The Tech Interactive at Home

COBUILD19

DNA Extraction

Isolating DNA from Food

Who says all the fun has to happen at The Tech Interactive? This DIY biotinkering activity can be done with inexpensive store-bought supplies and things you find around the house!

Experiment:	Use everyday items in your kitchen to investigate the DNA in your food.
BioTinkering Challenge:	Create something with the DNA you extracted. What can *you* do with it?

Subject:
Biology

Ages:
8+

Time:
<30 minutes

Key concepts:
BioDesign, Genetics, DNA, Proteins

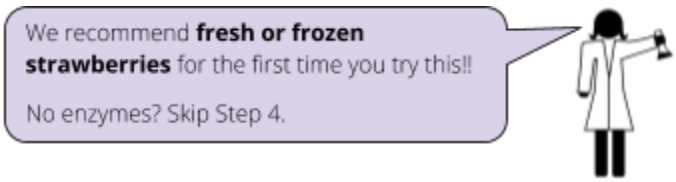
Introduction

Everything living has a teeny tiny set of instructions inside it, telling it how to grow and stay alive. That tiny instruction manual is called DNA. All plants and animals have DNA, which means we eat DNA at every meal!

Basic Ingredients

This is our starter list of ingredients, but feel free to try other things and get creative depending on what you have at home! We've **starred** our recommended choices, but feel free to try substitutions.

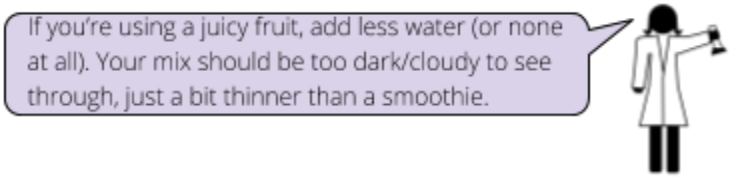
½ cup fresh fruit or vegetable	¼ teaspoon salt	3 teaspoons liquid soap	¼ cup alcohol	⅛ teaspoon enzymes	Kitchen tools
✶ **Berries** • Bananas • Citrus fruit • Peas	✶ **Table salt** • Sea salt • Flake salt • Pink salt • Black salt	✶ **Dish soap** • Hand soap • Liquid detergent	✶ **95% rubbing alcohol** • >50% rubbing alcohol • >50% ethanol	✶ **Meat tenderizer** • Pineapple juice (fresh) • Papaya juice (fresh) • Contact solution	✶ **Blender** ✶ **Strainer** ✶ **Clear cup** • Food processor • Coffee filter



Instructions

This is our starter set of instructions, but feel free to try modifications. Be sure to **write down** exactly what you do each time. This will help you keep track of how your changes affect the outcome, so you can decide what to do differently next time!

1. **Squish (or blend) your fruit with ¼ tsp salt and ¼ c water**
   Everything living is made up of **cells**. These are like tiny little building blocks that come together to make an entire plant/animal. The DNA instruction manual is protected inside the cells. By squishing your food, you're releasing lots of tiny cells into the water.



2. **Pour your mixture through a strainer**
   Since cells are teeny tiny, they'll still fit through the holes in a filter. You're removing the pieces that were too big/hard to break up, leaving a mixture that's mostly free floating cells!
   No strainer? Try coming up with another way to remove floating chunks and pieces! The fewer chunks in your liquid, the easier it is to see what happens.

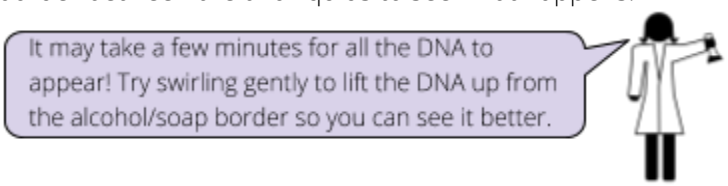
3. **Add 3 tsp soap and stir to mix**
   The outside of a cell is a greasy layer, which gives the cell its shape and makes sure everything stays inside. Soap breaks apart this grease, releasing everything inside the cell into the water! Let your mixture sit for 5 minutes or so to finish breaking open the cells.

4. **(Optional) Add ⅛ tsp enzymes and stir gently to mix**
   Your liquid mix has DNA in it… as well as everything else that was inside the cells! Cells have a lot of stuff inside them that helps them do their jobs. These are called **proteins**, and they do most of the real work inside a cell!
   Meat tenderizer is full of special proteins called **enzymes**. The enzymes found in meat tenderizer help break apart other proteins. This helps get rid of any proteins that are attached to the DNA in your mixture. It also removes any proteins that might break apart the fragile DNA!

5. **Pour a 1-2 inch layer into a clear cup**

6. **Slowly pour on alcohol, until there is a 1-inch layer on top**
   Be sure not to mix it! You want to have two distinct layers, with the soapy mix on the bottom and the alcohol on top. To avoid splashing, tilt the cup and pour the alcohol slowly down the side.

7. **Watch the DNA appear**
   DNA dissolves in water … but not alcohol! When the salty DNA comes into contact with alcohol, it will un-dissolve, or **precipitate**. Watch the border between the two liquids to see what happens!



8. **Collect your DNA**

Since DNA is sticky, you can sometimes get it to stick to a wooden toothpick, and lift it out of the alcohol. Otherwise, use a spoon. If you want to save the DNA, transfer it to a small container with fresh alcohol.

Keep Experimenting

Try getting DNA from other things
What else can you get DNA from? Do some sources work better than others? Does it matter if the food is fresh, frozen, dried, canned, or processed? Can you figure out how to see your *own* DNA? How well does it work if you use plant vs. animal (like eggs or small pieces of meat) for your starting source?

