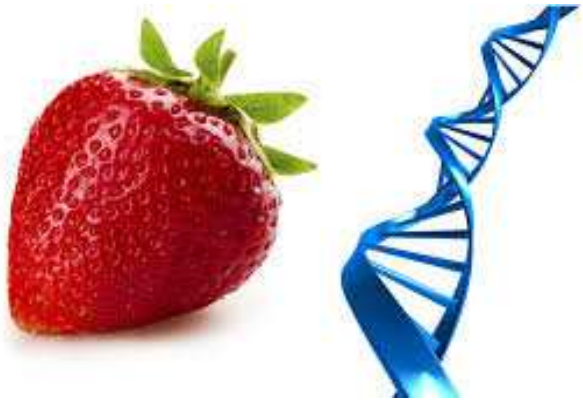
DNA in our Food? Extracting DNA from Strawberry

Teacher Guide



Supplementary Resources: See accompanying slides and other materials to help you teach this lesson at the BABEC website at www.babec.org

If you have questions, please contact us at babec@babec.org.

Version October 2017

NGSS Alignment

Disciplinary Core Ideas (DCI)	Components that align to the transformation curriculum?
LS1: From Molecules to Organisms: Structures and Processes	
LS1.A Structure and function	All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (PE: HS-LS1-1)
LS3: Heredity: Inheritance and Variation of Traits	
LS3.A Inheritance of traits	The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. (PE: HS-LS3-1)
LS3.B Variation of traits	Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (PE: HS-LS3-2)
LS4: Biological Evolution: Unity and Diversity	
LS4.A Evidence of common ancestry and diversity	Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. (PE: LS4-1)
LS4.D Biodiversity and humans	Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Human activity is adversely impacting biodiversity. (PE: LS4-6)

Science & Engineering Practices (SEP)	How does the Strawberry DNA Extraction Curriculum align?
1. Asking Questions and Defining Problems	It asks empirically testable questions concerning how the process of extracting DNA can be done easily using everyday household items. Engage with a phenomenom: separating DNA from other molecules like carbohydrates, proteins, fats. Students observe DNA precipitation and write I notice… I wonder….
2. Developing and Using Models	It creates opportunities for hands-on, iterative modeling of: cell membrane permeability, charge interactions between different components of the cell membrane and in the molecular structure of DNA.
3. Planning and Carrying Out Investigations	It follows a clear procedure, explains the purpose of the main steps in the protocol and allows the students to perform the experiment, make observations and make changes to the procedure to see how their investigation changes.
4. Analyzing and Interpreting Data	Students can analyze the results by changing the conditions of extraction.
5. Using Mathematics and Computational Thinking	Students are to use basic math to re-make the extraction buffer using a smaller scale.
6. Constructing Explanations and Designing Solutions	It provides tangible, empirical results. Students describe the importance of DNA extraction and how different organisms may require different methods of extraction.
7. Engaging in Argument from Evidence	Students can predict what would happen if they omit a certain reagent from their extraction buffer, perform the experiment, make observations and conclude by providing the evidence from their observations.
8. Obtaining, Evaluating, and Communicating Information	It has multiple opportunities for students to communicate basic scientific concepts: DNA structure & function, shared characteristics of organism, standard laboratory techniques, and ethical considerations to using human DNA for sequencing.

Cross Cutting Concepts (CCC)	How does the Strawberry DNA Extraction Curriculum align?
1. Patterns	DNA structures have a pattern. The structure of DNA does not change in any organism but the amount of DNA may change, or the DNA sequence may vary. Cells also consists of a pattern of organelles. By looking at just the cells, you may not be able to distinguish the origin of the cells.
2. Cause and Effect	The addition of certain chemicals change the molecular interactions thereby allowing the distruption of cells or the DNA to precipiate out of solution. Changing the chemicals may change the outcome.
3. Scale, Proportion, and Quantity	In this expermental process, reagents are used at specific amount. If the amounts are omitted or were to increase or decrease, this may alter the results of the experiment.
4. Systems and System Models	Cells are a system made of different components that have their own functions but interact to have cellular function.
6. Structure and Function	Cells and DNA have different types of structure: cellular and molecular. The interaction with other chemicals such as salt or detergent alters these structures.
7. Stability and Change	Cells are stable in certain environments. They can also change in certain environments. The addition of chemicals change the structure of the cells so they are no longer stable.

