KANSAS CORN STEM

Kansas Corn: DNA, What's it Look Like?

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KANSAS CORN COMMISSION

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Kansas Corn: DNA, What's it Look Like?
Grade Level: High School

Overview
It is important for students to understand what DNA is and how all cells utilize it. One major difference in this DNA lab is that we attempt to extract DNA from corn while we build a physical and mental model of the structure of DNA. After extracting DNA and building a model, the students then attempt to utilize their newly acquired knowledge of the structure of DNA to optimize the extraction of DNA from corn.

This lab has three parts: 1) DNA extraction from canned corn, 2) DNA modeling activity to be done while waiting for part 1 results, and C) student experimenting with DNA extraction procedure to obtain more DNA.

Kansas College and Career Ready Standards
Disciplinary Core Ideas:

- **MS-LS1-2.** Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- **HS-LS1-1.** Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

Learning Objectives
- Students will discover that DNA is the storage molecule for genetic information in the cell.
- Students will create a model of the structure of DNA.
- Students will extract DNA from corn using a specific protocol.
- Students will design an experiment to extract the most DNA from a specific amount of corn.
- Students will present their experimental results to the class.

Materials
- DNA, What's it Look like? PowerPoint (available at www.kansascornstem.com)
- Saran wrap (long roll)
- 32 ping-pong balls (8 per group)
- 55-gal. clear trash bags
- Ice-cold ethanol /isopropanol (75-95%)
- Household strainer
- Velcro
- Table salt
- Meat tenderizer
- Clear plastic cups
- 15-mL screw cap plastic test tubes

Kansas Corn: DNA, What's it Look Like?
Grade Level: High School

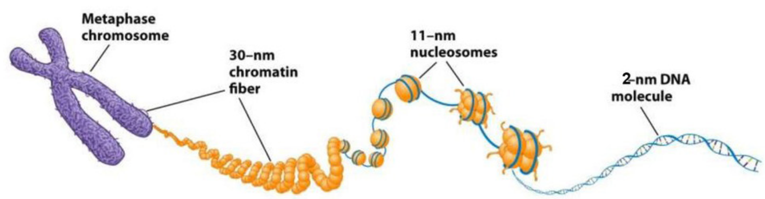
- 1.5-mL micro-centrifuge tubes
- Canned corn
- Tape
- 1 Sharpie
- Milk
- Liquid soap
- Butter

Safey Considerations

Be aware of student allergies or seeds treated with chemicals.

Background Information

Levels of DNA Packaging



- 2-nm double-stranded DNA molecule
- 11-nm nucleosomes
- 30-nm chromatin fiber
- Organization around a central scaffold

Source: https://socratic.org/questions/what-are-chromatin-and-chromosomes-made-from

Article from Science Daily (2009)

In recent years, scientists have decoded the DNA of humans and a menagerie of creatures, but none with genes as complex as a stalk of corn, the latest genome to be unraveled.

A team of scientists led by The Genome Center at Washington University School of Medicine in St. Louis published the completed corn genome in the Nov. 20, 2009 journal Science. This accomplishment will speed efforts to develop better crop varieties to meet the world's growing demands for food, livestock feed and fuel.

Kansas Corn: DNA, What's it Look Like?
Grade Level: High School

"Seed companies and maize geneticists will pounce on this data to find their favorite genes," says senior author Richard K. Wilson, Ph.D., director of Washington University's Genome Center, who led the multi-institutional sequencing effort. "Now they'll know exactly where those genes are. Having the complete genome in hand will make it easier to breed new varieties of corn that produce higher yields or are more tolerant to extreme heat, drought, or other conditions."

Corn, also known as maize, is the top U.S. crop and the basis of products ranging from breakfast cereal to toothpaste, shoe polish and ethanol. The corn genome is a hodgepodge of some 32,000 genes crammed into just 10 chromosomes. In comparison, humans have 20,000 genes dispersed among 23 chromosomes.

