

The DNA Obsession

This episode focuses on both the biological and chemical processes central to the transfer of genetic material. The story starts in the middle of the nineteenth century and turns into a mad race in the late 1940s. As in a crime novel, the main characters—scientists in Europe and America—zero in on their prime suspect, the DNA molecule. They are sure that the structure of DNA is the key to understanding the transfer. The rivalries and collaborations among a handful of scientists heat up as they compete to be the first to determine the actual structure of the molecule. In the end, James Watson, a brash young biologist, and Francis Crick, a post-graduate physicist, discover the now famous double-helix structure of the DNA molecule.

Lesson Planner

Day 1: Pre-viewing activity: DNAKWL
View Segment 1
Post-viewing activity: Word Splash!

Day 2: View Segment 2
Post-viewing activity: DNA Extraction Lab (or DNA White-Slimy Lab)

Day 3: View Segments 3 & 4
Home or group work: The Name of the Game

SEGMENT ONE: NUCLEIN = DNA

This segment introduces students to the first vestiges of DNA extraction, thanks to the work of Swiss biochemist Friedrich Miescher (1844–1895). Working in a German laboratory, Miescher was the first scientist documented to have extracted DNA from white blood cells. Miescher called the material he found, rich in nitrogen and phosphorus, “nuclein”; it was, in fact, DNA. Students are also given an introduction to the basic molecular structure of nucleotides.

Keywords

adenine	nucleotide
cytosine	ribonucleic acid (RNA)
deoxyribonucleic acid (DNA)	thymine
guanine	uracil
nuclein	

National Science Education Standards

Content Standard B, Scientific Inquiry

New ideas in science usually grow from the contributions of many investigators.

Content Standard C, The Molecular Basis of Heredity

Mutations, cell differentiation.

Learning Objectives

Students will:


- Identify Swiss biochemist Friedrich Miescher’s contribution to the history of genetics.
- Define Miescher’s gummy substance, which he called “nuclein,” by its proper name, deoxyribonucleic acid.
- Identify the five nitrogenous bases (A, C, G, T, U).


Pre-Viewing Activity

Day One: Distribute to students the KWL: What I Know, What I Want to Know, What I Learned, Where I Learned It activity sheet (SL-1a). Using the handout as their recording page (SL-1b), students will first examine their own knowledge base about

deoxyribonucleic acid, and then will work together as a full class to augment that knowledge. This activity introduces the topic of study by accessing prior knowledge and gaining attention to the topic. The final aspect of this activity has the students themselves offering ideas on how to garner the answers to questions they have about DNA. Teachers may keep the KWL charts to use at a later date as an assessment tool.

Viewing Activity

PLAY  through the first segment of the episode, directly from the musical opening through to the conclusion of the animated session depicting the computer keyboard and monitor showing the nitrogenous bases.

PAUSE  when the molecule is depicted full screen and the words “Acid, Sugar, and Base” are visible—at the point where the narrator says, “. . . with a sugar in the middle, and a phosphorus-containing acid or phosphate on one side, and nitrogen containing base on the other.”

Discussion Point

This is an ideal time to elaborate on the differences between DNA and RNA.

PLAY  until the graphic shows both DNA and RNA.

PAUSE  here for review and to check for student comprehension.

STOP  tape.

Discussion Point

Review the five nitrogenous bases.

Post-Viewing Activities

Word Splash! “Splash” refers to a haphazard arrangement of key words relating to the lesson content. Students scrutinize words posted in a disordered form and then try to make a relationship from all the words. This could be done on paper, on a blackboard, on the wall, or in presentation software such as PowerPoint™.

The Word Splash! Tactic can be employed at any time within a learning experience: beforehand, to determine pre-existing knowledge; during a lesson, to reinforce new or revisited material; or afterward, to assess information retention.

A variety of “report-out” techniques may be employed, such as pair-share, a graphic representation, general class discussion, or, as suggested in this lesson, writing the story. Students will compose a paragraph or two using the list of keywords provided at the beginning of Segment Two, below. Teachers should add keywords that best fit their students’ level of study. The end result of student-written paragraphs represents a tangible assessment of the students’ comprehension. Timing is important in this task; the activity is usually limited to three to four minutes.

