SCIENCE AT HOME

DNA EXTRACTION

GRADE: **12**

SBI4U

SUBJECT: BIOLOGY

STRAND: MOLECULAR GENETICS

TOPIC: DNA REPLICATION AND EXTRACTION FROM CELLS

EXPECTATIONS: A1.1, B3.2, D2.1, D2.3, D3.1, D3.5

VIDEO: youtu.be/wHIuL_hg5Bw

INTRODUCTION:

DNA molecules are a great example of how structure determines function in biology. DNA is a double helix, made up of two strands of nucleotides running in opposite directions, which come together to form a "twisted ladder." The rungs of the ladder are created when the nitrogenous base in each nucleotide forms a hydrogen bond with its complementary base on the opposite strand. Adenine (A) always pairs with thymine (T), and cytosine (C) always pairs with guanine (G).

This structure makes it very easy to make copies of DNA molecules both inside cells during DNA replication and outside cells in the lab. The hydrogen bonds holding the strands together can be broken, splitting the molecule into single strands. Because of complementary base pairing, each of these strands can act as a template to rebuild the double helix.

The order of these molecules creates a special code — a blueprint for creating you. Using a few simple tools and ingredients from around your home, you are now going to extract some DNA from another organism...

ACTIVITY: Extract DNA from food in your kitchen

TIME: 10 minutes

SAFETY: Don't eat any part of your experiment after you begin!

WHAT YOU NEED:

- Measuring cup
- Measuring spoons
- Sealable plastic bag
- Fruit source of DNA (anything that's easy to squish, like strawberries or bananas)
- ¼ cup water
- 1 tsp liquid dish soap
- 1 tsp salt
- Coffee filter (or cheese cloth)
- Funnel (or something to hold the coffee filter)
- Clear, narrow glass jar (a spice jar, a baby food jar or a small drinking glass)
- Isopropyl alcohol, rubbing alcohol or any liquid containing at least 40% alcohol (enough to fill your jar about ¼ full)
- Toothpick or skewer
- Kitchen scale (optional)

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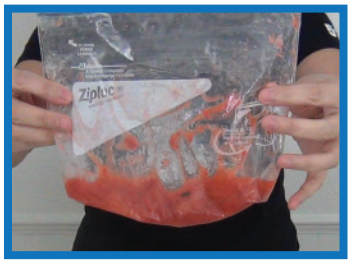
WHAT YOU DO:

- Put the alcohol in the freezer to chill for at least 30 minutes.
- Put the fruit into the plastic bag, then mash it up with your hands for about two minutes.



- Mix the water, dish soap and salt. Add 3 tbsp of this solution to your food mash, and mix it together in the bag for one minute.

- Put the filter into the funnel and the funnel into the jar. Pour the mixture from the bag into the filter, and let it drip into the jar until it's one-quarter full.

- Now get your chilled alcohol. Tilt the jar and pour the alcohol slowly down the side, until you have roughly equal volumes of alcohol and fruit mixture in the jar. Try to keep the layers from mixing.

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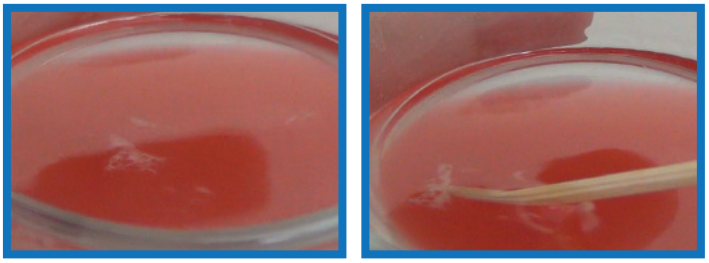
WHAT YOU DO (continued):



- Set the jar on a flat surface and don't move it. Look closely at what is happening at the interface where the two liquids meet.
- Look carefully and you should see white strands of DNA start to emerge. Dip your skewer into the DNA — it should stick to the skewer as you turn it — and gently reel it out.
- If you have a scale, measure the mass of DNA you extracted. (The easiest way to do that is to weigh the skewer both with and without DNA on it.)

WHY THIS MATTERS:

DNA extraction is the first step in a lot of work in genetics, including genetic testing and genetic engineering. Scientists break open the cells and nuclear membranes of living things, or the capsules of viruses, and then separate and purify the DNA (or viral RNA) found inside.

In order to do most experiments, scientists need a lot of DNA or RNA — more than they can usually manage to extract from the cells available to them. But they can use a technique called "polymerase chain reaction" (PCR) to make billions of copies of the region of DNA they want to study.

The process of PCR is very similar to the process your cells use to replicate DNA. First, the double-stranded DNA is separated into two single strands. Then, "primers" — short, single-stranded pieces of DNA — bind to those single strands. The primers are chosen so that they will flank the region that needs to be copied. Finally, an enzyme known as a "DNA polymerase" is added, and it reads the code on the single strand and adds the complementary nucleotides needed to build the new double-stranded pieces of DNA. This process is repeated over and over, and can generate billions of DNA copies from a single starting molecule.

PCR is widely used — in creating genetically modified organisms, in helping to solve crimes and in diagnosing diseases. COVID-19 testing, for instance, involves taking a sample from the respiratory tract — usually the nose — and using PCR to see if there is any RNA from SARS-CoV-2, the virus that causes the disease.

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TAKING IT FURTHER: Tinker

Now try experimenting on your own. See which variables you can change to extract more DNA from the same amount of starting material. (You will need to find a way to measure how much material you start with and how much DNA you collect.) Remember, a good experiment only changes one variable at a time. Keep track of what you change and how that affects the amount of DNA you get.

Challenge your friends! See who can develop the best protocol!

HINTS:

Think about your "reagents" — the chemicals you are using to do the extraction. What does each of them do? Do you think adding more or less of anything would make a difference? Is there anything else you could do or add to improve the protocol?

Some plants are polyploid — meaning they have more than two sets of chromosomes in each of their cells. Some can have up to 10 copies of each chromosome in each cell. That's a lot of DNA! Look up the "ploidy" — number of sets of chromosomes — that different plants have. Can you use this information to maximize your DNA yield?

Could you use vegetables, grains or legumes? Does the concentration, temperature or type of alcohol affect how much DNA you get?

MORE ONLINE:

Origami DNA
https://www.yourgenome.org/activities/origami-dna

Polymerase Chain Reaction
https://dnalc.cshl.edu/resources/3d/19-polymerase-chain-reaction.html

What is PCR used for?
https://www.sciencelearn.org.nz/image_maps/35-what-is-pcr-used-for

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