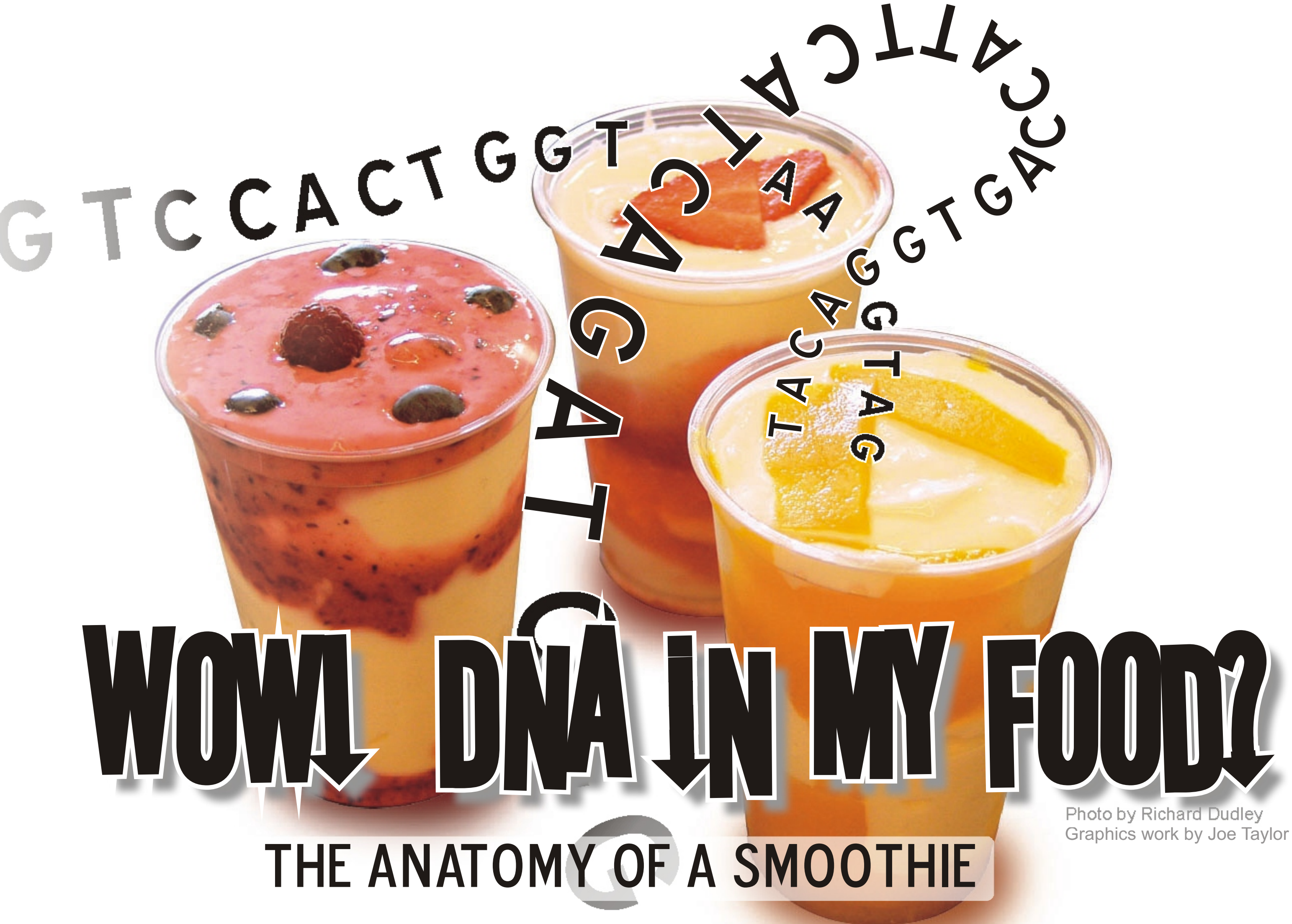

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WOW! DNA IN MY FOOD?

