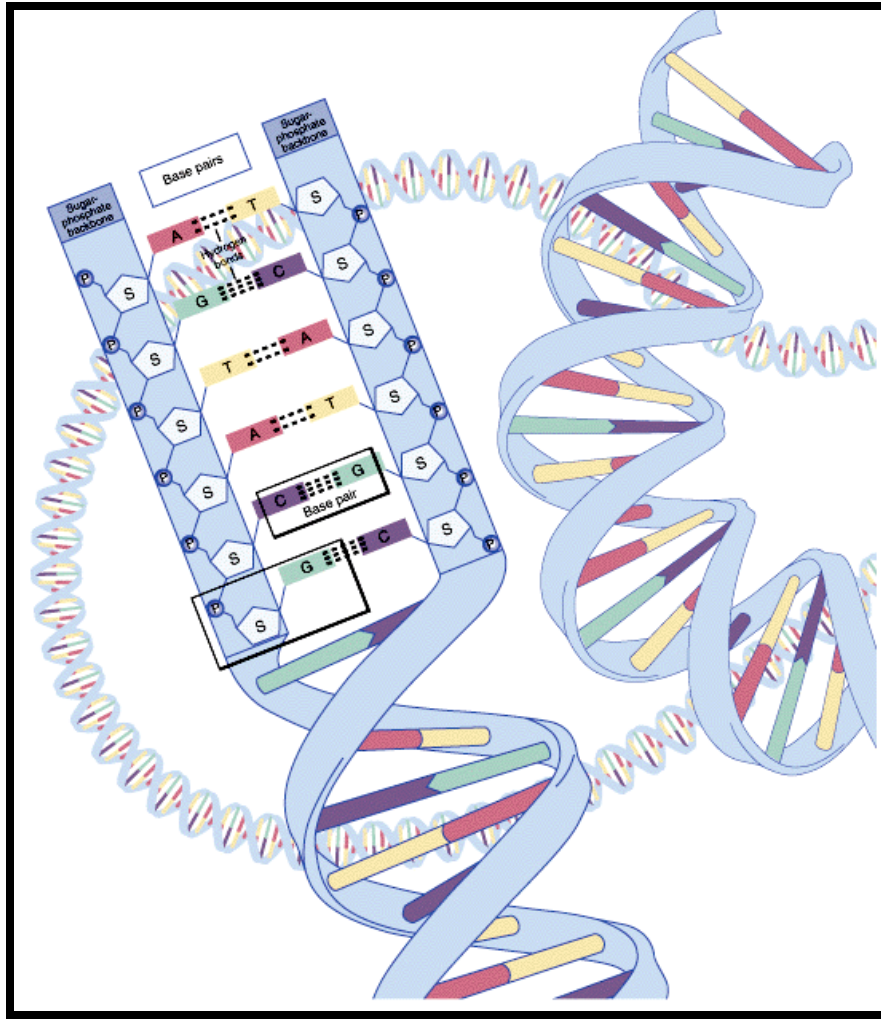


# Molecular Biology: First Steps—How To Extract DNA in Your Kitchen



## Prerequisites

None

## Acknowledgements

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# Molecular Biology: First Steps—How to Extract DNA in your Kitchen

## **Welcome**

Welcome to the study of molecular biology. DNA is the blueprint of life itself. This remarkable molecule contains the genetic code that defines what a particular organism is and, to a very large extent, how it behaves. You probably thought that professional scientists could extract and purify this exotic substance. But it's actually easy to extract and purify DNA from cells. And you're going to do it today!

By the time you've completed this week's lesson, you'll know all how to extract and purify the molecule of inheritance from just about anything that was once alive.

## **You will be able to...**

Extract DNA from fruits, vegetables, meats ... just about anything that used to be alive using chemicals that are probably already in your house.

