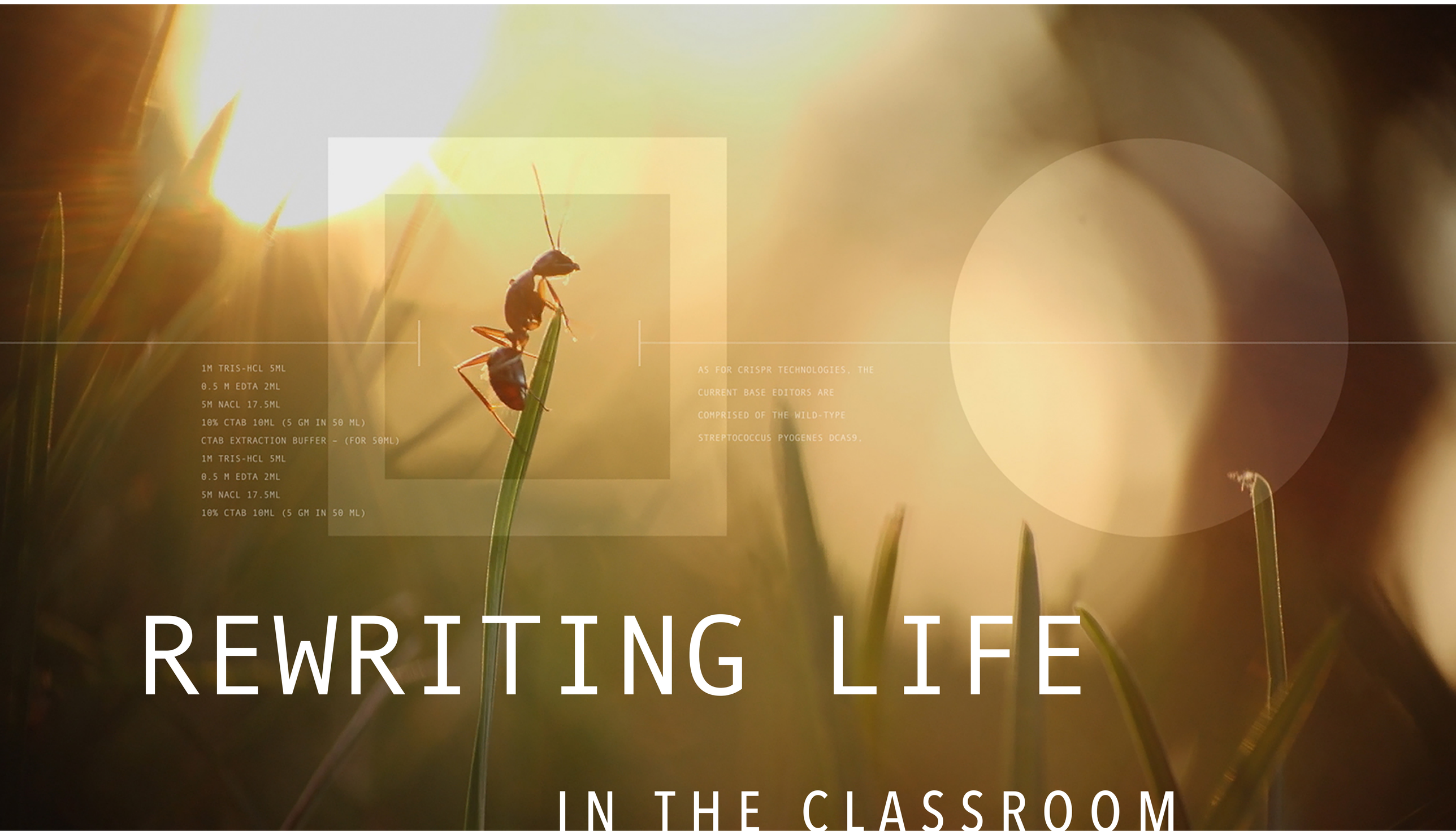
SHORT FILMS ABOUT CHEMISTRY



CLASSROOM LESSON PLAN

REWRITING LIFE

CLASSROOM LESSON

Lesson Preparation

- Prepare a monitor, internet access to the short film REWRITING LIFE.
- Prepare copies of *Student Handouts* for distribution.
- Gather approximately 20 post-it pads and markers or pens (enough for 1 per pair of students in the class).
- Using the template provided, copy onto card stock and cut out enough sets of DNA molecules, assembled in envelopes or baggies, so that each small group has one baggie or envelope containing at least 14 each of Adenine, Thymine, Guanine, and Cytosine (the contents of the baggies do not have to be identical).
- Gather centigram balances and calculators, enough for one per small group.

Key Words + Phrases

DNA, inherit, genetic, investigate, bacteria, infection, virus, prone, immune, molecular, molecule, strand, protein, hydrogen bond, disrupt, precise, bind, mutation, outcome, deletion, rearrangement, disable, sequence, genome, resolve, edit, subvert, repair response, nick, referee

Requirements

TIME 2 class periods

CLASSROOM MATERIALS

- Whiteboard and markers, chalkboard and chalk, or chart paper and markers
- Monitor/ projector, computer with internet access, or downloaded file of the short documentary, REWRITING LIFE
- Notebook paper
- Stu*dent Handouts*

LAB MATERIALS