THE ANATOMY OF A SMOOTHIE

Mike Zeller

ABSTRACT: While many students are able to speak at length about DNA, their fundamental understanding of the pervasiveness of DNA may still be unchanged. This activity is ideal for helping student link their classroom learning to their own daily experience and observations about DNA. Students also mentally engage by critically thinking about the physical and chemical properties of DNA. *This article promotes National Science Education Standards A and C and Iowa Teaching Standards 1, 2, 3, and 6.*

The title of this article may seem strange for a scientifically literate and savvy society. After all, it is supposed to be common knowledge that all cells have DNA. Since the late 1980s, science teachers have used activities in which students extract DNA from a wide variety of sources bacteria, onion, thymus and many types of fruits. DNA extraction was the "hook" and "cool science stuff" that excited our students in their genetics units. Science teachers felt good about bringing modern genetic technology to students, often called biotechnology. Students were being prepared for the world of the GMO, stem cells and cloning. As a high school science teacher with over twenty years of experience, I, too, believed that I had finally given my students an activity that was practical, provided a real life science experience, and helped students understand DNA.

After leaving the classroom I began working for Iowa State University's Office of Biotechnology as its Biotechnology Outreach Education Coordinator (BOEC). While working in this role my perspective changed regarding how well students were learning about DNA and biotechnology. I had come to realize that misinformation abounds and people struggle to differentiate pseudoscience from knowledge accepted within the scientific community. For example, many people incorrectly believe that "*ordinary tomatoes do* *not contain genes, but GM tomatoes do* (McHughlan, 2000)." As a second example, I once attended a "Science Night" at a local elementary school when a grade school parent commented, *"I didn't know bananas had DNA!"* I was amazed that more than a few people believe the food we eat is void of DNA unless it is an additive.

The Need for Something More

This was more than enough to get my attention. These off-hand comments coupled with my experiences in the field led me to the conclusion that many students lacked basic knowledge needed to understand the science of genetics (let alone biotechnology). More importantly, there was little awareness of how DNA structure and function are connected to everyday living. So what was my idea to help people make the connection between DNA and their lives? USE FOOD!

With the help of a colleague, who formerly was a family and consumer sciences teacher, we developed an activity. We wanted to use fruits from which DNA could be easily extracted and the same fruit used to make something that tasted good. The answer came as a fruit smoothie that students could eat. An added benefit of this activity is that it promotes good health and products such as honey, strawberries and soy tofu that are produced locally in Iowa. It has become our most popular activity, reaching a broad diversity of students and adults.

The Activity

This one-hour activity is usually completed after students have some knowledge of DNA structure. While many students are able to speak at length about DNA, their fundamental understanding of the pervasiveness of DNA may still be unchanged. This activity is ideal for helping student link their classroom learning to their own daily experience. As we shall see, the activity asks that students apply the things they know about DNA in order to make sense of the evidence that the final extract is actually DNA.

To download this activity from the Internet as either an html or pdf file, go to www.biotech.iastate.edu/publications/ed_resources/Laboratory_protocols.html and find the "DNA in My Food?" file listed under DNA Extraction.

I introduce the activity by getting students to think about and discuss the topic of DNA. I ask questions such as

- "What is the role of the DNA in an organism?"
- "Where is DNA located within an organism?"

These questions help students draw out their prior knowledge regarding DNA, and help me to identify both what students already know and any misconceptions. Knowing that students may struggle with these questions and may have difficulty forming clear answers, I encourage students to share their ideas by providing an open environment that promotes discussion. This sort of learning environment does not create itself, so I help encourage discussion by projecting my own inquisitiveness, initially accepting all student answers, and asking with genuine curiosity for students to elaborate. My positive facial expressions also make clear to the students that I am genuinely interested in their thinking. I work to bring more students into the conversation by asking questions such as

- "What do others of you think of [Dwight's] idea that DNA is the blueprint of a organism?" or
- "What are other functions of DNA besides its role in expressing an organism's traits?"