The $29.5-million maize sequencing project began in 2005 and is funded by the National Science Foundation and the U.S. departments of agriculture and energy. The genome was sequenced at Washington University's Genome Center. The overall effort involved more than 150 U.S. scientists at the University of Arizona in Tucson, Cold Spring Harbor Laboratory in New York and Iowa State University in Ames playing key roles.

The group sequenced a variety of corn known as B73, developed at Iowa State decades ago. It is known for its high grain yields and has been used extensively in both commercial corn breeding and in research laboratories.

The genetic code of corn consists of 2 billion bases of DNA, the chemical units that are represented by the letters T, C, G and A, making it similar in size to the human genome, which is 2.9 billion letters long.

But that's where much of the similarity ends. The challenge for Wilson and his colleagues was to string together the order of the letters, an immense and daunting task both because of the corn genome's size and its complex genetic arrangements. About 85 percent of the DNA segments are repeated. Jumping genes, or transposons, that move from place to place, make up a significant portion of the genome, further complicating sequencing efforts.

A working draft of the maize genome, unveiled by the same group of scientists in 2008, indicated the plant had 50,000-plus genes. But when they placed the many thousands of DNA segments onto chromosomes in the correct order and closed the remaining gaps, the researchers revised the number of genes to 32,000.

"Sequencing the corn genome was like driving down miles and miles of desolate highway with only sporadically placed sign posts," says co-investigator Sandra Clifton, Ph.D., of Washington University. "We had a rudimentary map to guide us, but because of the repetitive nature of the genome, some of the landmarks were erroneous. It took the dedicated efforts of many scientists to identify the correct placement of the genes."

Kansas Corn: DNA, What's it Look Like?
Grade Level: High School

Interestingly, plants often have more than one genome, and corn is no exception. The maize genome is composed of two separate genomes melded into one, with four copies of many genes. As corn evolved over many thousands of years, some of the duplicated genes were lost and others were shuffled around. A number of genes took on new functions.

Corn is the third cereal-based crop after rice and sorghum – and the largest plant genome to date – to have its genome sequenced, and scientists will now be able to look for genetic similarities and differences between the crops. "For example, rice grows really well in standing water but corn doesn't," explains co-investigator Robert Fulton, of Washington University. "Now, scientists can compare the two genomes to find variations of corn genes that are more tolerant to wet conditions."

The United States is the world's top corn grower, producing 44 percent of the global crop. In 2009, U.S. farmers are expected to produce nearly 13 billion bushels of corn, according to the U.S. Department of Agriculture.

Procedures for Instruction

Length of Time for Preparation: 20 minutes
Length of Time for Classroom Teaching: 50 minutes, 90 minutes with Claim, Evidence and Reason (CER) extension

Classroom Discussion

Introduce the topic and assess students for prior understanding.
Socratic Questioning:

- What is DNA?
- Where can we find DNA?
- How is DNA stored?
- Is DNA the same for plants and animals?

Procedure for Lab

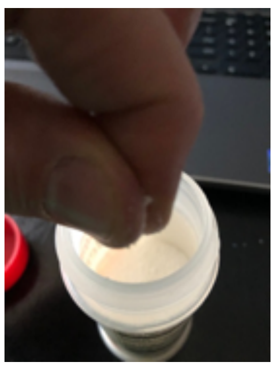
Part 1. Extraction of DNA from Canned Corn.

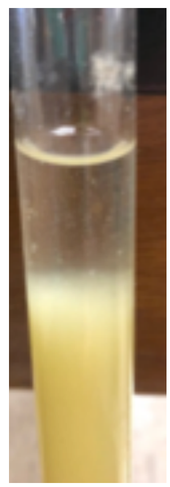
Procedure:

1. Blend 100 mL (1/2 cups) of canned corn, 1 mL (1/8 tsp.) of table salt, and 200 mL (1 cup) of cold water in a blender for 15-20 seconds.

