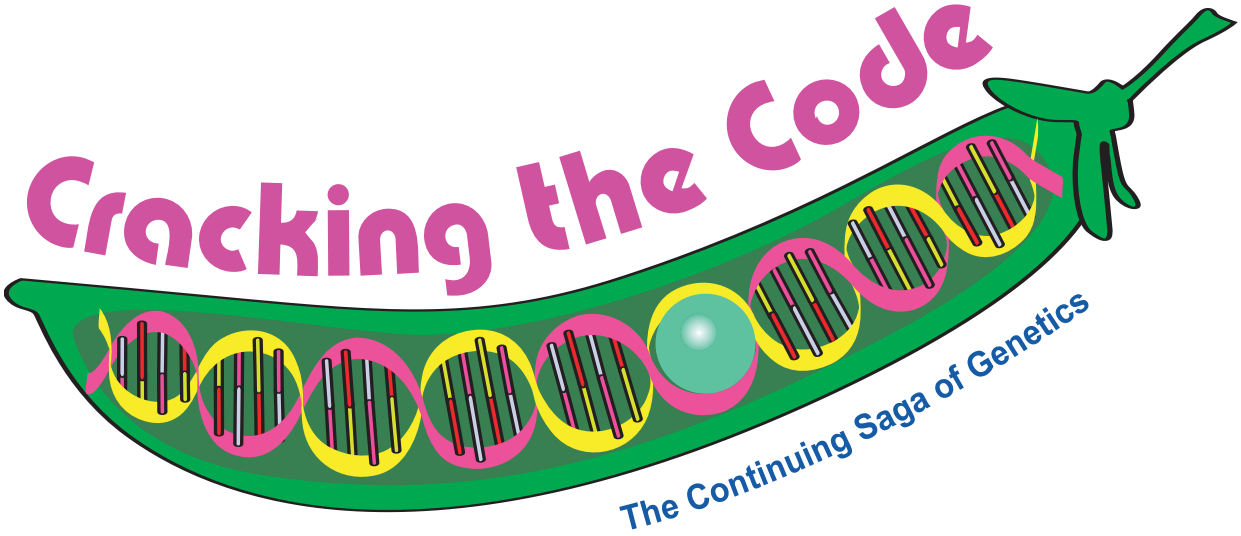

TEACHER'S GUIDE

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www.geneticstv.org

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TABLE OF CONTENTS

INTRODUCTION

Cracking the Code: The Continuing Saga of Genetics will inform young people of the remarkable history of genetic science, a history that is still in dynamic formation today. This series illustrates the dramatic stories of scientists who have contributed to our understanding of how genetic information is transferred from one generation to the next. The science of each discovery is carefully explained and illustrated. The video programs are arranged chronologically.

In this teacher's guide, you will find specific and detailed lesson plans for using these videos complete with pre-viewing activities, pause points in the video, discussion questions, classroom activities, labs, homework assignments, and assessments. Each lesson plan is geared to the National Science Education Standards (http://nap.edu/readingroom/books/nses/html) published by the National Academies Press, 1996). Online, at www.geneticstv.org, teachers may find correlations to their state standards.

USING VIDEO TO TEACH

In order to ensure that the use of video in the classroom is a true educational experience, it is necessary to strategically create an atmosphere of learning every time video is used. Students must learn viewing habits that are different than those they are used to at home—promoting active rather than passive viewing, centering full attention on the program, and participating in comprehension strategies that encourage thoughtful analysis of the content. Students should be engaged in predicting outcomes, drawing conclusions, and making inferences while viewing instructional video.