SEGMENT TWO: PRIME SUSPECT, DNA

Protein was first considered to be the possible source of heritable (genetic), trait transfer because of its complexity of 20 amino acids, as compared to the simplicity of only the four nitrogenous bases of DNA. But, the various events depicted in this segment brought DNA into the spotlight instead as the important stuff of the gene: Frederick Griffith’s studies of the strains of the bacteria, *pneumococcus*, and a transformation factor; Oswald Avery’s discovery of DNA as that transformation factor; and Joshua Lederberg’s experiments in the ability of bacteria to exchange genetic information as they reproduce. This segment epitomizes the synergism often occurring in scientific endeavor and discovery—scientific exploration does not happen in a vacuum.

Keywords

amino acids
genetic material
inheritance
protein
transformation factor




Learning Objectives

Students will:

- Describe the structure of a protein.
- Identify British physician Frederick Griffith's contribution to the ultimate discovery of DNA.
- Identify Canadian physician Oswald Avery and his colleagues, and their role in the discovery of the substance of inheritance.
- Identify Joshua Lederberg's experimentation with bacteria and their reproductive capabilities as another rung in the ladder to the discovery of the double helix.

Viewing Activity

This first segment portion is devoted to the study of Frederick Griffith in England in 1928. It is interesting to note that physicians, medical doctors rather than research biologists or chemists, made two of the major discoveries discussed in this segment. The two subsequent portions deal with Avery and Lederberg's experiments.

PLAY  tape. At the end of each segment portion describing a physician/scientist and his (and/or his team's) contributions, PAUSE  the tape to check for student comprehension. At the conclusion of the segment portion following Lederberg, PAUSE .

Discussion Point

How does each of these contributing pieces to the double helix puzzle fit with the others?

Post-Viewing Activities

To give students a sense of the excitement felt in the labs of Miescher, Griffith, Avery, and Lederberg, two separate DNA extraction labs are included at the end of this lesson. One is called "DNA Extraction Lab" (SL-2a and 2b), which is designed for teachers in a fully stocked biology laboratory setting. This first lesson, involving one complete class period and part of a second, is a full laboratory experience, providing students with a solid foray into the scientific method. The second, called "DNA—White and Slimy" (SL-3a and 3b), is a 30- to 40-minute activity that easily offers, in any classroom situ-

ation (or even at home), the opportunity for students to extract DNA.

SEGMENT THREE: PHYSICAL SETTING PLUS LIVING ENVIRONMENT

Converging thoroughfares of several different sciences formed the road to the discovery of DNA's double-helix structure. These seemingly unrelated access roads included photography, chemistry, mathematics, and physics as well as biology.

Keywords

Chargaff's rules
diffraction
x-ray crystallography

Learning Objectives

Students will:

- See that scientific endeavor often crosses the boundaries of traditional disciplines.
- Understand and use the discovery of the double helix structure as an example of the fact that scientific findings are built upon the work of others, done earlier.

Viewing Activity

This segment opens with the animated exposition of how the non-living sciences of chemistry and physics contributed to the breakthrough discovery of the shape of DNA. Archival video and photographs mesh with animation to tell the story of the race for the dou-



ble helix. It closes with Moxy Frúvous's musical review of the fundamental material.

It is recommended to view the complete segment once, without pausing. The flow of the time line is essential to student understanding. To reinforce the information gleaned in the initial viewing, utilize the strategy of REWIND and REPLAY. After viewing the entire segment without pausing, view it a second time, this time with pauses.

PLAY ▶ until the animated sequence depicting the DNA molecule in x-ray crystallography appears, and the X shape fills the screen. PAUSE ⏸ the tape here.

Discussion Point

Point out to your students that the visual arts as well as pure science played a role in this discovery. Discuss the importance of patterns and the art form of photography; it becomes apparent that the humanities can play a strong role in science. Challenge students to engage in a discussion of other ways in which the arts or humanities interact, such as the double role of DaVinci as an artist and scientist or the use of computer graphics to investigate forensic evidence.