2. Slowly pour the corn soup from the blender into a metal strainer positioned over a plastic cup. Make sure you allow all of the soupy mixture to drop the liquid portion into the cup. Slowly add 30 mL (2 tbsp.) of liquid detergent into the mixture and gently swirl the cup (do this slowly that you do not form bubbles). Let this mixture sit for 5-10 minutes. Gently pour this mixture into test tubes until they are about a third full.

3. Add a pinch of enzymes (meat tenderizer) into each test tube and stir gently. If you stir too hard, you will break up the DNA.





4. Tilt the test tube slowly, and pour ice-cold rubbing alcohol (70-95% isopropyl or ethanol) down the side of the test tube. You can use a disposable dropper pipet to slowly add the alcohol. You will add enough alcohol so that you have about a 1-in. layer of alcohol on top of the mixture. Let this tube sit for 5-10 minutes.

Kansas Corn: DNA, What's it Look Like?
Grade Level: High School

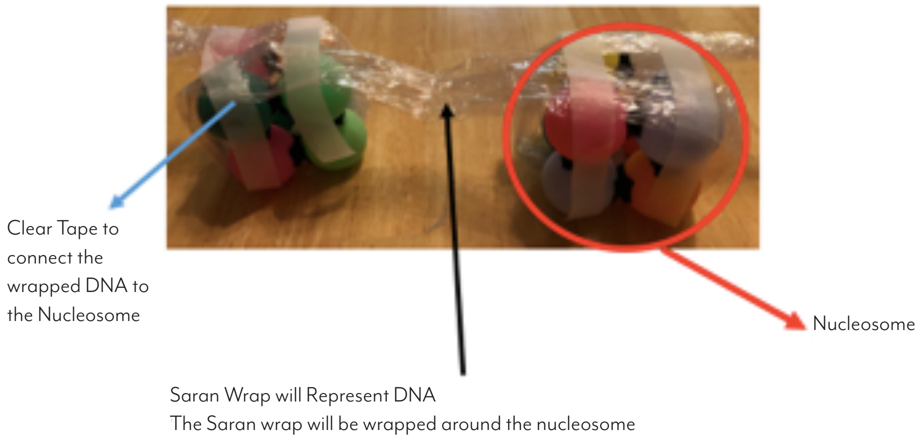
5. The DNA will begin appearing at the alcohol and water interface layer. You can use a disposable dropper pipet to gently collect the precipitated DNA. You can save the DNA by transferring it to a small container of alcohol (micro-centrifuge tube).

Part 2. Modeling DNA Structure: Let's make a model of DNA!

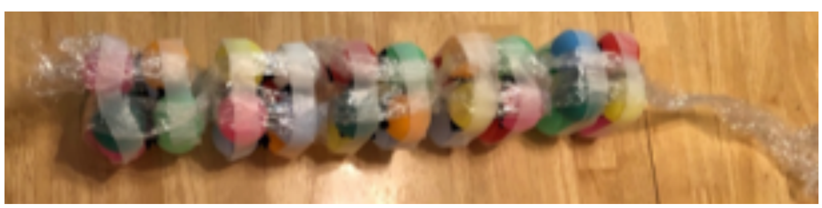
Procedure:

1. Each group will connect their 8 ping-pong balls into the arrangement of a double stack of 4 (see photo). These stacks represent a nucleosome (made up of 8 histone proteins).

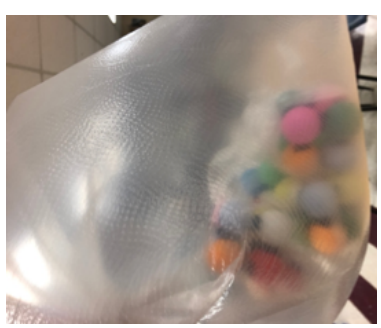
2. After all groups have their nucleosomes arranged, start with one group and pull out about 10 feet of Saran wrap. Squeeze this into a long rope shape and wrap it around one of the nucleosomes (see photo). Continue with the Saran wrap and wrap all of the other nucleosomes in a sequence. After all of the nucleosomes are wrapped with the Saran wrap, use a couple pieces of clear tape to secure the nucleosomes to the Saran wrapped DNA. The Saran wrap represents DNA.