- Basic crafting materials, such as: pompoms, yarn, string, popsicle sticks, stickers, clay, playdoh, beads, foam, straws, paper clips, glue
- Basic measuring tools, such as: rulers, weights, calipers, balances, measuring tape, graduated cylinders, springs, scales, etc.

TECHNIQUES + SKILLS

Vocabulary building, reading comprehension, large group discussion, small group work, working in pairs, problem solving, critical and analytical thinking, supporting ideas with examples, comparing and contrasting information sources, scientific investigation, research and analysis, research skills, measuring, listening skills, expository, creative, and responsive writing

Standards Alignments

NGSS HS-PS1-7

Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS HS-PS2-6

Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS 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.

NGSS HS-LS3-1

Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

CCSS.ELA-LITERACY.W.11-12.2

Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

CCSS.ELA-LITERACY.RH.9-10.2

Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text.

MS-LS3-1
Heredity: Inheritance and Variation of Traits

Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

MS-LS4-5
Biological Evolution: Unity and Diversity

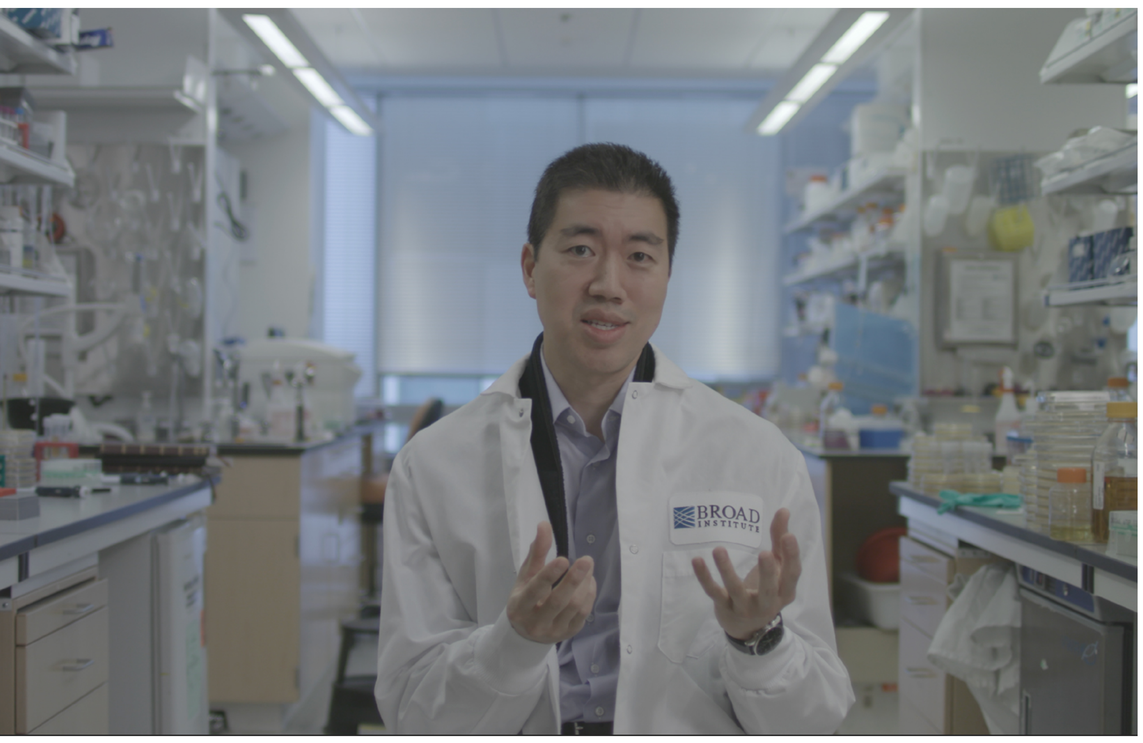
Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