PLAY ▶ until the end of the animation depicting the nitrogenous base pairs and their shapes; PAUSE ⏸ the tape.

Discussion Point

Take this opportunity to make sure that students fully comprehend the differences between purines (adenine and guanine) and pyrimidines (cytosine, thymine, and uracil).

PLAY ▶ until you hear Witkovski say: "They were the right people in the right place at the right time." PAUSE ⏸.

Discussion Point

This quote offers a tremendous opportunity for teachers to foster discussion of the nature of discovery and scientific endeavor. Ask students how many scientific breakthroughs

they think may have been the result of serendipity.

SEGMENT 4: SPLIT AND COPY

This short segment discusses how James Watson and Francis Crick publicized their discovery; also, how the structure of DNA revealed the "copying mechanism" of genetics, and how large a role obsession, rivalry, and collaboration can play in advancing human knowledge.

Viewing Activity

PLAY ▶ this segment through to the end. This segment is brief and affords no specific pause points within it. The conclusion offers a good opportunity for class discussion. STOP ⏹ tape.

Discussion Point

Can you think of other discoveries or innovations that were made because of a person or group's obsession or rivalry? (Possible answers: The space race between the United States and the Soviet Union; the Bill of Rights made to address the issues between Federalists and states-rights advocates; the Firefox Internet browser made to compete with rival Microsoft Internet Explorer; wireless WiFi Internet connections made to compete with DSL, ISDN, and cable Internet; digital satellite TV made to compete with cable TV.)

Post-Viewing Activity

The Name of the Game. Two supplementary handouts are included at the end of this lesson: a Teacher Lab Packet describing the activity The Name of the Game (TL-4a), and the student handout for the same activity giving clear instructions and a rubric (SL-4a, 4b, and 4c). This activity pulls together all the threads presented in this episode, woven into the tapestry that is the story of the double helix. Refer to the DNA time line and biographies of key scientists found at www.geneticstv.org/dna_obsession/activities.htm. Alternate activities on the Web site are good preparation for students to complete the Name of the Game assignment.

Suggested Reading

The Double Helix: A Personal Account of the Discovery of the Structure of DNA

by James D. Watson (London: Weidenfeld & Nicolson, 1968)

This is Watson's personal account of the race against time, professional rivalries, bureaucratic red tape, and ethics which all played a role in the momentous discovery of the double helix. ISBN: 074321630X

Gregor Mendel and the Roots of Genetics (Oxford Portraits in Science)

by Edward Edelson (New York: Oxford University Press, 2001)

When Gregor Mendel died in 1884, not a single scholar recognized his epochal contributions to biology. Twentieth-century scientists were stunned to learn that their findings about inheritance had already been made by Mendel three decades earlier. In an informed narrative, Edelson provides an inspired account of what a modest man can accomplish with dedication and ingenuity. ISBN: 0195150201 (paper)

Rosalind Franklin: The Dark Lady of DNA

by Brenda Maddox (New York: HarperCollins, 2002)

This is a powerful story of a remarkably single-minded, forthright, and tempestuous young woman who, at the age of 15, decided she was going to be a scientist, but who was airbrushed out of the greatest scientific discovery of the 20th century because she died before the Nobel Prize was awarded. ISBN: 0060184078

National Science Education Standards

<http://nap.edu/readingroom/books/nses/html>

Content Standard B: Scientific Inquiry

There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the

value of evidence, logic, and good arguments. And there is agreement that progress in all fields of science depends on intelligence, hard work, imagination, and even chance.

New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators.

Content Standard C: The Molecular Basis of Heredity

In all organisms the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlines heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a template mechanism). Each DNA molecule in a cell forms a single chromosome.

Links

BBC NEWS: Decoding Humanity

http://news.bbc.co.uk/hi/english/static/in_depth/sci_tech/2000/human_genome/timeline/default.stm

Time line of the race for the Human Genome Project to decode human DNA. (BBCi)

DNA from the Beginning

<http://www.dnaftb.org>

An interactive history of genetic science with biographies, animations, puzzles, and more.

DNA Interactive

<http://www.dnai.org/index.html>

An animated journey through DNA history and science. (Dolan DNA Learning Center at Cold Spring Harbor Laboratory).