Proven methodologies* for using video to teach

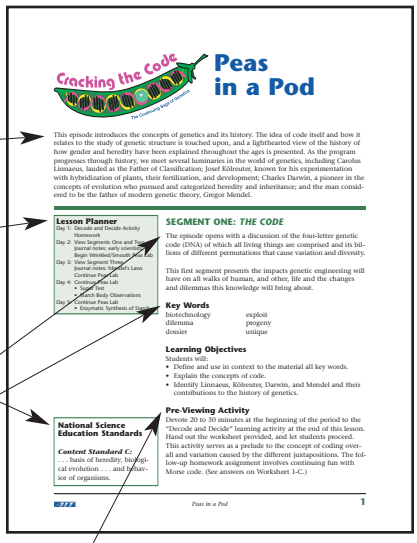
- Leave the lights on during viewing so that students remain alert.
- Explain why you are using the video by listing your learning objectives so that students begin their viewing with expectations of learning.
- Provide a specific focus or task for viewing that directs students to actively engage while watching the video; review the task to affirm that students were alert.
- Stand at the front of the class with a remote in hand so that the video can be paused if students seem puzzled or begin to lose interest.
- Pause to check for comprehension, to get students to predict what will happen next, or to ask them to expand upon information presented; pause at least once every 5–10 minutes; suggested pause points are provided in each lesson found in this guide.
- Rewind and review sections that are particularly difficult or content-dense.
- Freeze images on the screen to point out detail, or to expand on the content.
- Turn off the audio to get learners to focus on the visual content, to allow learners to recount information in their own words, or for the teacher to provide different narration.
- Always start viewing with a pre-viewing activity such as those suggested in this guide.
- Always conclude the lesson with a hands-on post-viewing activity such as a lab, research activity, or discussion; several suggestions can be found in this guide.
- Include the content found in the video in unit assessments; suggestions for project-based (authentic) assessments are provided in this guide.

*National Teacher Training Institute methodologies developed by Thirteen, WNET, New York, NY

HOW TO USE THIS CRACKING THE CODE TEACHER'S GUIDE

There is one unit in this guide for each video. Each unit is comprised of several parts:

- Synopsis of the episode: brief overview of the content
- Lesson planner: helps teacher with class organization and planning
- Brief reference to the National Science Education Standards addressed in this unit
- Segments: suggested sections of video which cover a specific idea or concept. For each section:
  - Brief synopsis of the segment
  - Key words
  - Pre-viewing activity and viewing activities with PLAY ▶ PAUSE ⏸ STOP ■ and REWIND ◀ along with suggestions for discussion, comprehension checks, or review
- Post-viewing activities
- References (if applicable)
- Complete list of National Science Education Standards published by the National Academies Press that are addressed in this unit
- Links to Web sites of interest
- Cross-curricular activities: ideas for combining this unit with other subjects


Cracking the Code

Peas in a Pod

This episode introduces the concepts of genetics and its history. The idea of code itself and how it relates to the study of genetic structure is touched upon, and a lighthearted view of the history of how gender and heredity have been explained throughout the ages is presented. As the program progresses through history, we meet several luminaries in the world of genetics, including Carolus Linnaeus, lauded as the Father of Classification; Josef Kölreuter, known for his experimentation with hybridization of plants, their fertilization, and development; Charles Darwin, a pioneer in the concepts of evolution who pursued and categorized heredity and inheritance; and the man considered to be the father of modern genetic theory, Gregor Mendel.

Lesson Planner

Day 1: Decode and Decide Activity
Homework

Day 2: View Segments One and Two
Journal notes: early scientists
Begin Wrinkled/Smooth Pea Lab

Day 3: View Segment Three
Journal notes: Mendel's Laws
Continue Pea Lab

Day 4: Continue Pea Lab
• Super Test
• Attach Body Observations

Day 5: Continue Peas Lab
• Enzymatic Synthesis of

National Science Education Standards

Content Standard C:
. . . basis of heredity, biological evolution . . . and behavior of organisms.

SEGMENT ONE: *THE CODE*

The episode opens with a discussion of the four-letter genetic code (DNA) of which all living things are comprised and its billions of different permutations that cause variation and diversity.

This first segment presents the impacts genetic engineering will have on all walks of human, and other, life and the changes and dilemmas this knowledge will bring about.

