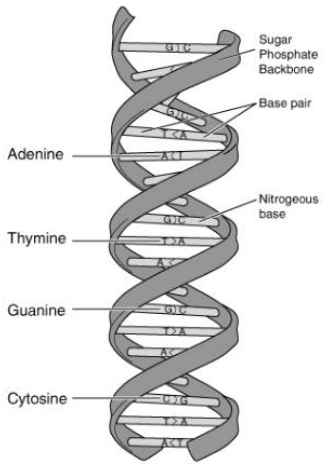
Lesson Plan for DNA Extraction

Written by Liz Roth-Johnson, activity adapted from BEAM at UC Berkeley

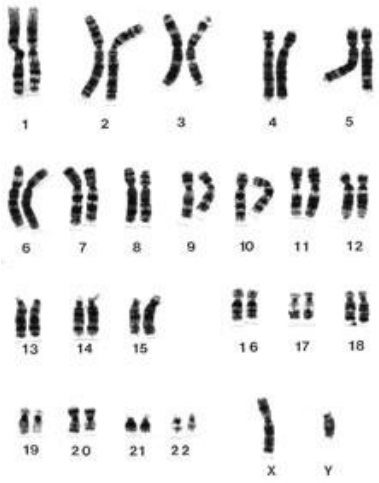
Introduction & Background Information for Mentors

Deoxyribonucleic acid, or DNA for short, is the genetic material of all living organisms. The structure of DNA consists of a sugar-phosphate "backbone" and the four nucleotides adenine, thymine, cytosine, and guanine. These nucleotides pair with one another (C with G and A with T) to form a double strand of DNA that resembles a twisted ladder.



The structure of DNA

DNA forms chromosomes



Humans have 46 chromosomes

This basic structure of DNA is the same among all organisms, which means the only real difference between our DNA and the DNA of a banana, giraffe, or goldfish is the particular order in which the four nucleotides are arranged. This order is important because DNA serves as a set of instructions for the cell. Some regions of DNA, known as genes, act as blueprints for proteins. Proteins make up much of the molecular machinery of the cell and are essential for cell function and survival.

DNA contains the genetic instructions that specify the traits of an organism. In our cells, DNA is found in the nucleus where it is organized into structures called chromosomes. All humans have 23 pairs of chromosomes. One set of chromosomes comes from Mom and one set comes from Dad, for a total of 46 chromosomes. Even though we can't look at what's going on in cells, we can see some of the genetic effects of DNA in the way we look and behave. Identical twins have exactly the same DNA, which is why they look exactly the same. Similarly, a parent and child share much of their DNA and will look similar to one another. Amazingly, the DNA sequence of *any* two humans is over 99.9% identical! So even though we may look different on the outside, genetically we're all very similar. The very small differences in our DNA (0.1%) contribute to our unique physical features.

Applications of DNA in science and engineering

DNA is used in many fields of science and engineering. For example, **Forensics scientists** use DNA in blood, skin, saliva or hair found at a crime scene to identify individuals with matching DNA through a process called DNA profiling.

Methods have been developed to purify DNA from organisms and manipulate it in the laboratory. By modifying an organism's DNA sequences, researchers can develop **genetically modified organisms**. Such organisms are widely used in medical research and in commercial agriculture.

The field of **bioinformatics** involves the manipulation and data mining of DNA sequence data. The development of techniques to store and search DNA sequences has led to advances in computer science, particularly in the areas of string searching algorithms, machine learning and database theory.

Finally, DNA contains hereditary information that is passed from one generation to the next. Over time, DNA accumulates small changes. By analyzing DNA and how it has changed over millions of years, we can better understand the **evolutionary history** of organisms.

Student Objectives

- Introduce the concept of DNA – what makes you "you"?
- Introduce the concept of heredity – where does DNA come from? Why do families look alike?
- Explain that DNA is in all living things, including us and the strawberries in the experiment.
- Introduce the molecular structure of DNA and its function in cells.
- Show students how much DNA there is in a single strawberry. How much DNA is in a person?
- Discuss what scientists and engineers do with DNA – why might isolating DNA be useful in a lab?

Outline for the Students

<u>As a class</u>

- Start by asking students about what makes different people look the way they do. Why do identical twins look exactly alike? Why do you look like your mom and dad? Why do you look more like your siblings than your best friend?
- Explain to the students that we have a molecule in our bodies called DNA that acts as a set of instructions for making us "us". Introduce the molecular structure of DNA by drawing it on the board or showing a picture. Point out the pattern of A, T, C, and G nucleotides and explain that the order of these nucleotides contains all the information that makes us the way we are: how tall we grow, what color our eyes are, how our different body parts work, and so on. Our DNA contains nearly *3 billion* of these nucleotides – enough information to fill up more than 3000 textbooks!
- Explain the hereditary concept of DNA. Half of our DNA comes from our Mom and half comes from our Dad, which is why we tend to look most like our parents and siblings (shared DNA). Identical twins share *all* of their DNA, which is means that the order of A, T, C, and G in their DNA is 100% the same!
- Now explain that *all* living things have DNA. For example, the strawberries in today's activity have DNA. The strawberry DNA *looks* like our DNA, but the *information* in strawberry DNA (the order of A, T, C, and G) is only about 60% the same as human DNA.