Genetic Science Learning Center at the Eccles Institute of Human Genetics

<http://gslc.genetics.utah.edu>

Providing curricula and professional development for teachers, and science enrichment and career programs for students (University of Utah Department of Human Genetics and School of Medicine).

Genetically Engineered Organisms: Public Issues Education Project (GEO-PIE)

<http://www.geo-pie.cornell.edu/gmo.html>

Extensive information on the debate surrounding genetically modified crops and organisms (Cornell Cooperative Extension, Cornell University).

Linus Pauling and the Race for DNA

<http://osulibrary.orst.edu/specialcollections/coll/pauling/dna>

Another perspective on the hunt for the double helix (Special Collections, The Valley Library, Oregon State University).

Nature

<http://www.nature.com/nature/dna50>

The science journal's special feature commemorating the 50th anniversary of the discovery of the DNA structure.

NOVA: Secret of Photo 51

<http://www.pbs.org/wgbh/nova/photo51>

This Web site accompanies the PBS series' episode (first shown in April 2003) depicting Rosalind Franklin's work and its contribution toward the discovery of the shape of the structure of DNA.

Cross-Curricular Activities

Language Arts: Assign student groups to read *The Double Helix* and one of the various published responses to the book. Conduct a debate on the merits of Watson's account of the events leading up to the discovery of the structure of DNA.

Social Studies: Explore the post-WWII era of McCarthyism and Linus Pauling's opposition to atmospheric testing of nuclear weapons. Pauling was refused a visa to travel to the conference where Watson first saw Rosalind Franklin's x-ray images of DNA.

This episode features many scientists who earned Nobel prizes. See the time line at www.geneticstv.net/DNA_Obsession/activities.htm for more details. Expand on the time line provided by adding other world events and other Nobel prize winners contemporary to the DNA scientists listed. Research the origin and process of the Nobel Prize. Consider the role that the Nobel Prize may have on modern society.

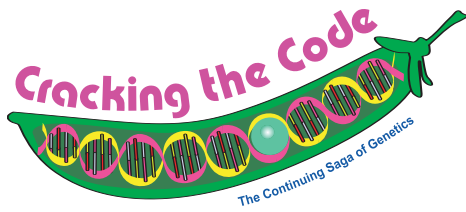
Visual Arts: Explore visual art representations of spirals and helices. Many indigenous cultures use spiral symbols to represent a life force, and the natural beauty and balance of this form still inspires contemporary artists today. Consider Frank Lloyd Wright's Guggenheim Museum, Duchamp's "Nude Descending a Staircase" (No. 2) or Robert Smithson's earthwork sculpture, "Spiral Jetty." Use these works or examples of spirals found in nature (seashells, galaxies) to create an original work of art.

WATSON AND CRICK SONG

Adenine, thymine, cytosine, guanine, oh
Adenine, thymine, cytosine, guanine, oh
Watson and Crick,
Pulled off a very slick trick,
When they unlocked the secret
Of the gene.
The facts they
Knew were quite few,
Just the occasional clue,
Pointing to DNA,
Not protein.
But what was its configuration.
How did it store information,
And allow for
Duplication
With only four nuc-le o-tides
Only four nuc-le o-tides
How they fit together must be where the secret
hides.
Adenine, thymine, cytosine, guanine, oh
Then using new facts,
Learned when an x-ray diffracts,
The pieces started to fall
Into places. (hey)
They began to play,
With models that could display,
A way to form DNA,
By linking bases.
Then they had their inspiration.
Let's give them a big ovation
For proposing



DNA
Was built just like a spiral staircase.
They proposed that
All our genes
Are built just like a spiral staircase,
Built just like a spiral staircase,
Each step made up of a double base.
Adenine, thymine, cytosine, guanine, oh
It's called a double helix,
Watson said to Crick.



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PART I: DNA KWL

(What I **K**now, What I **W**ant to Know, What I **L**earned, Where I Learned It)

The purpose of this KWL is to activate your prior knowledge about deoxyribonucleic acid, DNA. You will first spend about five minutes on your own, writing down anything that comes to mind with the prompt, **DNA**. Think of this as personal brainstorming.