## **And that will prepare you to...**

Explore the remarkable world of molecular biology from the comfort of your kitchen

## Background

DNA is the largest molecule known. A single, unbroken strand can contain many millions of atoms. When released from a cell, DNA typically breaks up into countless fragments. In solution, these strands have a slight negative electric charge, a fact that makes for some fascinating chemistry. For example, salt ions are attracted to the negative charges on DNA, effectively neutralizing them, and this phenomenon prevents the many separate fragments of DNA from adhering to one another. So by controlling the salt concentration, biologists can make DNA fragments either disperse or glom together. And therein lies the secret of separating DNA from cells.



*Figure 1: Kitchen laboratory includes most of the items needed to isolate DNA. A drinking straw, for example, can be used to add alcohol to the solution (center inset), and a coffee stirrer serves to spool the DNA (right inset).*

The procedure is first to break open the cells and let their molecular guts spill into a buffer, a solution in which DNA will dissolve. At this point, the buffer contains DNA plus an assortment of cellular debris: RNA, proteins, carbohydrates, and a few other bits and pieces. By binding up the proteins with detergent and reducing the salt concentration, one can separate the DNA, thus obtaining a nearly pristine sample of the molecules of inheritance.

## Practice

You'll first need to prepare a **buffer**—that is, a solution that tends not to change its acidity throughout your experiment. It keeps the system chemically stable.

Pour 120 milliliters (about four ounces) of **distilled or bottled water** into a clean glass along with 1.5 grams (1/4 teaspoon) of **table salt**, five grams (one teaspoon) of **baking soda** and five milliliters (one teaspoon) of **shampoo or liquid laundry detergent**. These cleaners work well because they have fewer additives than hand soaps--although do feel free to experiment other products.

The detergent actually does double duty. It both breaks down cell walls and helps to break down large proteins so they don't come out of solution with the DNA.

Professional scientists use would use pure table salt and distilled water, iodized salt and bottled water just fine. I even forgot to add the baking soda once and still got good results. In any case, **do not use tap water** because it's loaded with ions and (sometimes) biological material (yuck) that can contaminate your results.

DNA degrades fast, in a matter of minutes in some circumstances. So, to slow the rate at which your DNA degrades, **chill the buffer** by placing the glass in a bath of crushed ice and water before proceeding.

For a source of DNA, try the pantry. You can get great results with **onions, bananas and tomatoes**. But it's your experiment: choose your favorite fruit or vegetable. Dice it and put the material into **a blender**, or better, **a food processor**, then add a little water and mix things well by pulsing the blades in 10-second bursts. Or, even simpler, (but quite a bit more tedious), pass the pieces through a garlic press. These treatments will **break apart** (biologists say "**lyse**") some of the cells right away and expose many cell walls to attack by the detergent. With the cell walls broken down and ripped apart, the molecular guts of the cells will leach out into your buffer.

Place five milliliters of the minced vegetable mush into a clean container and mix in 10 milliliters of your chilled buffer. (Child medicine dispensers, which are available at every drug store, and are marked in milliliters units. Although most are only a two-milliliter capacity, they are cheap and easy to use for this experiment). **Stir vigorously for at least two minutes.**

Next you'll want to separate the visible plant matter from the molecule-laden soup. Professional scientists use centrifuges for this. (To learn how to build a your own centrifuge from a household blender, see the article "A Kitchen Centrifuge" on the Project's page at

[www.scifair.org](http://www.scifair.org).) If you've got access to one, spin the contents at low speed for five minutes and then delicately pour off at least five milliliters of the excess liquid into a narrow vessel, such as a clean shot glass, clear plastic vial or test tube.

If you do not have a centrifuge, then **straining the material through an ordinary coffee filter** will remove most of the plant refuse. With luck, any stuff that leaks through should either sink or float on top, so it will be a simple matter to pour off any solids into the sink and then pour the clear liquid into a clean vessel.

The solution now contains DNA fragments as well as a host of other molecular gunk. To extract the DNA, you will need to chill some **isopropyl (rubbing) alcohol** in your freezer until it is ice-cold. Most drugstores sell concentrations between 70 and 99 percent. Get the highest concentration (without colorings or fragrances) you can find.