Key Words

biotechnology
dilemma
dossier
exploit
progeny
unique

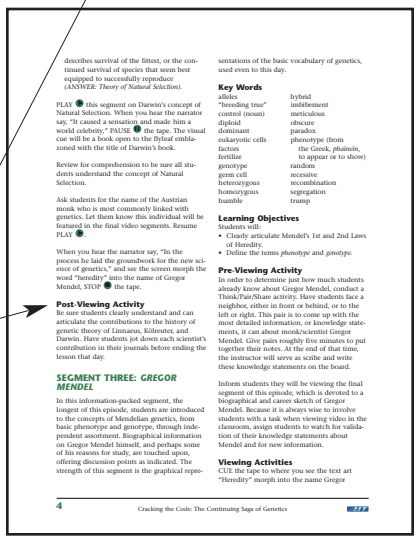
Learning Objectives

Students will:
- Define and use in context to the material all key words.
- Explain the concepts of code.
- Identify Linnaeus, Kölreuter, Darwin, and Mendel and their contributions to the history of genetics.

Pre-Viewing Activity

Devote 20 to 30 minutes at the beginning of the period to the "Decode and Decide" learning activity at the end of this lesson. Hand out the worksheet provided, and let students proceed. This activity serves as a prelude to the concept of coding overall and variation caused by the different juxtapositions. The follow-up homework assignment involves continuing fun with Morse code. (See answers on Worksheet 1-C.)

Peas in a Pod 1


describes survival of the fittest, or the continued survival of species that seem best equipped to successfully reproduce *(ANSWER: Theory of Natural Selection).*

PLAY ▶ this segment on Darwin's concept of Natural Selection. When you hear the narrator say, "It caused a sensation and made him a world celebrity," PAUSE ⏸ the tape. The visual cue will be a book open to the flyleaf emblazoned with the title of Darwin's book.

Review for comprehension to be sure all students understand the concept of Natural Selection.

Ask students for the name of the Austrian monk who is most commonly linked with genetics. Let them know this individual will be featured in the final video segments. Resume PLAY ▶.

When you hear the narrator say, "In the process he laid the groundwork for the new science of genetics," and see the screen morph the word "heredity" into the name of Gregor Mendel, STOP ■ the tape.

Post-Viewing Activity

Be sure students clearly understand and can articulate the contributions to the history of genetic theory of Linnaeus, Kölreuter, and Darwin. Have students jot down each scientist's contribution in their journals before ending the lesson that day.

SEGMENT THREE: *GREGOR MENDEL*

In this information-packed segment, the longest of this episode, students are introduced to the concepts of Mendelian genetics, from basic phenotype and genotype, through independent assortment. Biographical information on Gregor Mendel himself, and perhaps some of his reasons for study, are touched upon, offering discussion points as indicated. The strength of this segment is the graphical representations of the basic vocabulary of genetics, used even to this day.

Key Words

alleles
"breeding true"
control (noun)
diploid
dominant
eukaryotic cells
factors
fertilize
genotype
germ cell
heterozygous
homozygous
humble
hybrid
imbibement
meticulous
obscure
paradox
phenotype (from the Greek, *phainein*, to appear or to show)
random
recessive
recombination
segregation
trump

Learning Objectives

Students will:
- Clearly articulate Mendel's 1st and 2nd Laws of Heredity.
- Define the terms *phenotype* and *genotype*.

Pre-Viewing Activity

In order to determine just how much students already know about Gregor Mendel, conduct a Think/Pair/Share activity. Have students face a neighbor, either in front or behind, or to the left or right. This pair is to come up with the most detailed information, or knowledge statements, it can about monk/scientist Gregor Mendel. Give pairs roughly five minutes to put together their notes. At the end of that time, the instructor will serve as scribe and write these knowledge statements on the board.

Inform students they will be viewing the final segment of this episode, which is devoted to a biographical and career sketch of Gregor Mendel. Because it is always wise to involve students with a task when viewing video in the classroom, assign students to watch for validation of their knowledge statements about Mendel and for new information.