Unit Overview

This lesson is the first of the "Getting Started" series which includes DNA extraction, micro-pipetting and gel electrophoresis. This series introduces students to concepts and lab fundamentals that may prepare them to perform more advanced PCR labs including DNA extraction from their own cheek cells, insects (*Wolbachia PCR*) or food materials (GMO PCR) and setting up multiple types of PCR reactions. Furthermore, suggested activities follow different dimensions of NGSS.

Suggestions for Background Learning Activities:

- Look at plant cells and identify the cell wall, cell membrane, cytoplasm and nucleus. Additional organelles can be studied.
- Using large cell model as manipulative, show the cell wall, cell membrane, cytoplasm and nucleus and DNA molecules.
- The nucleus is surrounded by the nuclear membrane (envelope), which protects the DNA molecules.
- DNA molecules code for proteins and are made of millions of atoms.

Activity #1 – DNA Vocabulary Review (refer to vocabulary knowledge worksheet on page 4)

Activity #2 – Reading with pictures (see page T5)

1. Allow the students to read the small paragraph and or use the graphics to understand each component that will be used in this experiment.
2. Revisit vocabulary knowledge worksheet by filling in the definitions

Activity #3 – I notice, I wonder…

1. Show youtube video: https://www.youtube.com/watch?v=J3Pf1XKrn-Q
2. Students fill out I notice, I wonder on the Student Worksheet. Use some of the vocabulary from the Vocabulary Knowledge worksheet
3. Discuss what they are observing and what questions they may have

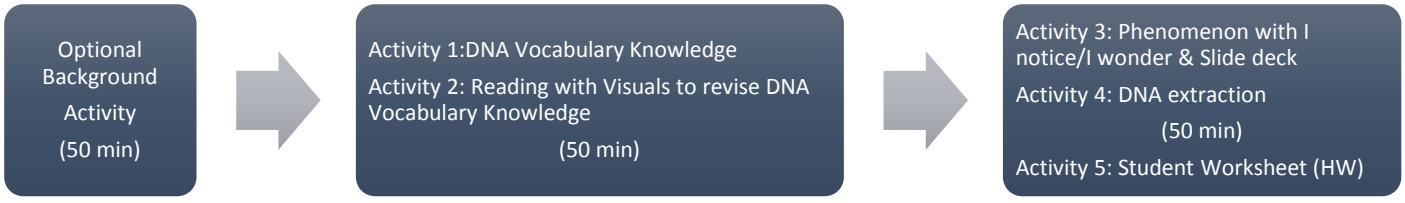
Activity 4 – DNA extraction protocol

1. Make the extraction buffer as a class demo (make enough for the whole class)
2. Direct instruction with I do then you do. Have students follow protocol as teacher does.
3. Make observations as the procedure is followed onto the Student Worksheet.
4. Explain or ask students to explain:
   a) Mashing the strawberries physically breaks-down the strawberry
   b) Adding the extraction buffer makes chemical changes
   c) The soap dissolves the lipid-rich cell membranes, allowing the DNA to leave the nucleus and cell
   d) The salt (NaCl) neutralizes the phosphate backbone and helps to neutralize and unravel the DNA
   e) The alcohol creates an interface with the strawberry and buffer solution, in which the DNA strands are precipitated into the alcohol

Activity 5 – Student Worksheet (see PowerPoint slides)

- Use this worksheet for observations and to answer questions.
- What do scientists do with the extracted DNA?
- Why extract DNA? What are they used for?