In smaller groups

- Ask the students if they think they will be able to see strawberry DNA. Why or why not? Explain to the students that even though single pieces of DNA are microscopic, every single cell in a strawberry (and a person) contains a copy of the DNA. A single strawberry can contain millions of cells, while the human body has *trillions* of cells! When we isolate strawberry DNA, we are really seeing millions of microscopic DNA molecules lumped together.
- Before the experiment, ask the students what they expect DNA to look like. Will it look like our DNA? Will it have a color? Will it be hard or soft? How much will there be? By looking at the amount of DNA in a single strawberry, the students will get a sense of their own DNA and how much DNA must exist in an entire human body, which is much bigger than a strawberry.
- After the experiment is over, explain to the students that scientists and engineers can use isolated DNA for a wide range of applications. DNA found at a crime scene can help police catch the bad guys (sort of like molecular fingerprints). DNA can also be changed in a lab to make "genetically modified organisms" that have special properties. Many food crops, such as corn, are genetically modified.

Overview of the Lesson Process (about 1 hour)

- Introduce the concept of DNA (about 10 minutes)
- Explain the activity, going over *all the instructions* ahead of time (about 5 minutes)
- Extract the DNA (about 30 minutes, depending on number of mentors)
- Discuss the experiment, explain what scientists do with DNA, and clean up (about 15 minutes)

Materials	Qty per group	Estimated Cost (approx. 10 + groups)	
Dish soap (such as Dawn)	--	small bottle	$3
Salt	--	26 oz container	$1
Heavy duty Ziplock Bags	1	Ziploc freezer quart (40)	$4
Strawberries	1	1 lb	$5
Coffee filters	1	bargain brand filters (200)	$3
Rubber bands*	1	box (750)	$1
Clear plastic cups (supplied by mentors)	1		$0
99% Isopropyl alcohol (rubbing alcohol)	10 ml	16 oz	$4
Flat wooden sticks (flat toothpics)	a few	small bag	$3
Ice/icepacks (to keep isopropanol cold)*	--	discarded shipping ice packs	$0
Lots of paper towels to clean up	--	1 roll	$1
		Total	**$25**

*starred items can/should be reused (prices based on shop.safeway.com/superstore)

Experiment

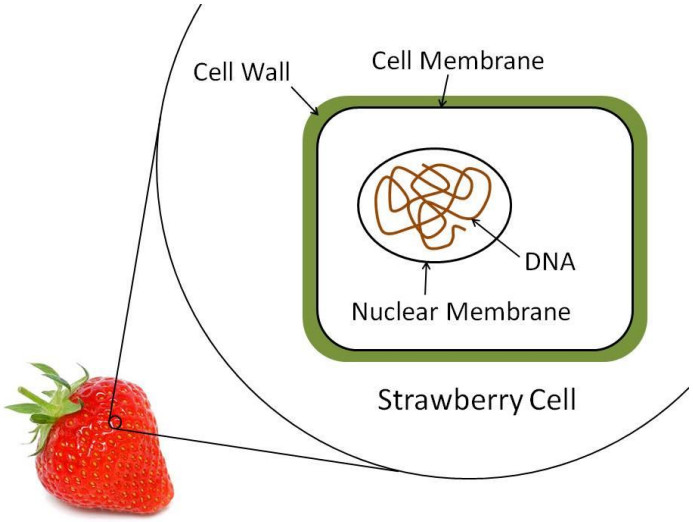
prepare ahead of time

1. Mentors prepare Lysis Buffer by mixing 90ml water, 10ml dish soap, 2g salt. This will be enough buffer for about 8 separate groups/extractions

at the school

1. Place 1 strawberry in each Ziploc bag. Seal bags with as little air as possible.
2. Mash the strawberry carefully and thoroughly – avoid breaking the plastic bag. Gentle massaging for about 2 minutes should be sufficient.
3. Add 12ml Lysis Buffer to the bag, reseal, and mash for another minute or so.
4. Place a coffee filter over a plastic cup and secure with a rubber band.
5. Carefully pour the contents of the Ziploc bag out into the filter. Allow most of the liquid to drip into the cup (you can gently stir the mashed strawberry mixture with a wooden stick).
6. Remove and dispose of the coffee filter/mashed strawberry.
7. Tilt the plastic cup and slowly pour 10ml ***cold*** isopropanol down the side. (**do not mix!**) The colder the isopropanol is, the better the extraction will work.
8. Wait and watch as the DNA begins to precipitate and goopy white strands start to appear.
9. Use the sticks/toothpicks to scoop out the goop – that's the DNA!
10. If sealable, airtight tubes are available, DNA can be stored in isopropanol indefinitely.

How does this experiment work?