If you notice any differences, try to figure out *why* they happen. Do you think one source has more cells and less water? Or maybe more *intact* cells, that are still protecting the DNA inside? Have you considered if some sources have *other stuff* (like special proteins) that hitchhikes along with the DNA in your final result?

Experiment with the basic recipe
Does it matter how much of each ingredient you use? Or what type of ingredient? Does it matter how long you let the mixture sit during each step?

Get creative!
What else can you do with the DNA? Here are just a few ideas to get you started:

- Investigate the physical properties of DNA. What happens if you put it in water, vinegar, soda, or something else? What happens if you leave it out to dry?
- Have an amulet or small vial? Make it into jewelry or a unique decoration
- Try dissolving it in ink to make a DNA marker or pen, or a water-based paint to create a unique piece of art
- Look at it up close with a magnifying glass or microscope. What do you notice about the DNA?
- Observe it over several days. Does it change or break down over time? What if you store it in the freezer instead? How well does it last if you use enzymes in the experiment, compared to if you leave them out?

Troubleshooting

Struggling to see any DNA? Here are a few things that might help

Skip the blender
Blenders and food processors do really well at breaking up food... but they can also chop up the DNA into tiny pieces! Squishing or mashing the food item instead can leave it more intact.

Adjust your amount of water
If you can see through your mixture in Step 2, you might have too much water! This could reduce the amount of DNA you see at the end. Some foods like watermelons and grapes already have a high amount of water, so adding more might dilute the concentration of DNA.

Allow more time

Step 3: It can take some time for soap to break open all the cells! If the cells are still intact, all your DNA will still be in the fruit layer at the end. Try letting the soap sit for 5-15 minutes to finish breaking open cells.

Step 4: It can take a bit of time for the enzymes to finish working. If they don't have enough time to break up extra proteins, your DNA at the end might have some unwanted hitchhikers attached to it. And if any of those hitchhiking proteins like to break up DNA.... you might end up with less DNA than you want. Try letting the mixture sit for 5-15 minutes to give the enzymes enough time to finish.

Step 7: DNA will precipitate into alcohol ... when it comes in contact with it. So the DNA at the bottom of the fruit layer won't immediately show up in the upper layer. If you let the final layers rest for 5-60 minutes, it will give the DNA in the bottom layer more time to diffuse to a place where it touches the alcohol.

Chill your alcohol

Try putting your alcohol in the freezer before you use it! This helps for two main reasons:

First, the colder a liquid is, the harder it is to get something to dissolve in it. If we want something to dissolve, hot is better. And if we want something to un-dissolve (precipitate), cold is better! In hotter liquids, the tiny molecules are moving around quickly. This constant motion makes it harder for the DNA molecules to stay in contact with each other, which prevents them from sticking together. In cooler liquids, the molecules are moving around slowly. This slower movement helps the DNA pieces stay in contact with each other long enough to clump up.

Second, colder temperatures slow down chemical reactions. Your mixture will have some natural enzymes in it from the fruit/veggies that break apart DNA. In colder temperatures, these enzymes work more slowly. This keeps your DNA intact for longer**!**

Choose a food with a high concentration of intact cells and DNA

Any plant or animal based food has DNA in it,but in highly processed foods it might be too degraded and broken to see.

DNA can be damaged by lots of different things. Repeated freezing and thawing can damage it, slowly breaking it down over time. High temperatures can also cause the DNA to break down more quickly than normal. Treatments that break open cells can also harm the DNA, as it can expose the DNA to a less friendly environment.

Common Questions

What are those enzymes even doing? It doesn't look different!
Their work is done on a microscopic scale, making it hard to watch! Ideally, they will help break apart some of the proteins found in cells. This includes proteins that are naturally attached to the DNA, and proteins normally found in cells that may chew up the DNA.

It's also possible that your source doesn't have any working enzymes. Expired meat tenderizer, frozen/processed/old pineapple juice, or expired contact lens solution might be full of "dead" enzymes that don't work anymore.

What's special about meat tenderizer, pineapples, papayas, and contact solution?
Meat tenderizer is a mix of enzymes that people have specifically chosen for their ability to break apart other proteins. It's used to break down proteins in meat that might make it tough and hard to eat! The enzymes in meat tenderizer actually come from pineapples and papayas!

Similarly, people have specifically chosen enzymes for contact lens solution that are good at breaking up proteins that build up on contact lenses from human tears. That helps keep contact lenses nice and clean!

Why would there be proteins in a cell that break DNA? Wouldn't that be bad?
Normally, the DNA is protected in a special compartment inside the cell, called the nucleus. Those DNA-breaking proteins exist elsewhere in the cell, carefully kept far away from the DNA. In this experiment, you're breaking apart the whole cell, which mixes everything together.

I've heard strawberries have more DNA, and that's why they work best.
Strawberries have around twice as much DNA per cell than humans. But it *looks* like they have lots more because you're getting a lot of a hitchhiker protein along for the ride called pectin.

The strawberry genome (its entire DNA instruction manual) is actually a bit shorter than ours, about 1/4 the size. But while we have two copies of each piece of DNA, strawberries have eight copies of every piece! That means that overall, each strawberry cell has about twice as much DNA as a human cell.

What's *really* in the white stuff I got?
It will be a mix of nucleic acids, including both DNA and RNA. Plus any stuck-on proteins that were not removed by the enzymes! The alcohol layer will also have some proteins that are invisibly dissolved in it; moving the DNA to fresh alcohol will help get rid of those.

Can I see DNA with a microscope?
The DNA helix is too small to see with a regular microscope you might have at school or at home. You'd need a very powerful microscope to see it: an electron microscope, to be precise! Seeing the helix at all was hard enough that the first people to see it won a Nobel prize!