3. To show how a chromosome is formed, you will need to pull all of the nucleosomes together to make a condensed arrangement of the DNA. This is how a chromosome forms (just much more condensed).



4. When the arrangement is condensed, place the whole arrangement in a large 55-gal. clear trash bag. The trash bag represents the nuclear membrane.



5. Line 6 desks up in a straight line and place the nucleus on one side of the desks. The desks represent the cell membrane.
6. Looking at our class model, what are some barriers that we need to get through to get to the DNA? Cell membrane (desks) and nuclear membrane (clear bag).
7. What are those barriers made up of? Bi-lipid layers (fats)
8. How can we get rid of those fats? Detergent (soap) breaks a part bi-lipid layers
9. Melt a small amount (1 tbsp.) of butter in a microwave oven, then slowly add 3-4 drops of liquid soap to the melted butter. What do you see happening around the soap drops? This step shows how detergent (soap) can break lipids down.
10. The nucleosomes are made up of histone proteins. If we want to extract DNA, we will need to get rid of those histone proteins. We can do this by adding salt to make the proteins precipitate out.
11. Add 2 tbsp. of salt to 50 mL of warm tap water. Stir this mixture until most of the salt dissolves. Pour about 50 mL of whole milk into a clear plastic cup. Pour your 50-mL salt/water mixture into the cup with the milk and stir for 1 minute. Let this mixture sit for about 5 minutes. What separation do you see? This step shows how salt precipitates out milk proteins.
12. DNA is negatively charged, and it will come out of the solution at the interface of the alcohol layer and the filtrate. We look for the DNA to appear at the alcohol layer interface.

Part 3. How to get More DNA from Corn.

Project goal: Your group's goal is to obtain the greatest quantity of DNA from 3 tbsp. of the canned corn provided. You can only alter the materials we provided. Once you have changed your procedure, you will need to describe exactly why you made the changes that you did.

The diagram below shows the structure of a kernel of corn. Your DNA extraction from Part 1 of this lab simply used the whole corn kernel to extract DNA. The quantity of DNA extracted from Part 1 is not optimal. The more DNA that is extracted, the better chance we have to obtain useful DNA for further experiments. Now that you have some knowledge of the protocols needed to extract DNA from corn, you will now need to attempt to obtain the greatest quantity of DNA from 3 tbsp. of canned corn. You will need to attempt to extract DNA from the embryo portion of the corn seed by cutting out the embryo portion with some scissors. Pool all of the corn embryos together, and that pool of corn embryos is what you will use to extract the DNA from. Compare the quantity of DNA from the whole corn kernel with the quantity of DNA from the embryos. Prepare a whiteboard that describes your procedures and graphically shows the difference in DNA quantities from the two procedures. Attempt to explain any differences that were obtained.

Kansas Corn: DNA, What's it Look Like?
Grade Level: High School

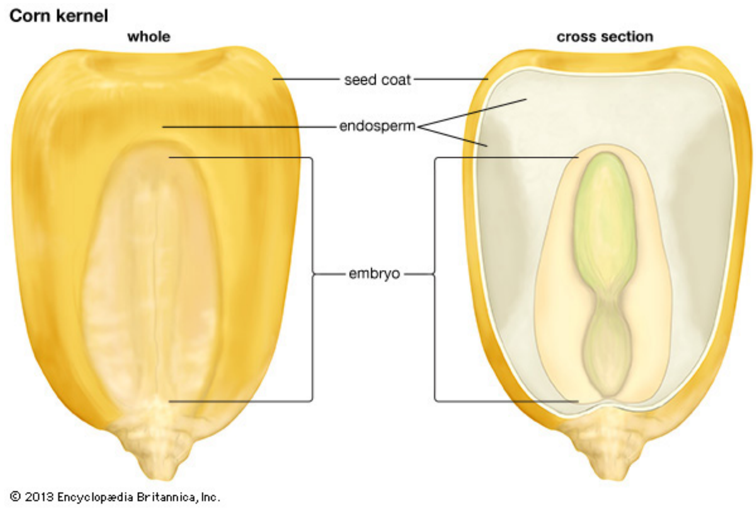


Image from 2019 Encyclopedia Britannica

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Teacher Resources
Visit www.kansascornstem.com for additional resources and teacher tips.