Once I feel that students have a working understanding of the role and location of DNA, I next set the stage for our activity through a series of questions and discussion.

- "What are examples of genetically modified foods that you could find at a grocery store?"
- "What does it mean for a food item to be genetically modified?'

Students likely have heard of genetically modified foods, but may not understand what it really means. The questions above will uncover their collective knowledge and provide an opportunity to address misconceptions or points of confusion. I continue with

- "A friend and I were discussing genetically modified foods and they claimed to have read that genetically modified foods do not contain DNA. How would you respond the them?"

This question gets students speculating about the logic of food items having no DNA, whether genetically modified or not. Within the class it is common for students to hold opposite positions. Some students state foods do contain DNA, and others state that food does not contain DNA. I do not provide students an answer to this question. Instead, we put our question to the test. I tell students that I have some food items that we can test for DNA, but that it would be a shame to waste food. So, while we test our food for the presence of DNA, we also get to eat our results! This creates a need to discussion lab safety (Text Box 1).

While many biology labs are designed to involve students in decision-making about what steps to follow, this lab requires providing specific directions in order for students to reach the desired results. Minor deviations from the directions can ruin the results. Therefore, students must follow prescribed steps. To better mentally engage students, questions can be posed throughout to help them consider the rationale for the steps they follow. Furthermore, students could be engaged with discussions that compare/contrast step-by-step procedures with how real science likely works.

TEXT BOX 1
Classroom Safety when Working with Food

A side note to this activity is the realization that eating in a lab setting is not a good safety procedure. However with sensible forethought and planning it can be safely done in a formal lab setting that has been cleaned thoroughly or away from the lab in a lecture section of the classroom. Check your school's policies concerning food in any classroom and/or visit with your administration about your plan to have food in your classroom for the students. I recommend that all chemicals and DNA extraction parts of the lab be set at one location in the classroom, and all materials that have the potential to be consumed be set on the opposite side of the classroom. To be even more cautious, students could first eat as much as they want of their smoothies, so long as they leave enough to run the extraction experiment. Then do the extraction lab. This way, students eat while the chemicals are put away, and then stop eating before the chemicals are brought out.

Fruits of the Labor: Making Smoothies

Students first combine the ingredients (Figure 1) needed to make a smoothie in a blender.

FIGURE 1
Smoothie Ingredients

- package of tofu (cut into pieces)
- package of frozen strawberries, partially thawed
- 1 ripe banana (cut into pieces)
- 1 cup of orange juice (add more for a thinner consistency
- 2 tablespoons of honey

Ask students:

- "Which of these ingredients do or do not contain DNA?"
- "What is your reasoning?"

These questions help students bridge their classroom knowledge concerning DNA to what I might call their "street knowledge" what they believe about DNA outside the classroom. At this point, blend the ingredients and have students sample their smoothies in small, 5 ounce cups. Tell them they can eat as little or as much as they want, so long as they leave behind three large scoops to be used in the DNA extraction. Before extraction, have students throw away or recycle their spoons so that it is made clear that they are to stop eating.

Budding Scientists: Extracting the DNA

Students use the following directions to extract DNA:

1. Add 25 mL of water to your smoothie and mix for 30 seconds.

2. In a second cup, make a solution consisting of 1 teaspoon of shampoo and two pinches of table salt. Add 20 ml (4 teaspoons) of distilled water or until the cup is 1/3 full. Dissolve the salt and shampoo by stirring with a popsicle stick slowly to avoid foaming.

3. To the solution you made in step 2, add three heaping teaspoons of the banana mixture from step 1. Mix the solution with the popsicle stick for 5-10 minutes.

4. While one member of your group mixes the banana solution, another member will place a #2 cone coffee filter inside the second 5 oz plastic cup. Fold the coffee filter's edge around the cup so that the filter does not touch the bottom of the cup.

5. Filter the mixture by pouring it into the filter and letting the solution drain for several minutes until there is approximately 5 ml (covers the bottom of the cup) of filtrate to test. It takes 15 minutes for the DNA solution to filter with this version of the protocol.