DAY 1

1 As students arrive, have the following quote written on the board, overhead, or on chart paper:

> **"In the end, just like everything in the natural world, it's all just chemistry."**
>
> *– David Liu, Professor, Broad Institute and Harvard*

2 Allow 10 minutes for students to free write about this quote. What does Professor Liu mean when he says that everything is just chemistry? Encourage students to explore this idea, and use examples from their learning in class, as well as their experiences in the world.



3 When students have had time to reflect on this quote, allow 5-10 minutes for volunteers to read their writing. Conduct a short, whole group discussion around the responses and how they relate to the learning of chemistry.

4 Divide the class into pairs. Give each pair a post-it pad, a marker or pen, and a copy of *Student Handout: Scientific Spelling*.

5 Once they all are settled with their materials, announce to the class that they will have 10 minutes to complete the assignment.

6 Allow a minute for students to attempt to figure out what to do.

Note: The purpose of this introduction is to illustrate why it's important to have written instructions – which will lead into an introduction to DNA. Therefore, confusion and frustration is not only anticipated, but welcome at this time.

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DAY 1 (cont.)

7 After a few minutes of confusion, stop the class. Ask the students what happened. Possible responses might be: "We have no idea what we're supposed to be doing!" or, "We don't understand this assignment!" Ask the class why they are confused. Highlight the importance of written instructions. Without written instructions, everyone would be doing a different thing, or nothing, or the wrong thing, and there would be chaos.

8 Distribute *Student Handout: Spelling Instructions*. Allow a moment for students to read it to themselves.

9 Explain that you will be giving them a series of challenges. Using just the letters they have in front of them, they need to spell out a word in the category you give them. Tell them that if they don't have the right letters, they should get as close as possible, to be creative, and that they'll get extra credit for longer words

10 Tell the class that their first challenge is to use the letters they have in front of them to spell the name of an ANIMAL.

Note: Some possible answers might be: bat, moth, goat, hog.

11 Allow 30 seconds for students to complete the challenge with their partner, and write their answer in the appropriate space on their handout. After 30 seconds, ask for volunteers to call out their pair's answer

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DAY 1 (cont.)

12 Now tell the class that they will be swapping out one or two of the letters in a very specific manner. Explain that any student pair that used an "A" in their challenge word should swap it out for a "T." Any pair that used a "T" should swap it for an "A." Any student pair that used a "G" in their challenge word should swap it for a "C." Any pair that used a "C" should swap it for a "G." In this way, all the A's will become T's and all the G's will become C's, and vice-versa.

Some possible results of this shuffle might be: goat becomes cota; bat becomes bta; moth becomes moah, etc.

13 Allow 30 seconds for students to complete the shuffle with their partner, and write their answer in the appropriate space on their handout. After 30 seconds, ask for volunteers to call out their pair's answer.