Suggested Timeline for this activity:



Teacher's Background

DNA extraction is a fundamental procedure used in many types of experiment. It is a simple protocol so students are introduced to how to read protocols or procedures including the practice of reading ahead and following the procedures accurately. Extracting enough DNA onto a rod is a fun activity allowing students to "see" the DNA they isolate.

In this activity, ripe strawberries are the source for DNA extraction. Strawberries range from being diploid to polyploid (up to 10 ploidy) so their DNA is abundant and easy to extract. Strawberries are also, by nature, very easy to squish and break down as they contain cellulase and pectinase that break down cell walls.

Students get to try this experiment twice. The first time, students follow the protocol. The 2nd time, they will omit one chemical from their extraction buffer to see if the extraction buffer still works with a missing component.

Purpose of the reagents in this procedure:

- **Shampoo or dish soap:** Helps to dissolve the cell membrane, a lipid bilayer.
- **Sodium Chloride (NaCl):** A salt that dissociates to Na^+ and Cl^-. The Na^+ surrounds the negative charge of the DNA phosphate backbone thereby neutralizing the charges and allowing the DNA to come out of solution or precipitate when alcohol is added. The salt also helps the proteins remain dissolved in the aqueous layer to prevent precipitation with the DNA.
- **Ethanol or isopropyl alcohol:** Allows the DNA to come out of solution. DNA will clump up, making it visible and easy to isolate on a stirring rod.

Inventory Sheet:

Listed below are the reagents and consumables provided in the "DNA in our Food? Strawberry DNA extraction kit" from BABEC, as well as additional reagents and consumables. Make sure also to read the list of equipment needed for this laboratory activity. For this activity, a team is considered a group of 4 students. The kit contains enough reagents for **40 students (10 teams),** performing the experiment **2 times**.

✔	Item	Storage	Amount Per Kit	Amount Per Team for performing the experiment twice
	91% Isopropanol (works best when very cold)	Freezer (-20˚C)	200mL	8mL
	Cheesecloth or Coffee Filter	Room Temp (20–25ºC)	21 pieces	1 piece
	Test Tube/15ml Falcon Tube	Room Temp (20–25ºC)	11	1
	A bacterial loop, coffee stirrer or any type of rod	Room Temp (20–25ºC)	21	1
	Ziplock/Sandwich Bags	Room Temp (20–25ºC)	25	2 bags
	Small Funnel	Room Temp (20–25ºC)	10-15	1
	Plastic Cups or Beakers	Room Temp (20–25ºC)	20-30	1
	Spoons	Room Temp (20–25ºC)	10-15	1
	For Extraction Buffer			
	NaCl or Table Salt (non-iodized)	Room Temp (20–25ºC)	50 tsp	2 tsp
	Dish Soap	Room Temp (20–25ºC)	200mL	10mL (2tsp)

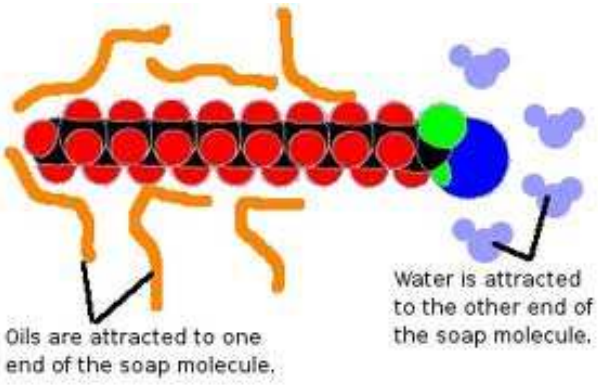
Reagents/Consumables NOT Provided in the BABEC Kit

✔	Item	Storage	Total needed	Amount Per Team
	Strawberries	Freezer (-20˚C) thaw before use or; Refrigerator (4ºC)	20-30	½ or 1 strawberry (depends on the size of the strawberry
	Other fruit, like kiwi	Freezer (-20˚C) thaw before use or; Refrigerator (4ºC)	10	varies