Lab Analysis
Let students discuss their ideas, and guide the discussion without telling them if they are right or wrong.

- Why didn't we get a large quantity of DNA from corn using our procedure?
- Why is ice-cold alcohol used in our procedure?
- What are nucleases? What do they do?
- How much DNA should we be able to get from canned corn?

Assessment
Whiteboard Explanations

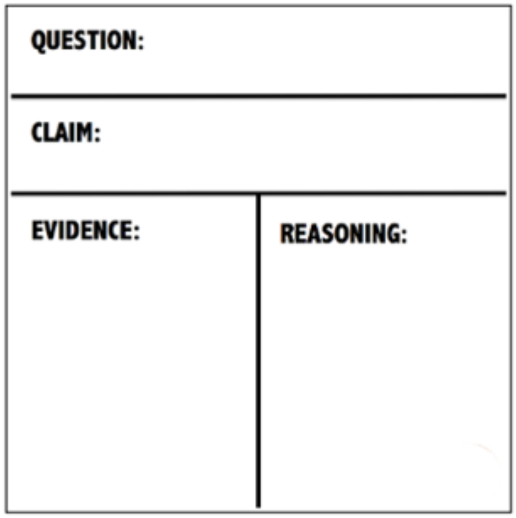
Whiteboard explanations – all groups will create a whiteboard that contains the following format and they will present their whiteboard explanations to the class for review.

Claim, Evidence, Reason (CER) whiteboarding activity. Students are posed with a question they will test, write out their claim (hypothesis), provide evidence (their data), and reasoning.

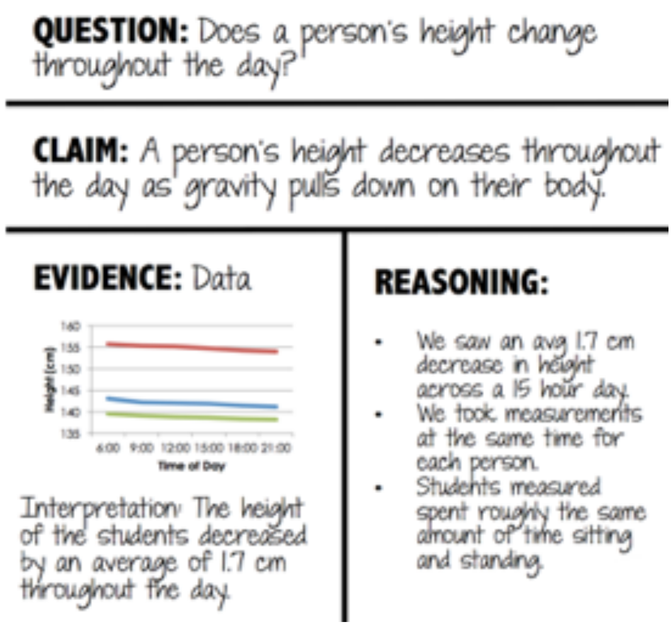
Kansas Corn: DNA, What's it Look Like?

Grade Level: High School

Question for all groups to work through is, "How can you get the DNA out of the cell nucleus and then the cell?"



Example Whiteboard Response:



Science and Agriculture Careers

To learn more about agriculture careers, visit www.agexplorer.com. You can also find career profiles at www.kansascornstem.com.

Kansas Corn: DNA, What's it Look Like?
Grade Level: High School

Sources

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Argument-Driven Inquiry in Biology: Lab Investigations for Grades 9-12
By: Victor Sampson, Patrick Enderle, Leeanne Gleim, Jonathon Grooms, Melanie Hester, Sherry Southerland, and Kristin Wilson , NSTA Press.

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.