6. Obtain a test tube of cold alcohol. For best results, the alcohol should be as cold as possible.

7. Fill the plastic pipette with banana solution and add it to the alcohol.

8. Let the solution sit for 2 to 3 minutes without disturbing it. It is important not to shake the test tube. You can watch the white DNA precipitate out into the alcohol layer. When good results are obtained, there will be enough DNA to spool on to a glass rod or toothpick. You could also use a Pasteur pipette that has been heated at the tip to form a hook to retrieve some of the DNA. DNA has the appearance of white, stringy mucus.

Class Discussion

Students likely won't realize that the extracted goo is actually DNA. To help student make this connection I have them take a second toothpick and try to spread the goo apart to see that it forms strings. I then ask

- "Think about the structure of DNA. How does this knowledge help us support the idea that what we observe is actually DNA?"

If students struggle with this question, I help them make the necessary connections through the following question,

- "What are the building blocks of DNA?"

From prior learning, I can lead students to state that DNA is formed from nucleotides connected in long chains. Then I ask,

- "How does this knowledge about DNA fit with our observations about our 'goo-like" DNA?"

This sequence of questions and discussion often provides enough evidence to demonstrate that we are indeed looking at DNA. However, further tests can be completed to increase students' certainty:

(1) Place some of the extracted DNA from the toothpick on a piece of blue litmus paper and allow it to dry. When the DNA dries, the litmus paper will turn red indicating an acid (nucleic acid).

(2) The physical appearance of DNA in alcohol is a white strand. By preparing a wet mount slide of the extracted DNA and staining it with methylene blue, you can observe strands of DNA at the edges of globs using a high power (400X+) microscope. Actually, these strands are thousands of smaller DNA strands stuck together. The strands appear darker on their outside portions. The darkness indicates a greater density on the outside of the strands, a characteristic commonly found in helical molecules.

(3) DNA can be dissolved in water, demonstrating that the backbone structure of DNA is a sugar (ribose). Sugars dissolve in water but not alcohol.

Curriculum Placement Options

In the activity described above, students are asked to reflect on their prior learning about DNA to make connections to things they observe. They are asked to apply what they have learned to a real world example. Importantly, this extraction activity could also be used to introduce a unit on DNA. Instead of having students explain the properties of the extracted DNA, the observed properties could be used to raise questions about DNA.

- "Why does the DNA we extracted look 'stringy'?"
- "Why does the DNA indicate an acidic pH on litmus paper?"

By having students first observe some of the properties of DNA, they can be encouraged to make connections to more detailed learning about DNA's molecular structure. For example, after learning of DNA's helical structure, students could be asked what evidence they have from their observations that fits with a the helical structure of DNA.

Whenever the activity is placed in the curriculum, tying students' ideas and thinking about DNA to concrete experiences is an important part of the learning process. The activity described above provides insight and detail for completing the DNA extraction and what kinds of evidence/observations ought to be brought to students' attention for either later reflection with future learning or for application of prior learning.

Conclusion

Extracting DNA from a variety of sources is nothing new. But using it to connect students with the role DNA plays in our everyday lives is necessary. This activity helps students make this connection while learning about the physical and chemical nature of DNA. Science learning that is fun, cheap and practical no wonder it is by far our most requested activity!

References

DNA Free Food Society web site: www.netspeed.com.au/ttguy/default.htm

McHughen, Alan, 2000. *Pandora's Picnic Basket: The Potential And Hazards of Genetically Modified Foods*. Oxford University Press, New York, NY. pp87.

Mike Zeller works with the biotechnology outreach education program at Iowa State University. He has trained over 1,800 Iowa teachers, providing them with equipment, supplies, and curriculum packages. Mike received both the Regents Award for Faculty Excellence and the Distinguished Service Award by the Iowa Science Teacher Section of the Iowa Academy of Science. Mike can be contacted at mzeller@iastate.edu.