(1) 5-minute think time, writing about what you know

You'll find on SL-1b a page divided into four columns, asking you to list what you already know about DNA, what the class knows, what you should know, and how you can find the answers to the questions you have. In this five-minute opening activity, you will fill in Column I: *"What do I know about DNA?"*

(2) 10-minute, whole-class, chart writing

Functioning as a whole class, you and your classmates will now provide a recorder, or scribe, with your ideas for Column II: *"What does the class know about DNA?"* Give yourselves about 10 minutes to contribute as much known information as possible.

(3) Instructor review and discussion of misconceptions . . . variable time allotment

There may be some misconceptions, but your instructor will discuss these once the list is generated.

(4) 15-minute question generation

Now a 15-minute block of time will be used to generate questions about DNA, providing the material for Column III: *"What do we want to know about DNA?"*

(5) Who, What, Where, When, Why, How?

At this point there should be a class discussion of what steps need to be taken in order to find the answers to the class's questions (the material to fill Column IV: *"How can we find answers to our questions?"*).

Your chart and the class chart should resemble the figure below.

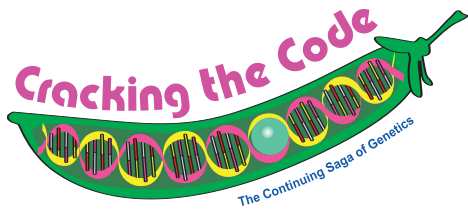
What do I know about DNA?	What does the class know about DNA?	What do we want to know about DNA?	How can we find answers to our questions?

Figure 1.2. A typical KWL chart used as a learning strategy and graphic organizer.

What do I know about DNA?	What does the class know about DNA?	What do we want to know about DNA?	How can we find answers to our questions?

(6) Action Plan

Here is where you and your classmates, as a class led by your instructor, determine “*Where do we go from here?*”



The DNA Obsession

DNA EXTRACTION LAB

For this laboratory experience to be successful, a working biology lab is a prerequisite.

All cells contain DNA. Prokaryotic cells (bacteria) have no nucleus, so their DNA is not bound by a nuclear membrane. DNA is not capable of crossing the nuclear membrane, because it is too big to penetrate the nuclear pores. To free the DNA for observation requires destruction of membranes and, in the case of some organisms, cell walls.

Recall that cell membranes are composed of lipids and proteins, primarily lipids. What will break down or emulsify lipids? Those of you who have washed dishes should easily recall ... right: detergent!

But there is yet another dilemma. Once the DNA is exposed to the cytoplasm, which contains all kinds of enzymes (proteins) capable of chewing up DNA, a second problem must be overcome. These proteins, DNA “shredders,” must be rendered inactive. The tool of choice is called a protease (PRO-tee-aze), a chemical capable of destroying protein enzymes.

Consider Fredrich Miescher’s use of the enzymes in the stomach of a pig. Miescher knew that stomach juices contain chemicals that break down proteins. In this laboratory learning experience, you will not be using pig stomach juices but an easily obtainable substitute for such. In other words, you will use a protein to destroy a protein.

How do bacteria prevent destruction of their DNA? Bacteria have one circular chromosome attached to their cell membranes. The ends of their DNA are not exposed to chemical onslaught, and special chemicals called methyl groups protect the other portions.

As you work through this laboratory experience, please be mindful of safety procedures. Wear goggles and handle all materials and glassware appropriately.

Materials per group (2–3 students)

- 250 mL beaker
- hot plate
- 1.5 grams of non-roasted (raw) wheat germ
- thermometer
- pH paper (range 5–9) or a pH meter
- 5 mL of detergent (Palmolive®) or any other clear variety
- test-tube rack (beaker or some container to hold a test tube at a 45° angle)
- baking soda
- 3 grams of Adolph’s® natural meat tenderizer
- 6 mL ice-cold 95% ethanol