14 Repeat this process in quick succession, using the remaining prompts: spelling an adjective (i.e., hot, sad, mad, etc.) a verb (has, got, come, eat, etc.); a name, and a noun

Note: In subsequent shuffles, suggest other rules. For example, swapping A's for C's, or T's for G's. Alternatively, instruct students to add a random letter or delete one. For example, "Delete the second letter in your word."

15 When they've completed the assignment, ask the class what the difference was between trying to complete the lesson without instructions, vs. having detailed written instructions. Then ask the class what happened when they changed the spelling of their words. Do they still make sense within the assigned categories? Are they still real words, with any meaning at all?

16 Tell the class that within each organism there are written instructions – instructions that tell the organism's cells how to develop, what their role is within the organism. These written instructions are called DNA. DNA spells out the genetic code for every living thing.

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DAY 1 (cont.)

17 Explain that, just like in the activity they just completed, without instructions, the development of an organism would go terribly wrong. And, within those instructions, if there is even just one or two letters swapped, missing, or shuffled, the entire thing makes no sense. The tiniest mistakes or differences in DNA can be the difference between health and sickness, or even between a human being and a chicken or a grasshopper.

18 For homework, students should conduct online research and write a short answer to the following prompt:

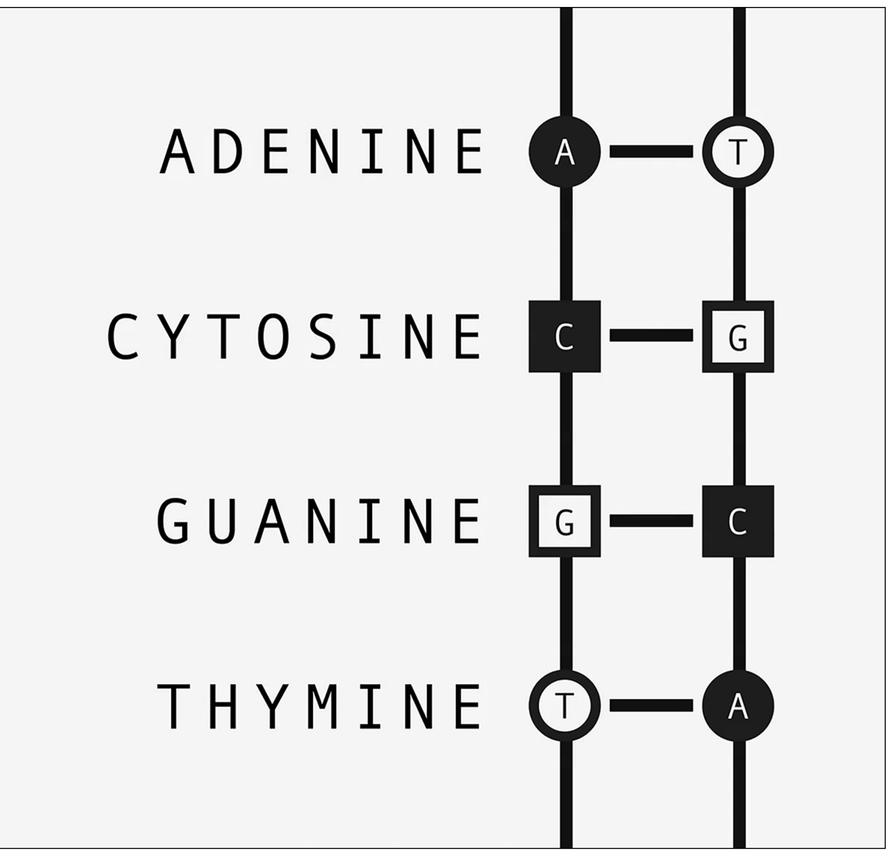
> *What, exactly, does DNA have to do with chemistry? How does the existence and function of DNA support Professor Liu's statement that everything in the natural world is "just chemistry?"*

DAY 2

1 Conduct a quick review of the learning from Day 1. Use some or all of the following questions to guide the discussion:

- What happens to a process when the instructions for that process are missing or misspelled?
- How does this relate to the development and health of organisms?
- What is DNA?
- What does DNA do?
- What happens if there is a spelling mistake or a letter missing in an organism's DNA?
- How do you normally catch a grammar, wording, or spelling mistake in your writing? When you notice a mistake in your writing, what are the different ways that you can fix it?