DNA is found within the nucleus of each strawberry cell. To make the DNA accessible, we first break open, or lyse, both the cell and its nucleus. We first mash the strawberries to mechanically break apart the tough cell walls of the strawberry cells. Once the cell walls have been broken apart, the cells are still surrounded by a membrane made up two layers of fat molecules (called a lipid bilayer). The detergent in our lysis buffer cuts through the fatty enclosure of the cell as well as the second fatty membrane surrounding the cell's nucleus. This works much in the same way soap cuts through food grease. The salt in the lysis buffer helps keep molecules like DNA stable. At this point, the DNA is free from the cell/nucleus and is floating around in the buffer. DNA is not soluble in alcohol, so we add isopropanol to our mixture to precipitate the DNA. The precipitate forms visible, white strands of DNA that can be extracted using a thin wooden dowel or a skewer.

Why use strawberries? Unlike humans who have 2 copies of each chromosome, cultivated strawberries have 8 copies of each chromosome. With a total of 56 chromosomes (7 unique chromosomes x 8 copies) per cell, strawberries have a lot of DNA to extract!

Resources

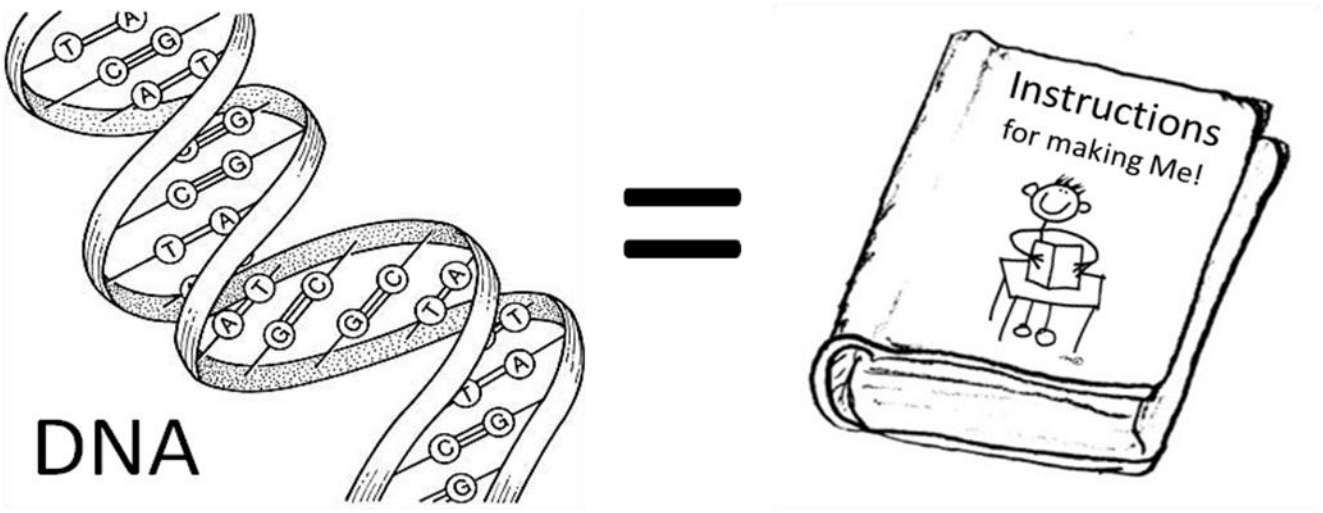
UCSF SEP Lesson Plan: http://seplessons.ucsf.edu/node/217
University of Utah's Learn.Genetics: http://learn.genetics.utah.edu/
Tour the Basics: http://learn.genetics.utah.edu/content/begin/tour/
How to extract DNA from anything: http://learn.genetics.utah.edu/content/labs/extraction/howto/

DNA Extraction Worksheet

Introduction

Why do you think identical twins look the exactly the same?

You have a molecule in your body called "DNA" that acts like a set of instructions. All DNA is made up of four chemicals, called "nucleotides" that are represented by the letters A, T, C, and G. Your DNA contains almost 3 billion of these nucleotides. Written out, all those A's, T's, C's, and G's would fill up nearly 3000 textbooks! The specific order of these four nucleotides encodes the instructions that make you look the way you do.



Half of your DNA comes from your mom and half comes from your dad. Because you share some of your DNA with your mom and dad, you look more like them.

We're not the only living things with DNA. In fact, *all* living things have DNA! In this lesson, we are going to isolate DNA from strawberries. On the outside, strawberry DNA looks like your DNA. However, the *information* in strawberry DNA – the order of the A, T, C, and G nucleotides – is different from the information in your DNA. This ordering of nucleotides is what distinguishes all living things from each other.

Before the Experiment

Do you think you will be able to see the strawberry DNA? Why or why not?

What do you think the DNA will look like? Explain in words and draw a picture.

How much DNA will there be?

After the Experiment

What did the DNA look like? Explain in words and draw a picture.

How much DNA was in one strawberry? Estimate how much DNA is in your entire body.

What is one thing scientists and engineers use DNA for?