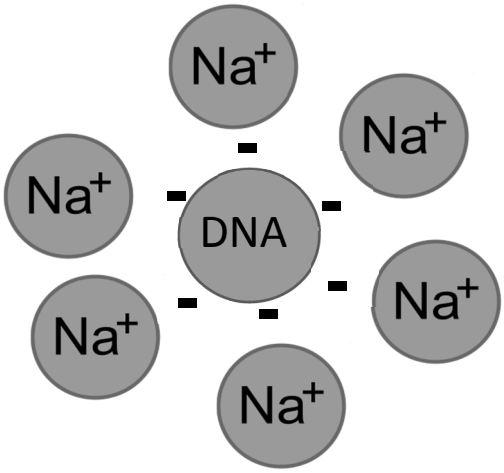
Students: Read the description below. Use the visuals to help you understand how each component of the DNA extraction works.

Extracting DNA from a plant cell or an animal cell is an easy process. The items you need are: soap or detergent, salt and alcohol. Cells are made of lipids or fats. Detergents are great at lysing or disrupting the cell and nuclear membranes of each cell to release the DNA. DNA is a large molecule that is negatively charged. Salt can be sodium chloride or NaCl. When dissolved in water, the NaCl will come apart to become so positive ions (Na^+) or negative ions (Cl^-). The positive ions (Na^+) surrounds the DNA to neutralize the negative charge. Alcohol then pulls the water away from the DNA (while dissolving the other components like proteins and fats) to precipitate or allow the DNA to come out of solution. You can see the clumps of DNA from this experiment!

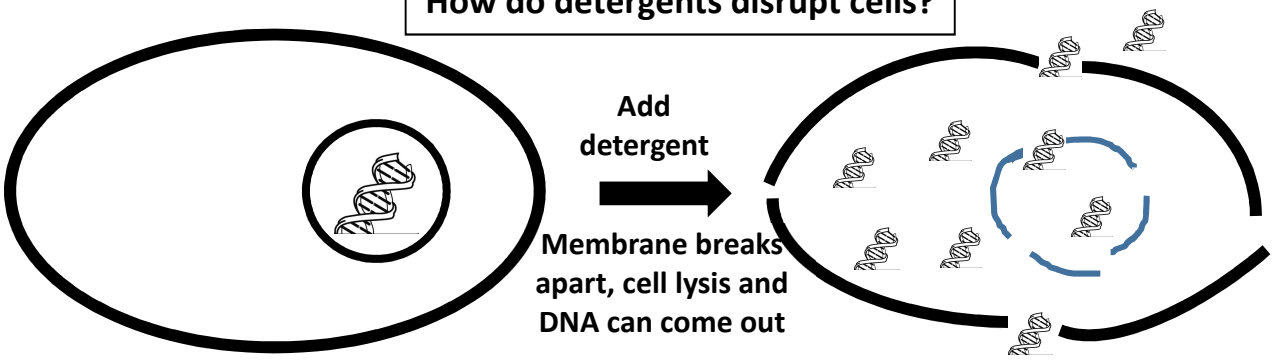
Detergents work via polar interactions



Salt: Positive and negative charges cancel each other out. DNA is now neutral.



How do detergents disrupt cells?