Using a **drinking straw**, carefully deposit about 10 milliliters (exact amount is not critical) of the chilled alcohol on top of the DNA solution. To avoid getting alcohol in your mouth, just dip the straw into the bottle of alcohol and close off the top with the pad of your finger. Allow the alcohol to stream slowly down along the inside of the vessel by tilting the glass slightly. The alcohol, being less dense than the buffer, will float on top. Where the two liquids meet, **you should see a gelatinous sludge suddenly appear. That sludge is DNA.**

Gently insert a narrow rod through the layer of alcohol. A wooden coffee stirrer, a plastic chopstick or a glass swizzle stick works great. Gingerly twirl it back and forth with the tip of the stick suspended just below the boundary between the alcohol and the buffer solution. Longer pieces of DNA will then spool onto the stick, leaving smaller molecules behind. After a minute of twirling, pull the stirrer up through the alcohol, which will make the DNA adhere to the end of the stick and appear as a transparent viscous sludge clinging to the tip.

Although these results are impressive, this simple low-tech procedure does not yield a pure product. Professionals add enzymes that tear apart the RNA molecules to make sure they do not get mixed up with the DNA.

Even after the most thorough extraction, some residual DNA typically lingers in the vessel, forming an invisible cobweb within the liquid. But with a little more effort, you can see that material, too. Some dyes, like methylene blue, will bind to charged DNA fragments. A tiny amount added to the remaining solution will thus stain tendrils of uncollected DNA. You can get this dye from the resources available online through the **LABRats Supply Bureau** (coming soon). But you should also experiment with other easily available dyes, like food coloring or clothing or hair dyes. Do they work? I'm not telling but I invite you to find out. Add only the tiniest possible droplet: you want

all the dye molecules to bind to the DNA, with none left over to stain the water.

Exciting as it may be, extracting an organism's DNA is only the first step in most biological experiments. You'll probably want to learn what further investigations you can do--for example, sorting the various DNA fragments according to their lengths. The method to do this is called "**electrophoresis**" and it uses a weak electric current to sort molecules by their net electric charge. The technique is easy to learn and can be done at home out of things you've got in your kitchen.

I'll show you how to do it next week.

## Cool Projects

Here are a few great experiments that can lead you to championship science fair projects. If none of these appeal to you, that's fine. Learn more and ask your own questions. Doing what interests *you* is the always the best way to approach any science project.

**Question One:** How much DNA can be found in different plant and animal products?

Extract DNA from equal quantities of different varieties of fruits, vegetables and other material in your kitchen. Pick ten different sources. In addition to fruits and vegetables, try flour, egg whites or egg yolks, sugar, hamburger and so on. Extract DNA from equal amounts of each one and carefully compare the quantities you find.

The easiest way to do this is to measure the volume of the DNA. That can be done by measuring the amount of water the DNA displaces when it is submerged in a thin tube. If you don't have a test tube, you can use four inches of clear vinyl tubing from a hardware store, plugged at one end.

Xerox a ruler and then cut and glue the ruler along the tube. Now, wet a stirring stick, then break off a standard length, say two inches (5 cm), submerge it inside the tube and record the height of the water column. Then carefully remove it with a pair of tweezers. Next, collect all of the DNA on your stirring stick that you can, and break off the end of the stick into the same standard length making sure that it contains all of the DNA. Then submerge it in the tube. The difference in the heights of the water column determines the volume of the DNA.

Does this suggest any other questions to you?

**Question Two:** How do environmental factors affect DNA?

Pulverize enough organic matter from a single source (say, an onion) to do the extraction many times. Then divide the pulp up and expose the different samples to different levels of some environmental stress, like sunlight, heat, cold, or time. Use your imagination. What do you think might affect the results?

Use the method outlined in Question One to find the volume of DNA that can be extracted after the stress has been applied. Plot the amount of DNA extracted verses the size of the stress and explain your results. What implications do your results have for researchers who use DNA to unearth the past?

Now go out and do great things!

Dr. Shawn