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BACKYARD BIOLOGY



Photography by Howard Call

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BACKYARD BIOLOGY

Kitchen Counter DNA Lab

Extract, purify, and experiment with the blueprint of life.

By Dr. Shawn



DNA is perhaps the most extraordinary structure in all creation. Its famous double helix is the longest molecule known and regulates the life processes in every cell on Earth. Even more, the code that DNA carries is the actual blueprint of life itself. The human recipe, for example, consists of roughly 3 billion molecular bits of information laid out in a precise sequence.

Perhaps most amazingly, this miraculous winding staircase directly links every creature on Earth to our ancient and common past — far back to when evolution first began shaping the biological forms that would ultimately populate the world we know today. By examining the differences between the DNA in our bodies and that in other organisms, we can tell when our species diverged from chimps, apes, and even primordial fish.

The properties of this massive molecule are so mysterious and wondrous that most folks assume

only the enlightened priesthood of laboratory biologists can extract and study it. Not so. In fact, anyone can extract, purify, and experiment with DNA at home.

When released from a cell, DNA typically breaks up into filaments. In solution, these strands have a slight negative electric charge, which makes for some very useful chemistry. For example, the more negative sections of one DNA strand will tend to attract the more positive regions of another. This causes DNA molecules to clump together and fall out of solution. However, if salt is added, its positive ions are attracted to the DNA's negative charges, effectively neutralizing them. This stops the fragments from adhering and keeps them floating in solution.

So, by controlling the salt concentration, anyone can make DNA fragments either disperse or clump together. And therein lies the critical secret of separating DNA from cells and manipulating it at home,

ISOLATING THE DNA

Extraction

Here's how it works. First, you'll need a salty solution, called a buffer, into which DNA can dissolve. Next, you'll need to break open a bunch of cells and let their molecular "guts" seep out into your buffer. Then, you'll want to add a special enzyme that will destroy unwanted molecules, such as proteins, which would otherwise contaminate your results. Finally, you'll have to reduce the salt concentration enough to cause the DNA molecules to clump together and fall out of solution.

Step One: Build the Buffer

First, you'll need to whip up your buffer (see recipes on next page). Pour 120ml (about 4 oz.) of distilled or bottled water into a clean glass container. Add the table salt and baking soda, and stir vigorously. After they have dissolved completely, stir in the detergent. Shampoos and liquid laundry detergents that contain sodium lauryl sulfate (check the label) work well.

Next, add the tenderizer by wetting a toothpick, inserting it into the meat tenderizer, and transferring it to the buffer. Meat tenderizer contains an enzyme called papain that breaks up proteins so they won't come out with the DNA. Pineapple juice and contact

lens cleaning solution also contain protein-busting enzymes, so, alternatively, you can add a drop of one of these two liquids.

Lastly, because DNA degrades fast (sometimes in a matter of minutes), you'll want to slow the pace of destruction by chilling the buffer in a bath of crushed ice. If the buffer becomes cloudy, you've chilled it too much. In that case, warm it just enough to clear it.

Step Two: Get the DNA

For a source of DNA, try the pantry. You can get great results with raw onions, garlic, bananas, or tomatoes. But if it's your experiment, choose your own personal favorite fruit, veggie, meat (fresh or frozen), or fungus.

Once you've secured your DNA source, you'll need to process its cells to extract their organic molecules. First, use a knife to dice the material into small pieces. Put the material into a blender and pour in just enough distilled or bottled water to cover the chunks. Then break up (or lyse, as biologists say) the cells by pulsing the blades in short bursts until you've blended the material into a slushy mass. This will rip open some of the cells directly and expose many more cell walls and nuclei to the detergent's attack.

Finally, you need to leach out the organic molecules. Place 5ml (1 tsp) of the minced mush into a



TAKING IT FURTHER

DNA Experimenting

WELCOME TO THE WORLD OF MOLECULAR BIOLOGY

There are two types of experiments that are particularly easy to do, and I recommend that even the most adventurous experimenters start with one of these: discovering how much DNA can be extracted from different organisms under different circumstances, and exploring the conditions that cause DNA to degrade.

Measuring the amount of DNA you've extracted from a sample couldn't be simpler. First, measure the inner diameter of your straight-walled container holding the DNA. Once you know that number, just measure the thickness of the sludge. With that information, it's easy to calculate the volume of DNA you've produced: the equation is $V = \pi D^2 T / 4$, where D is the inner diameter of the vessel and T is the thickness of the layer of DNA sludge. Next, divide the volume of extracted DNA by either the volume or the mass of the material it came from. The simplest way to do that is to accurately measure how much mush you put into your buffer, and then process all of the buffer to extract every scrap of the DNA that leached into it. If you have an accurate scale, weigh your sample before processing it. If not, just measure the volume of the material before you blend it.

Example: Suppose you processed 5g of onion into 10ml of buffer and extracted 1ml of DNA. How much DNA did you get from each gram of onion? Easy! Just divide what you got by what you started with: 1ml DNA / 5g onion = 0.2ml/g.

You can also run experiments with the DNA itself. Usually, the first step is to remove the DNA sludge. It takes a little practice, but you can do it using a clean glass and a swizzle stick. Gently insert the stick through the layer of alcohol and swirl it very slowly in the same direction, with the tip suspended just below the top of the buffer solution. Longer pieces of DNA will spool into the glass, leaving smaller molecules behind.

After a minute of swirling, slowly pull the stirrer up through the alcohol. This will make the DNA adhere to the end of the stick, where it will appear as a transparent, viscous, "spoollike" clump

clinging to the tip.

If you now resuspend the molecules in a fresh batch of buffer, you can expose them to chemicals, sunlight, temperatures, or anything else that might break up the DNA. Make a new batch exactly as before and chill it, but don't bother adding the detergent. Submerge the swizzle stick and gently agitate for several minutes as the DNA dissolves into the buffer. Then divide the buffer equally into 2 clean glass containers. Expose one — your test sample — to whatever agent you wish to test. Leave the other — your control — alone. Then process both as quickly as possible and compare the amount of DNA you can extract from each buffer. The difference between the volumes from your test and control is a measure of how much damage your agent does to DNA.

If this sounds too easy, keep in mind that DNA is fragile stuff and it can be affected by lots of subtle things that might escape your notice. Getting consistent results takes practice, so make sure you vary the exposure and that your plotted data shows a regular behavior before drawing any conclusions.

COLD STORAGE

It's actually easy to store your DNA for later use. Just place the "snot bulb" swizzle stick and all, in a container filled with ice-cold Isopropyl alcohol and put it in the freezer. Your DNA will keep almost forever.

DR. SHAWN'S DNA EXTRACTION KIT

As a special service to MAKE readers, Dr. Shawn has assembled a kit that contains everything you need to perform at least 20 DNA experiments, including a 100-ml buffer, a 100-ml Isopropyl alcohol, a fast-flow filter, a generous amount of nontoxic DNA stain, a protein-busting enzyme, a shatterproof graduated test tube, a laboratory-style glass DNA extraction rod, and complete instructions. The cost is \$27 + \$4 shipping (U.S. only). You may send a check to: 5600 Post Rd. Suite 114-341, East Greenwich, RI 02818, or call (401) 398-7001, or order online at scifair.org.

Dr. Shawn (Shawn Carlson, Ph.D.) is a MacArthur Fellow and the former executive director of the Society for Amateur Scientists. To learn more about the society, visit sas.org.

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