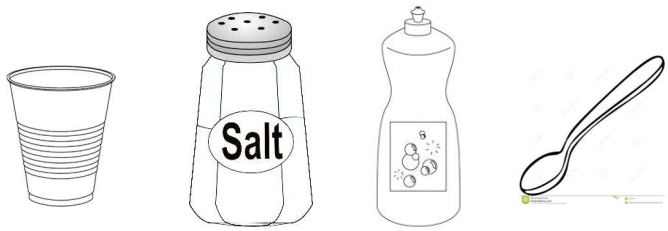


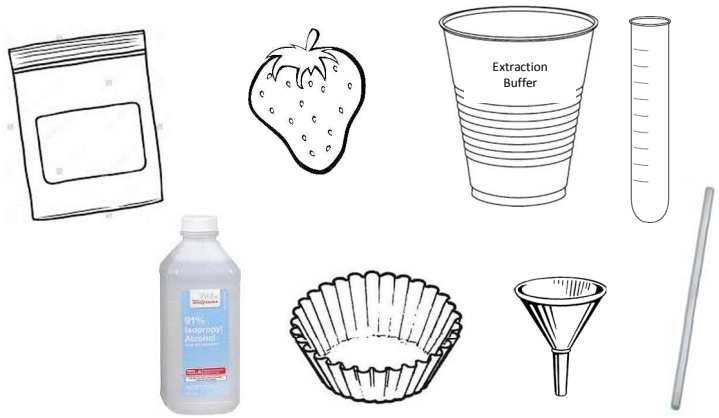
DNA in our Food? Extracting DNA from Strawberry
Student Guide

Introduction:
DNA extraction is a fundamental procedure used in a lab that is simple and effective. Extracting enough DNA to spool onto a rod is a fun activity allowing students to "see" the DNA they isolate. In this activity, ripe strawberries are the source for DNA extraction. Strawberries range from being diploid to polyploid (up to 10 ploidy – that means lots of copies of chromosomes) so their DNA is easy to extract. Strawberries are also, by nature, very easy to squish and break down as they contain cellulase and pectinase that break down cell walls.

Learning objectives:
1. Understand the process of DNA extraction; why certain chemicals are used to obtain nuclear DNA.
2. Observe the extracted DNA
3. Know different reasons to why scientists extract DNA from various organisms.
4. Learn how to read a procedure or protocol.
5. Steps to reading procedures: 1) Read through the whole procedure first; 2) ask clarifying questions; 3) follow procedure, and read ahead if there is down time!

Getting Ready: The teacher may make the extraction buffer as a demonstration so students can see the reagents that go into the buffer. You will need…

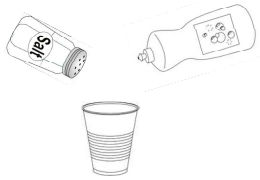
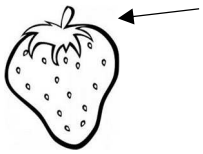
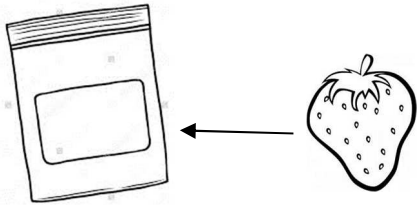
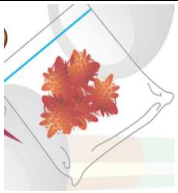
For the extraction buffer:	Items:
☐ A Cup ☐ Salt ☐ Dish soap ☐ Spoon	

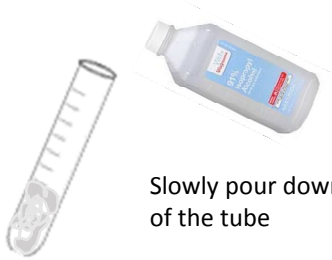
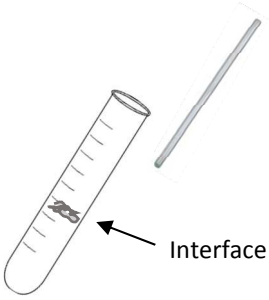
For the activity:	Items:
☐ A Ziploc Bag ☐ One Strawberry ☐ Extraction Buffer ☐ One Test Tube ☐ A Stirring Rod ☐ Alcohol ☐ Cheesecloth or Coffee Filter ☐ Funnel (if available)	