2 Explain that today's class will be focused on DNA, which are the written instructions for life. Tell the class that they will be investigating DNA and looking at how spelling mistakes, and editing tools, work with these instructions to enable or disable healthy development and functions within organisms.



3 Divide the class into groups of 3-5 students. Provide each group with a bag of DNA base molecule cutouts (each bag can contain a different amount or combination of molecules, but should have approximately 10-14 cutouts of each base: Adenine, Thymine, Guanine, and Cytosine). Instruct students to open the bag and separate the molecules into like groups.

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DAY 2 (cont.)

4 Explain that DNA is comprised of just four types of base molecules – Adenine, Thymine, Guanine, and Cytosine. These molecules are assembled in different amounts and different patterns to create the chemical code for every living organism on the planet – from bacteria to humans.

5 Ask one student from each group to hold up one base molecule "A." Tell the class that this stands for Adenine. Ask another student from each group to hold up one base molecule "T." Tell the class that this stands for Thymine. Ask a third student to hold up a base molecule "C." Tell the class that this stands for Cytosine. Ask a fourth student to hold up a base molecule labeled "G." Tell the class that this stands for Guanine. These are the 4 base molecules that combine to create DNA.

6 Instruct the groups to set their DNA base molecule cut outs aside and to turn their attention to the front of the room. They will now be watching a very short video about DNA, and a technology called CRISPR that can help scientists edit mistakes that are found in DNA, similar to the way we edit and correct spelling mistakes in our writing.

7 Before starting the film, distribute *Student Handout: Viewing and Note Taking Guide*. Explain that because it is a very short video, and has a great deal of information presented quickly, they should complete the note taking prompts as they watch the film.

8 Play the film, REWRITING LIFE (total running time: 6:04).

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DAY 2 (cont.)

9 After viewing, conduct a short, whole group discussion about the film. Use some or all of the following questions as a guide:

- How and where was CRISPR discovered?
- What is CAS-9?
- What is a double stranded break in DNA? What happens to a DNA molecule when there is a double stranded break?
- DNA base molecules always pair exactly the same way. Which base molecules ALWAYS pair with one another?
- Why is this detail – the specific pairing patterns of DNA base molecules – relevant to the application of CRISPR in curing genetic disease?
- What is the difference between CRISPR and CRISPR 2.0 (base editing)?
- Why is CRISPR 2.0 (base editing) a better solution for potentially curing genetic diseases than CRISPER 1.0?
- Why do scientists want to "nick" the healthy strand of DNA when they edit the other strand of the pair? How does this nick affect the DNA's repair response?
- What are some of the genetic diseases that could potentially be cured or prevented by using CRISPR DNA editing?

10 Tell the class that they will now be investigating the molecular composition of DNA, by assembling DNA strands and measuring the molecules.

11 Distribute *Student Handout: Measuring Molecular Composition La*b. Allow a minute or two to read the instructions on the handout aloud.

12 Instruct each group to count the total number of base molecules in their collection, and the amount of each kind. Then instruct them to sort, weigh, and measure the base molecules, and record their findings in the chart on their handout.

