



DNA: The Fiber of Our Lives

The Puzzle:

Hypothesis: Is this white stuff string or DNA?

Procedure: How can we find out? *We could TEST it.*



What are substances we have on-hand to test it with? *Water and air.*



Let's look at the properties of string: It is solid in air and it is solid in water.

Let's look at the properties of DNA: It is solid in air and it *dissolves in water.*

So water is the tester.

String is cotton, so grab a piece of lint or a thread off your clothes to act as the string test.

We have one piece of white stuff and one piece of string or cotton. How can we have multiple pieces and also have some to take home? *Cut it into smaller pieces!*

Put a sample of the white stuff and a sample of string, or cotton on the tabletop.

Put a drop of water on each sample. What happens?

Observations: Does the white stuff dissolve? What does the cotton string do?



Conclusion: Yes and no, the fact that the white stuff dissolves only proves that it isn't string. It helps narrow down the possibilities of what it could be and it is still a possibility it isn't DNA. This is called a **Null Hypothesis**, we can prove it isn't cotton, but we can't prove it's DNA. Next, any good scientist would test it again. Formulate several hypotheses and make a collection of conclusions to come to the right one.

It is actually DNA though. It is purified DNA that has been dried and coiled around itself to make it into what you see right now.

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DNA Tubes made by hand by Paul Pierick, University of Wisconsin Biotechnology Center

The DNA Tube

Most people have never seen purified DNA. And when they do, they often think it's just string. In doing so, they've been both skeptical and creative: They look at the label, they look at the stuff and they come up with an alternative idea. We encourage people to test their alternative idea.

The Puzzle

Is there an easy way to test if the white stuff is string or DNA? What happens if you put cotton string in water? Most people know the string gets wet, but does not dissolve. What happens if you put DNA in water? Most people don't know, but they'll guess that it dissolves (& in fact DNA does dissolve in water). So water becomes the tester. We encourage people to take a small snippet of the white stuff in the DNA tube and put it on a tabletop. We ask them also to find a piece of lint or thread from a cotton garment so they have a known piece of cotton, and put that on a tabletop near the snippet of white stuff. Then we ask people to put a drop of water on each piece, and ask: Does either dissolve? If the white stuff dissolves is this proof that it's DNA? Many people will at first say yes. But some will point out that if the white stuff dissolves, it's not really proof that it's DNA, it's only proof that it's not cotton. In this way, the DNA Tube can be more than "Show and Tell." The DNA Tube can be a "Think and Test" Tube. It illustrates the power of experiment and a difference between proof and disproof.



Developing Science Savvy: Transforming How We View & Do Science

The Puzzle of the DNA Tube is a good parable for how we know what we know and how science probes the unknown. Here are some themes illustrated by the DNA Tube.

The label tells us the white stuff is DNA. The label is an appeal to authority.

People often doubt that it's DNA. Skepticism is a cherished trait to scientists.

This doubt also indicates that people have some inkling or naïve theory of what DNA should look like. The suggestion that the white stuff is actually cotton is an example of making connections. New ideas must compete to displace existing ideas: so learning often depends first on unlearning.

Now the puzzler has a hypothesis (the white stuff is DNA) and a null hypothesis (it is not DNA) and an alternative hypothesis (it's cotton string). Different hypotheses need to be constructed so that they make different predictions. Now the challenge is to have the creativity and the ingenuity to come up with a way to test or discern between those ideas. Water is the tester and gives the Logic Fork: if the white stuff is DNA, then it is expected to dissolve. If the white stuff is cotton, then it is expected to not dissolve.

This is the Archimedes Eureka Point: not when you know the answer, but you know how you're going to get the answer.

Now comes the challenge of designing the experiment. First, the scientist plans ahead and realizes that it's better to take a sample of white stuff, rather than using all of it. That leaves some white stuff for repeating the tests to confirm.

Second, the sleuth can anticipate alternative interpretations and add fair comparisons to exude those. For example, if the white stuff dissolves, a skeptic could say, "how do know that your tap water doesn't dissolve cotton?" Rather than argue about it, the scientist tests it. The scientist takes some known cotton (from clothes, for example) and tests whether it dissolves in water side by side with the white stuff.

Now comes the Prometheus Thinking. Prometheus can be translated as the "Knowledge Aforethought." Scientists can anticipate the possible results and lay out the conclusions they'll make for each positive result. If the white stuff is DNA, and the cotton is cotton, and the water is water, then scientists would expect that the white stuff will dissolve and the cotton will not. If both the white stuff and the cotton were to dissolve, then this would not be evidence that the white stuff is DNA. If the cotton were to dissolve, then something would be amiss—either the "cotton" is not really cotton, or the "water" is not really water, and the scientist knows the test would not be valid and so the scientist would make no conclusions about the white stuff.

Scientists know they can keep it simple: just put the white stuff on a tabletop, and some cotton near it. And drop some water on each then the scientist watches and records.

In drawing the conclusion the scientist is careful to distinguish between proof and disproof. If the white stuff dissolves in water and the cotton does not, this does not prove that the white stuff is DNA. It only proves that it is not cotton. As one fifth-grader pointed out, the white stuff could just be cotton candy