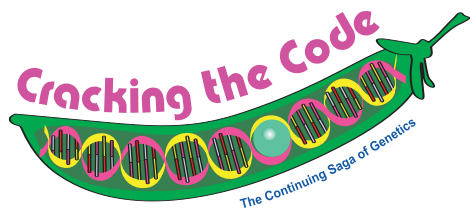
- 2 15-mL (small) test tubes
- glass stirring rod, or wooden skewer, or Pasteur pipette
- 100 mL of distilled or tap H₂O
- graduated cylinders (10 mL and 100 mL)
- 9 mL of a 4% sodium chloride solution
- boiling water bath
- 9 mL diphenylamine solution
- 3 mL DNA standard solution

Protocol

1. Place 100 mL of H₂O in a beaker and heat to 50° to 60° C.
2. Add 1.5 grams of raw wheat germ and stir until dissolved.
3. Add 5 mL of detergent, maintaining the temperature at 50° to 60° C and stir constantly.
4. Add 3 grams of meat tenderizer.
5. Prepare a baking soda solution of 50 mL H₂O and a teaspoon of baking soda in a separate beaker. Use this solution to bring the wheat germ mixture to a pH of ~8.
6. Maintain the temperature at 50° to 60° C, stirring for another 10 minutes.
7. Remove solution from heat and place 6 mL of wheat germ mixture into a test tube.
8. Slowly and carefully pour 6 mL of the ice-cold ethanol down the inner edge of the test tube so it is layered over the wheat germ suspension.
9. Allow the mixture to stand (undisturbed) for approximately five minutes. Observe the interface region for the appearance of DNA strands, and record your observations.
10. Put your initials on and mass a small piece of filter paper. Record the mass. Using an eyedropper or Pasteur pipette, draw up the DNA from the alcohol layering and place on filter paper. Allow this to dry overnight. Reweigh the filter paper the next day. Calculate the DNA extracted per gram of wheat germ and record your calculation.
11. Remove the DNA from the filter paper and place in a test tube, which contains 3 mL of 4% salt solution. Add 3 mL of diphenylamine solution. Label tube.
12. Place 3 mL of the standard DNA solution into another test tube and add 3 mL of diphenylamine solution. Label tube.
13. In a third test tube place 3 mL of 4% salt solution and 3 mL of diphenylamine solution. Label tube.
14. Place all three tubes in a boiling water bath for 5 minutes. Record color changes over the time period. Diphenylamine reacts with deoxyribose (found in DNA) and produces a color in the blue range. It is a positive indicator for DNA presence.

WORKSHEET

Student Name: _____

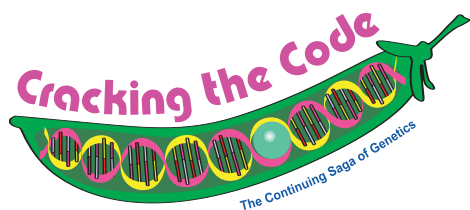


The DNA Obsession

ANALYZING AND INTERPRETING COLLECTED DATA

1. DNA looks like _____.
2. Considering DNA and ethanol plus water, make a statement about the solubility of DNA:
3. Calculate DNA yield from wheat germ:
 - Subtract initial weight of filter paper from final dry weight of filter paper **and**
DNA = _____ grams (this will allow you to know actual weight of DNA)
4. In order to calculate your DNA yield per gram of wheat germ, divide the amount of dry weight obtained from 1.5 grams of wheat germ.
5. **(My yield is: _____/gram of wheat germ)**
6. Why was the wheat-germ solution heated?
7. Of what significance was the stirring for five minutes?
8. Why is it important to use ice-cold ethanol as opposed to ethanol at room temperature?

We wish to thank Anthony "Bud" Bertino, retired biology teacher, and Cornell Institute of Biology Mentors of New York State for the ideas used in this activity. Their inspirations allow for national dispersion.



The DNA Obsession

DNA—WHITE AND SLIMY

When discussing DNA, it is a good idea to have some familiarity with this important molecular stuff. Science is based on questioning and on observations, so let's do a bit of both ...

We will use some kitchen chemistry and a few easily obtainable materials to make observations and reflect on questions.