Viewing Activities

CUE the tape to where you see the text art "Heredity" morph into the name Gregor

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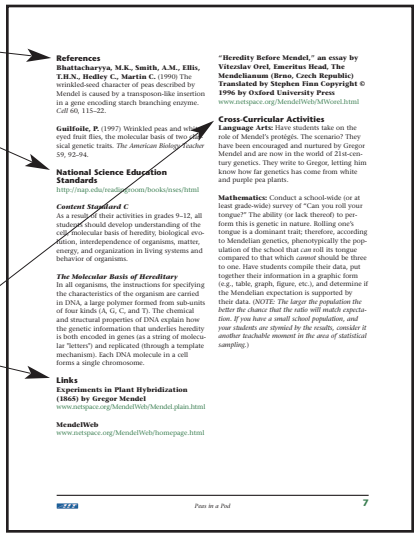

References

Bhattacharyya, M.K., Smith, A.M., Ellis, T.H.N., Hedley C., Martin C. (1990) The wrinkled-seed character of peas described by Mendel is caused by a transposon-like insertion in a gene encoding starch branching enzyme. *Cell* 60, 115-22.

Guilfoile, P. (1997) Wrinkled peas and wingless fruit flies, the molecular basis of two classical genetic traits. *The American Biology Teacher* 59, 92-94.

National Science Education Standards

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

Content Standard C

As a result of their activities in grades 9–12, all students should develop understanding of the cellular and molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems and behavior of organisms.

The Molecular Basis of Hereditary

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

Links

Experiments in Plant Hybridization (1865) by Gregor Mendel
www.netspace.org/MendelWeb/Mendel.plain.html

MendelWeb
www.netspace.org/MendelWeb/homepage.html

"Heredity Before Mendel," an essay by Viteslav Orel, Emeritus Head, The Mendelianum (Brno, Czech Republic) Translated by Stephen Finn Copyright © 1996 by Oxford University Press
www.netspace.org/MendelWeb/MWorel.html

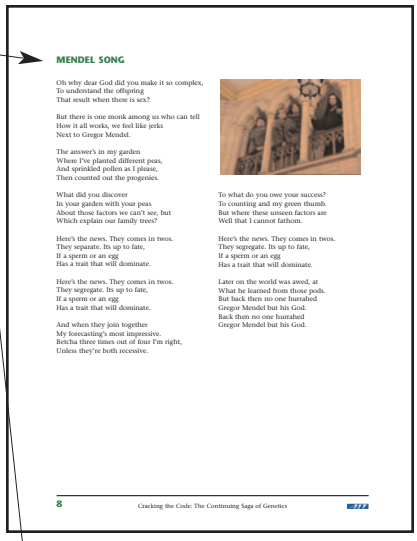
Cross-Curricular Activities

Language Arts: Have students take on the role of Mendel's protégés. The scenario? They have been encouraged and nurtured by Gregor Mendel and are now in the world of 21st-century genetics. They write to Gregor, letting him know how far genetics has come from white and purple pea plants.

Mathematics: Conduct a school-wide (or at least grade-wide) survey of "Can you roll your tongue?" The ability (or lack thereof) to perform this is genetic in nature. Rolling one's tongue is a dominant trait; therefore, according to Mendelian genetics, phenotypically the population of the school that *can* roll its tongue compared to that which *cannot* should be three to one. Have students compile their data, put together their information in a graphic form (e.g., table, graph, figure, etc.), and determine if the Mendelian expectation is supported by their data. (*NOTE: The larger the population the better the chance that the ratio will match expectation. If you have a small school population, and your students are stymied by the results, consider it another teachable moment in the area of statistical sampling.*)

Peas in a Pod 7

- Lyrics for the song(s) found in the episode
- Worksheets or handout materials to be copied and distributed to students
- Lab packets and instructions to teachers for completing labs
- Rubrics for assessment of authentic learning activities



MENDEL SONG

Oh why dear God did you make it so complex,
To understand the offspring
That result when there is sex?

But there is one monk among us who can tell
How it all works, we feel like jerks
Next to Gregor Mendel.

The answer's in my garden
Whore I've planted different peas,
And sprinkled pollen as I please,
Then counted out the progenies.

What did you discover
In your garden with your peas
About those factors we can't see, but
Which explain our family trees?

Here's the news. They comes in twos.
They separate. Its up to fate,
If a sperm or an egg
Has a trait that will dominate.

Here's the news. They comes in twos.
They segregate. Its up to fate,
If a sperm or an egg
Has a trait that will dominate.

And when they join together
My forecasting's most impressive.
Betcha three times out of four I'm right,
Unless they're both recessive.