BABEC
BAY AREA BIOTECHNOLOGY EDUCATION CONSORTIUM

Name: _____

Period: _____

DNA in our Food? Strawberry DNA Extraction Lab Activity	
☐ Step 1 **Observe your teacher making the EXTRACTION BUFFER.** • In a plastic cup or beaker: 2 tsp of salt and 10ml of dish soap in 100ml of water (or ½ C of water) • Mix by stirring	
☐ Step 2 Remove any green leaves from the strawberries	 Remove the green parts.
☐ Step 3 Put the strawberry in a plastic bag and gently squish the strawberry with your fingers for 2 minutes *What does the squishing do to the strawberry?*	
☐ Step 4 Add 10 mL of the Extraction Buffer to the bag, remove the air and close the bag *What does the extraction do to the strawberry?*	10mL  Or use a medicine cup 
☐ Step 5 Squeeze, massage and squish gently, mixing for 1 minute.	
☐ Step 6 Pour the extract onto the cheesecloth in the funnel and let it drip into the beaker Squeeze to speed up the process *Why do you need to filter it through the cheesecloth?*	 1  2  (3 optional)

☐ Step 7 Add 4 ml filtered strawberry mush to a test tube, or about 1/4 full in the test tube.	
☐ Step 8 Slowly add 4ml (or an equal volume) of alcohol ***down the side of the test tube***. Let sit about 2 minutes while observing the interface between alcohol and strawberry solution. *What happens when you add the alcohol? What do you notice?*	 Slowly pour down side of the tube
☐ Step 9 Dip the rod into the tube at the interface between the alcohol and strawberry layers; begin spooling the DNA	 Interface: DNA
☐ Step 10 Store the DNA in a small tube filled with water	
☐ Optional: Repeat your steps, but omit a reagent when making your extraction buffer or change the amount of salt, detergent, alcohol used. Use math to proportion out your reagent to make 10mL.	
☐ Last Step Put away items, clean up area and wash hands.	

DNA in our Food? Vocabulary Knowledge Rating Name: _____

Period: _____

Date: _____

Vocabulary Knowledge Rating: For each term, please mark your level of familiarity with a ✓. Then provide a definition.

Terms	**Know it.** I can define this!	**Seen it.** Maybe it means…	**New to me.** Totally guessing here.	**Definition** in your own words
Dissolve				
Salt				
Alcohol				
Attract/repel				
Positive/Negative charge				
Neutral charge				
Polar/non-polar				
Interface				
Lyse				
Charge of DNA				
Precipitate				
Cell membrane				
Nuclear membrane				

DNA in our Food? Extracting DNA from strawberries Name: _____

Student Worksheet Period: _____

Date: _____

1. Watch the video closely. Write down what you observed.
   I notice…

2. Now, think of questions you have and write down what you wonder about.
   I wonder…

3. Perform your experiment by following the procedures on pages 2-3, writing down your observations.

4. Observations:
   a. What did you observe after adding the extraction buffer & squishing? Did you notice bubbles? Do you see the plant cell walls breaking up? What is the consistency of the strawberry?

   b. What did your strawberry extraction look like after you filtered the big chunks out?

   c. What did you observe after you added the alcohol?

d. What do you see on the stirring rod? What do you think other DNAs will look like?

e. If you looked at the DNA under a microscope, explain how the DNA differs from cells.

f. Are there other organisms you would like to isolate the DNA from? Why?

g. How would the procedure differ, if any if you were to isolate DNA from other organisms? Why?

5. What do scientists do with the extracted DNA? What would you like to do with your own DNA?

6. Now match the procedure with what it is doing to help isolate the DNA from the other materials in the cell.

_____a. Squish the fruit to slush

_____b. Mix in a detergent

_____c. Add the salt

_____d. Filter your extract through cheesecloth

_____e. Layer cold alcohol over the extract

A. Break apart large plant cells to allow the extraction buffer to work.

B. Precipitate the DNA (allow the DNA to clump together)

C. Separate large cell parts, broken cell wall and membranes from proteins, carbohydrates and DNA

D. Neutralize the DNA so it has no charge

E. Dissolve cell membranes