DNA FOR DINNER?

DNA for Dinner

LESSON 3

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:

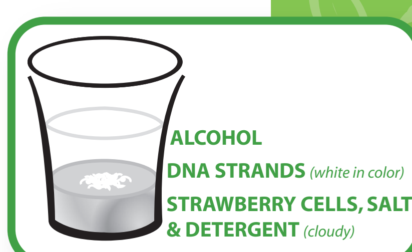
- 1 small ripe tomato, 2 kiwi fruits or 6 strawberries.
- ¼ cup water.
- ½ teaspoon salt.
- 1 blender (can be shared among groups).
- 1 tablespoon liquid dishwashing detergent (Palmolive preferred).
- Cloth or coffee filter for straining.
- Isopropyl (rubbing) alcohol.
- 1 8-ounce clear plastic glass.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

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 FOR DINNER?

LESSON 3
HANDOUT 3.1

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.

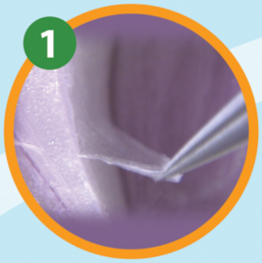
4

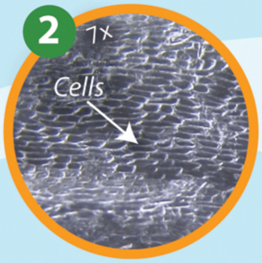
Slowly bring the ends of the "rubberband DNA" together until it curls on itself into a mass of tight, overlapping loops. That is supercoiling!

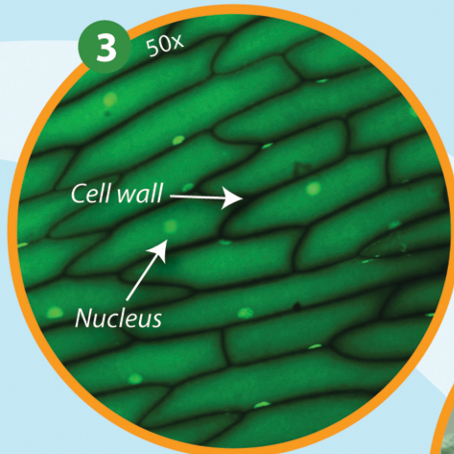
DNA FOR DINNER?

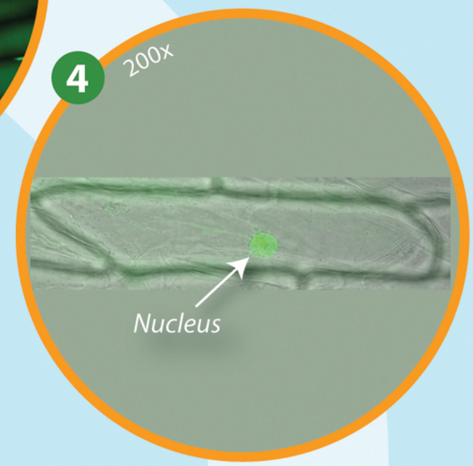
LESSON 3
HANDOUT 3.2

Tour d'Onion



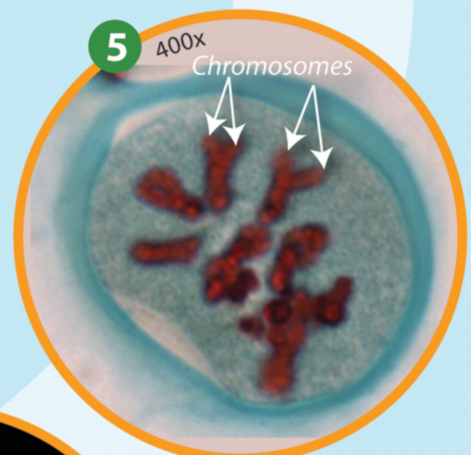


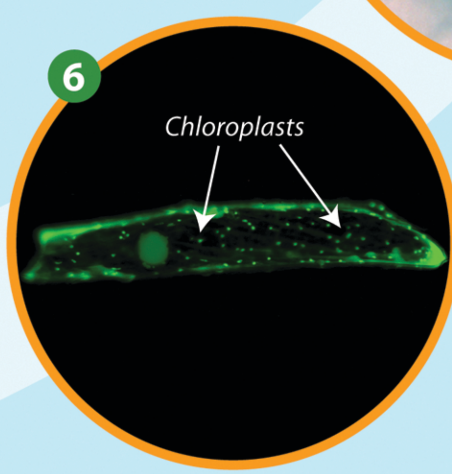




Take a trip!

PLACES TO SEE:
Cell
Cell wall
Nucleus
Chromosome
Chloroplast
Gene





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

DNA FOR DINNER?

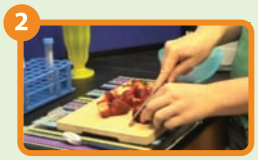
LESSON 3 HANDOUT for DESSERT

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


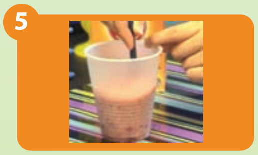
Remove leaves, stems, skin (from kiwi and tomato) and chop coarsely.

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.

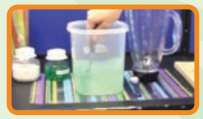
6


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:

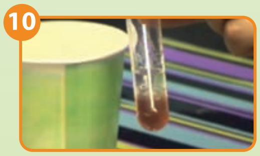
- 4 tablespoons dishwashing liquid (e.g., Palmolive)
- 3 teaspoons iodized salt
- Add water to 1 quart

8


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

9

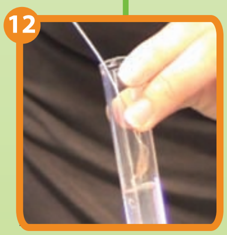

Add ½ teaspoon (2 milliliters) of this mixture to small transparent glass or plastic tube, using "eye dropper".

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