To what do you owe your success?
To counting and my green thumb.
But where these unseen factors are
Well that I cannot fathom.

Here's the news. They comes in twos.
They segregate. Its up to fate,
If a sperm or an egg
Has a trait that will dominate.

Later on the world was awed, at
What he learned from those pods.
But back then no one hurrahed
Gregor Mendel but his God.
Back then no one hurrahed
Gregor Mendel but his God.

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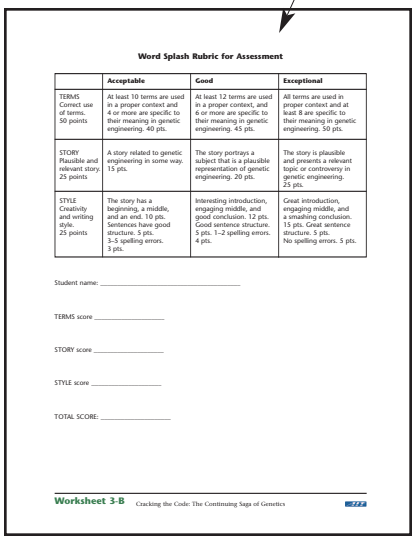


Word Splash Rubric for Assessment

	Acceptable	Good	Exceptional
TERMS Correct use of terms. 50 points	At least 10 terms are used in a proper context and 4 or more are specific to their meaning in genetic engineering. 40 pts.	At least 12 terms are used in a proper context, and 6 or more are specific to their meaning in genetic engineering. 45 pts.	All terms are used in proper context and at least 8 are specific to their meaning in genetic engineering. 50 pts.
STORY Plausible and relevant story. 25 points	A story related to genetic engineering in some way. 15 pts.	The story portrays a subject that is a plausible representation of genetic engineering. 20 pts.	The story is plausible and presents a relevant topic or controversy in genetic engineering. 25 pts.
STYLE Creativity and writing style. 25 points	The story has a beginning, a middle, and an end. 10 pts. Sentences have good structure. 5 pts. 3–5 spelling errors. 3 pts.	Interesting introduction, engaging middle, and good conclusion. 12 pts. Good sentence structure. 5 pts. 1–2 spelling errors. 4 pts.	Great introduction, engaging middle, and a smashing conclusion. 15 pts. Great sentence structure. 5 pts. No spelling errors. 5 pts.

Student name: _____

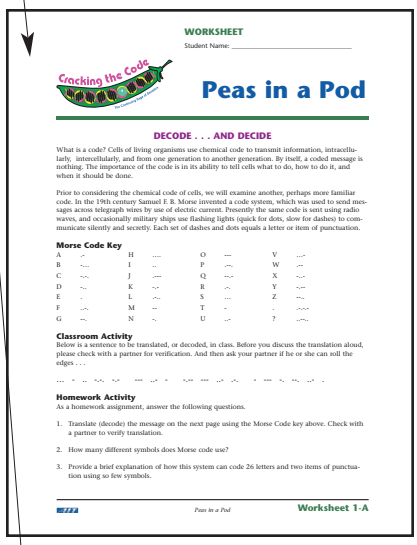
TERMS score _____

STORY score _____

STYLE score _____

TOTAL SCORE: _____

Worksheet 3-B Cracking the Code: The Continuing Saga of Genetics



WORKSHEET

Student Name: _____

Cracking the Code

Peas in a Pod

DECODE . . . AND DECIDE

What is a code? Cells of living organisms use chemical code to transmit information, intracellularly, intercellularly, and from one generation to another generation. By itself, a coded message is nothing. The importance of the code is in its ability to tell cells what to do, how to do it, and when it should be done.

Prior to considering the chemical code of cells, we will examine another, perhaps more familiar code. In the 19th century Samuel F. B. Morse invented a code system, which was used to send messages across telegraph wires by use of electric current. Presently the same code is sent using radio waves, and occasionally military ships use flashing lights (quick for dots, slow for dashes) to communicate silently and secretly. Each set of dashes and dots equals a letter or item of punctuation.