As you perform the steps in this learning experience, you need to record your observations and thoughts. Try to answer these questions:

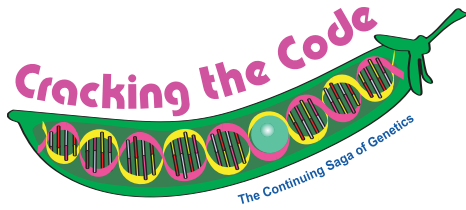
What's in the wheat germ?	
Why use warm or hot water?	
Why use dish detergent?	
Why use meat tenderizer?	
Why do we need ice-cold ethanol?	
Why do we tilt the tube?	
What do the solutions look like?	
What is a supernatant—or, how did it get its name?	
Why did we need to use unroasted wheat germ?	

Materials

- unroasted wheat germ (this can be purchased at a health-food store or co-op)
- dish detergent (clear is best)
- one wooden skewer (these are the wooden sticks used for barbecues)
- one clear plastic cup
- a glass or plastic test tube
- something to measure mL amounts of liquid
- Adolph's® meat tenderizer (this brand works the best)
- a plastic pipette or eye dropper
- teaspoon
- ethanol (an alcohol) works best—you might try the drug-store alcohol used for a disinfectant
- warm (or hot) water
- a stirring implement

Procedure

- Place one to two teaspoons of unroasted wheat germ into a cup.
- Fill the cup $\frac{1}{3}$ full of warm water (or you may try hot water) and stir for 10 minutes.
- Place 3–5 mL of dish detergent into the cup and stir for five minutes.
- Add 1 tsp of meat tenderizer and stir for five minutes.
- Let the slurry settle.
- Pour the supernatant into a test tube (about $\frac{1}{3}$ full).
- Tip the tube at a 45° angle and slowly pour about 1 to $1\frac{1}{2}$ inches (remembering that 2.54 cm = 1 inch) of ice-cold ethanol down the side of the tube.
- Keep the test tube at an angle for about five minutes and make careful observations.
- Use the wooden skewer and attempt to wind the DNA.



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THE NAME OF THE GAME

Student Notes

As many of you who are video gamers know, even the most elaborate computer-graphics laden video game begins on paper. It all starts with an idea. In video games, board games, even word games, that idea simply moves along a path to an elevated outcome.

Your task in this activity is to take the facts of the time line associated with the historical elements leading up to Watson and Crick's discovery of the master molecule, which we know as *deoxyribonucleic acid* (DNA) and turn them into a game . . . a board game, just like Monopoly®, Pictionary®, Scruples®, Scattergories®, or any of the board games you've played. The key is that your game must have a path, start to finish, that is a representation of the history leading to Watson and Crick's discovery of the Double Helix in April 1953, and of DNA as the material responsible for transmitting genetic data in reproduction.

Parameters

The following are the only specified parameters.

- The end product must be a board game—defined as a game played on a board with tokens of some kind serving as representation of the player moving from start to finish.
- The game rules must reflect a minimum of two and maximum of six players.
- The pathway of the board layout must represent an accurate time line identifying the markers in history in the pathway to discovery of DNA as the entity responsible for carrying inherited genetic material.

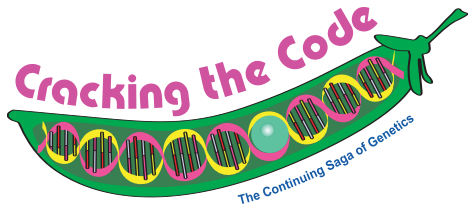
Suggestions/Tips

1. **Use your imagination.** Dice, or any other method to propel tokens on the board, may be used. For example, advancement or losing ground from one space on the board to the next could be determined by correct or incorrect answers of questions pre-printed on drawn cards.
 - One scenario: Someone who correctly answers to Joshua Lederberg's work was built on the discoveries of _____ (answer: Griffith and Avery), might move ahead five spots on the board. As a negative, one might draw a card that says, "Rosalind Franklin died of radiation in 1958, nearly five years after Watson and Crick's discovery of the double helix. Exposure to radiation occurred in her work in X-ray crystallography. Move your piece back to Miescher's German castle lab."
 - Another scenario: "Use the techniques of the game of Charades to get fellow contestants to guess the following: 'Double Helix'." Without saying a word, the player would have to use body movement to represent Double Helix.

