "You must look some other place."

Frog agreed. He quietly sat watching the sides of the highest mountain to the west while Deer stared into the darkness of the eastern plain. After hours and hours of waiting and watching, Frog suddenly yelled, "Look! I see the first rays of the sun. I win."

When Deer turned to look west, he had to agree that Frog had been the first to see the rays of the sun and Frog had seen them by looking away from the sun.

How could this be?

A Mexican Folktale, adapted from "Tongues of the Monte" by J. Frank Dobie and "More Stories to Solve: Fifteen Folktales from Around the World" by George Shannon