Morse Code Key

A	.-	H	....	O	---	V	...-
B	-...	I	..	P	.--.	W	.--
C	-.-.	J	.---	Q	--.-	X	-..-
D	-..	K	-.-	R	.-.	Y	-.--
E	.	L	.-..	S	...	Z	--..
F	..-.	M	--	T	-	.	.-.-.-
G	--.	N	-.	U	..-	?	..--..

Classroom Activity

Below is a sentence to be translated, or decoded, in class. Before you discuss the translation aloud, please check with a partner for verification. And then ask your partner if he or she can roll the edges . . .

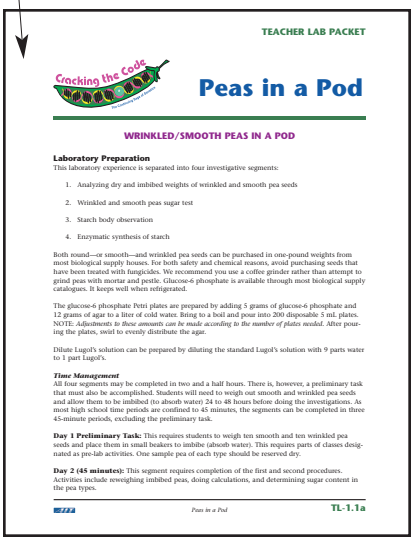
... . .. -.-. .-.- --- ..- . -.-- --- ..- .-. . --- -. --. ..- . .

Homework Activity

As a homework assignment, answer the following questions.

1. Translate (decode) the message on the next page using the Morse Code key above. Check with a partner to verify translation.
2. How many different symbols does Morse code use?
3. Provide a brief explanation of how this system can code 26 letters and two items of punctuation using so few symbols.

Peas in a Pod Worksheet 1-A



TEACHER LAB PACKET

Cracking the Code

Peas in a Pod

WRINKLED/SMOOTH PEAS IN A POD

Laboratory Preparation

This laboratory experience is separated into four investigative segments:

1. Analyzing dry and imbibed weights of wrinkled and smooth pea seeds
2. Wrinkled and smooth peas sugar test
3. Starch body observation
4. Enzymatic synthesis of starch

Both round—or smooth—and wrinkled pea seeds can be purchased in one-pound weights from most biological supply houses. For both safety and chemical reasons, avoid purchasing seeds that have been treated with fungicides. We recommend you use a coffee grinder rather than attempt to grind peas with mortar and pestle. Glucose-6 phosphate is available through most biological supply catalogues. It keeps well when refrigerated.

The glucose-6 phosphate Petri plates are prepared by adding 5 grams of glucose-6 phosphate and 12 grams of agar to a liter of cold water. Bring to a boil and pour into 200 disposable 5 mL plates. NOTE: *Adjustments to these amounts can be made according to the number of plates needed.* After pouring the plates, swirl to evenly distribute the agar.

Dilute Lugol's solution can be prepared by diluting the standard Lugol's solution with 9 parts water to 1 part Lugol's.

Time Management

All four segments may be completed in two and a half hours. There is, however, a preliminary task that must also be accomplished. Students will need to weigh out smooth and wrinkled pea seeds and allow them to be imbibed (to absorb water) 24 to 48 hours before doing the investigations. As most high school time periods are confined to 45 minutes, the segments can be completed in three 45-minute periods, excluding the preliminary task.

Day 1 Preliminary Task: This requires students to weigh ten smooth and ten wrinkled pea seeds and place them in small beakers to imbibe (absorb water). This requires parts of classes designated as pre-lab activities. One sample pea of each type should be reserved dry.

Day 2 (45 minutes): This segment requires completion of the first and second procedures. Activities include reweighing imbibed peas, doing calculations, and determining sugar content in the pea types.