2. **Presentation of your game counts.** It has to LOOK like it is fun to play. This involves wise use of color, graphics, and artistic design. Perhaps your board is three-dimensional, or physical movement is part of the game.
3. **Get it right.** Make sure your data is correct.
4. **Get it balanced.** A game with too much information in one area, while neglecting another, is not going to score well. For instance, providing too much data on Watson and Crick and not enough about the contributions of Friedrich Miescher is not a proper balance. The historical reality of correlation in research throughout history is not remarkable to the history of genetics; it represents history and science overall. Make use of these connections in your game. One example might be to have a “bridge” on the board: If a player lands on one specific spot—perhaps a spot depicting Miescher’s German laboratory where the discovery of nuclein occurred—he can cut short a long path of the game by jumping directly to a spot further along on the path/time line (such as the English lab of Griffith and his discovery of the transformation factor within the pneumococcus bacteria).
5. **Have fun!**

"The Name of the Game" Rubric

	Excellent	Very Good	Good	Fair	Poor	Failure
Content						
<i>Accuracy of Material</i>	5	4	3	2	1	0
<i>Depth of Individual Information</i>	5	4	3	2	1	0
<i>Depth of Overall Time line</i>	5	4	3	2	1	0
<i>Game Awards and Penalties reflect synergisms (real-life associations) in history of genetics</i>	5	4	3	2	1	0
<i>Grammatically/ Structurally Error Free</i>	5	4	3	2	1	0
Creativity						
<i>Game Design</i>	5	4	3	2	1	0
<i>Presentation</i>	5	4	3	2	1	0
<i>Attention to Detail</i>	5	4	3	2	1	0
<i>Marriage of Fact and Design</i>	5	4	3	2	1	0
<i>Meeting Specified Parameters</i>	5	4	3	2	1	0
Best Possible Scores in each Category	50	40	30	20	10	0
Corresponding Letter Grade	A+ (50-45)	A (44-42) A- (41-39) B+ (38-36)	B (35-32) B- (31-29) C+ (28-27)	C (26-24) C- (23-20) D+ (19-17)	D (16-15) D- (14-10)	F (9-0)



The DNA Obsession

THE NAME OF THE GAME

Teacher Notes

One of the best ways for students to display their interest and passion for a subject is to show how they can “play” with it. And games are one way to accomplish this.

The purpose of this activity is to have students demonstrate their level of capability in addressing the following techniques.

- Recognition of major historical milestones on the path to discovery. In this instance, the culminating event is Watson and Crick’s 1953 paper describing the DNA molecule.
- Research techniques in determining the importance of events and/or people’s contributions to discovery.
- Idea development and presentation of facts which meet multiple learning styles and interests.
- Making connections between scientific events and their placement in history.

Educators have used games to encourage learning in pre-school and elementary school-age children for generations. However, this rationale should be universal for students of all ages. The likelihood of a student remembering a fact that has been presented in a colorful, enjoyable, and dramatic way is far greater than if that same knowledge is presented only as a read, spoken, or heard fact. (“Cone of Experience,” Edgar Dale, *Audio-Visual Methods of Technology*, 1949, International Thomson Publishing, 3rd Edition, January 1969, ASIN: 0030890063) The percentage of retention of material is also greater for students garnering the data by using as many small- and large-motor skills as possible at the time. (WNET/Thirteen, National Teacher Training Institute, binder materials 1996, 1997) For this reason, teachers should encourage students to come up with hazards and/or rewards in their games that involve such tools as pantomime or some other physical activity.

Having your students use a game-creation format as the vehicle for demonstrating their mastery of DNA’s history is a great way for them to construct their own learning. Give students a free hand, and their creativity will soar. Offering all students this opportunity also provides a pathway to recognized excellence for those students who have trouble with science but perhaps are artistically oriented. It is one more tool in your arsenal of teaching mechanisms—and it’s fun!

If time permits, allow your students both to review the historical materials and to perform peer review of the assorted games (the project can be an individual one or a group endeavor). The material will then be reinforced in a memorable way for all students, resulting in a rewarding learning experience.