Peas in a Pod TL-1.1a

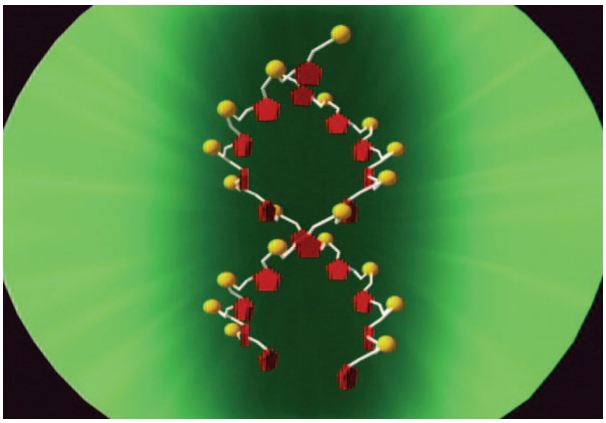
Use this guide to plan your lesson, with the lesson planner as a reference. Select key words for review. Note pause points and discussion questions that you want to use. Gather materials and copy handouts/worksheets as necessary.

HOW TO USE THE CRACKING THE CODE VIDEOS

The Cracking the Code videos are specifically designed to provide a context for the study of genetics in the biology classroom. The context is the history of scientific discovery and the drama that accompanies the enterprise of science. Each episode uses interviews with living scientists and narration over video in a documentary style to give a sense of the places and people involved in this story. But the videos also use three other techniques to illustrate concepts and events:

1. Carefully crafted music videos that reiterate and emphasize key concepts

2. Humorous animation depicting historic scientific endeavor



3. Colorful and detailed 3-D animation to illustrate the scientific concepts presented

Instructional Tactics

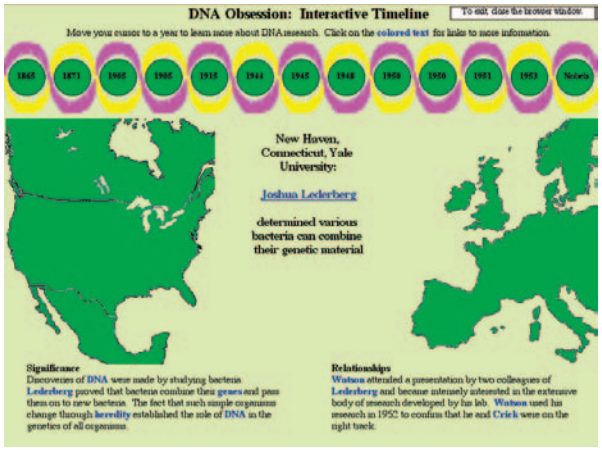
Each video supports several days of classroom learning activities. It is not recommended to view an entire video in a single class. The videos contain too much information to be fully comprehended if watched all in one sitting.

You may elect to view only part of a video in class and leave viewing of the complete video as an assigned task. If so, it is recommended that learners be encouraged to view the video in groups and be assigned specific questions to discuss and report.

You may elect to view only certain videos within the series. The material presented in this series is arranged chronologically, but it is not necessary to view all the videos. The first three programs, because they recount the unfolding history of genetics in the order of the scientific events that defined the science, should be viewed in order, however.

Make the lyrics of the songs available to students to follow along when they view the videos. This introduction of the content in a different media format will assist the learner in grasping concepts and understanding new vocabulary terms.

Use the interactive time line found on www.geneticstv.org to emphasize the context of genetics history. The time line displays not only when scientific events related to genetics occurred but also where they occurred. Relate the events portrayed in the videos to other historic events of the same period.



Always include content from the video in student assessment activities and make it clear to students that they will be held responsible for learning this information.

INSTRUCTIONAL STRATEGIES SUGGESTED IN THIS GUIDE

This guide emphasizes small group activities, quick student observations, authentic and continuous assessments, lab work that explores the concepts from the videos in a new way, and contextualized homework activities.

Student Journal

Suggestions are included for journal assignments in each unit. Journal work encourages reflection, which is important not only for comprehension and retention, but also for transfer of knowledge to novel situations. Students often need specific, detailed assignments with deadlines for effective use of the journal as an instructional tactic. Be sure the journal assignment is clear and offer to start the process by brainstorming in class or discussing the journal assignment in groups.

Reviewing student journals is a good way for instructors to gauge the effectiveness of their teaching and to inform course adjustments. Frequent feedback also helps students to develop their own learning style.

Small Group Work

Cooperative learning groups are recommended for discussion questions. A specific methodology for selecting and assigning groups is left up to the preference of the instructor. Alternating between whole class discussions and group work will provide a change of pace and promote the broadest level of engagement for students.

Think-Pair-Share and Think-Pair-Share-Square

An effective and widely used structure for facilitating cooperative communication and learning is "Think-Pair-Share-Square" (Kagan, 1989). "Think-Pair-Share" requires each student to think about and respond to a question, discuss answers with a partner, then share their own or their partner's answer with the whole class or another group. There are many variations in this structure that may include writing and reading a partner's answer(s), or combining answers collaboratively into one. In the "Think-Pair-Share-Square" each set of students is matched with another pair to form a square of four students. The square shares their answers to come up with the best response. The discussion may end with the square or each square may report their final answer to the whole class.

These communication structures are effective anytime in class discussions but are particularly useful to introduce a lesson or to recap and relate information learned in a new context at the conclusion of a lesson. Kagan suggests use of these structures/strategies for developing thinking skills, promoting communication skills, and encouraging information sharing.

Reference

Cooperative Learning Resources for Teachers by Spencer Kagan (Capistrano, CA: Resources for Teachers, 1989)

Concept Maps

A concept map is a visual representation of a topic, an idea, or a system. Concepts maps are useful to record discussions or to recount particularly complicated information. To create a map, set the topic, idea, or system name(s) on a large page of paper or on the board, and write words or draw pictures around it, making connecting lines between items that relate. You may use different colors or types of lines (dash, wavy) to indicate different relationships. Once learners are familiar with the process, encourage them to use concept maps while viewing video to make notes or to record their own reactions to the information being presented.

Using Analogies

"An analogy is a comparison of two things that are similar in some ways, but otherwise not alike" (Hackney and Wandersee, 2002). When learners select an analog (something with which they are familiar) and relate it to a target (something with which they are not familiar) they promote their own learning. Each learner comes to a learning experience with a distinct set of life experiences and knowledge. It is this personal context of the learner that is activated in a meaningful way when using analogies.

Some advantages of using analogies are (Boo and Toh, 1997):

- They are valuable tools in conceptual change learning.
- They provide visualization and understanding of the abstract by pointing to similarities in the real world.
- They may incite pupils' interest and hence have a motivational effect.
- They force the instructor to take into consideration pupils' prior knowledge and may reveal misconceptions in previously taught topics.

A useful form of analogy is allegory: a form of writing in which the student becomes the object, concept, or topic being discussed and tells the reader about the experience (DuPré, 1987). For example, students compose a friendly letter describing their job and co-workers as they represent one of the raw materials used in photosynthesis.

Analogies can be presented in a variety of ways: posters, collages, brochures, T-shirt designs, music, lyrics, movement, or dramatics. Use a concept map to assist learners in developing strong and creative analogies. Work in cooperative groups so that learners can access the ideas and feedback of their peers. Whatever the mode, analogies can be a useful strategy in the teaching/learning experience.

References

The Power of Analogy
by M. Hackney and J. Wandersee (Virginia: National Association of Biology Teachers, 3, 2002)

Use of Analogy in Teaching the Particulate Theory of Matter
by H.K. Boo and K.A. Toh (Teaching and Learning, 17(2), pp. 79–85: Teaching & Learning, 1997)

Tired of Reading the Same Homework Assignments Over and Over Again This Year?
by M. DuPré (Rush-Henrietta School District 1–24, 1987)

Extending Science into the Home

Genetics is a science that is particularly influenced by society. Therefore, it is important for students to have a social context for considering the issues and information presented in these lessons. Homework activities encourage the learner to explore these concepts within the context of their own community and family values.

Teachers are encouraged to allow students to take videos home to view with their families and to assign students to complete activities found at www.geneticstv.org at home.

Lab Work

The labs in this guide have been tested in high school classrooms by the authors and found to

be useful and illuminating activities. Lab packets are provided for students and teachers. Suggested materials and sources are also listed at www.geneticstv.org.

On the Cracking the Code Web site you will find:

- State-by-state curriculum correlations for each video
- Worksheets and lyrics for the songs in the videos
- A PDF version of this guide
- Interactive student activities that reinforce concepts presented in the videos
- Information about the creators of these materials
- Information on how to order DVDs or videos
- A place to provide feedback to the creators of these materials