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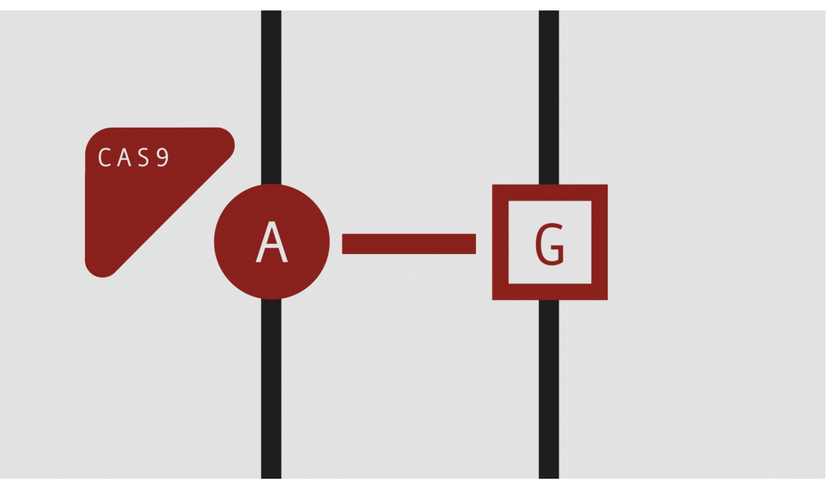
DAY 2 (cont.)

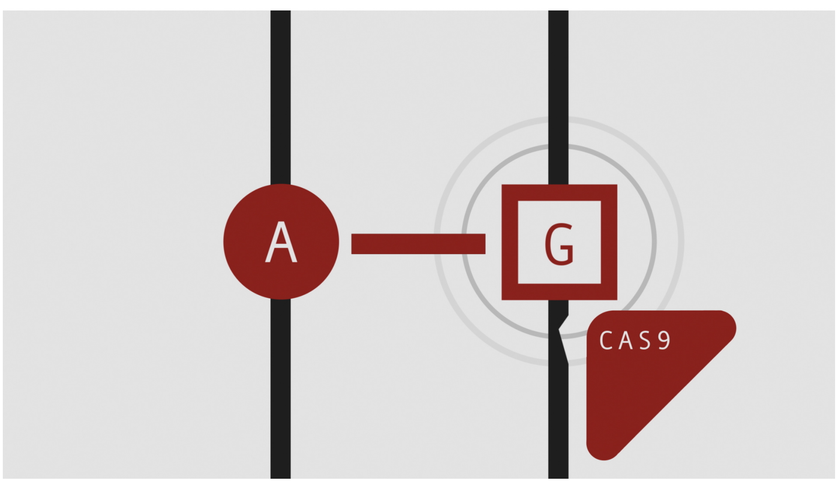
13 Allow 15 minutes for students to work in their small groups to work through the instructions on their handout, and complete their lab.

14 When the groups have finished measuring and recording their findings, distribute a copy of *Student Handout: Curing Disease With CRISPR Base Editing* to each group. Allow the remainder of class time for students to build and edit double stranded DNA sequences for each of the genetic diseases that are listed.

15 For homework, students should conduct some very preliminary research into another genetic disease that was not listed on their handout. They should be prepared to present their findings on the following points:

- What is the genetic disease you selected? What are the symptoms of this disease?
- What is the genetic mutation that causes this disease?





Alternatively, students should write a 1-page reflective response to the following quote from the film, considering how it relates to their study and understanding of chemistry, and science in general. Students should use specific examples to support their reflection.

> *"It was one of those moments where you hear a proposed solution and you sort of stand in awe of how beautiful the solution is, and how the natural world occasionally fits together in just the right way that makes sense and is simple and easy rather than hard and complex, even though the problems you're trying to tackle at the outset can seem almost insurmountable."*
>
> *– David Liu*

SCIENTIFIC SPELLING

CHALLENGE	ORIGINAL SPELLING	SHUFFLED SPELLING
ANIMAL		
ADJECTIVE		
VERB		
NAME		
NOUN		

1. How did you know what to do with this handout?

2. What did you need in order for this handout to make sense?

3. What happened to your challenge words when you shuffled the spelling? Are any of the words in the “Shuffled Spelling” column real words? Do any of them make sense in the category that they’re associated with?

4. What is one “take away” that you learned from this activity?

SCIENTIFIC SPELLING - INSTRUCTIONS

1. For this activity you will be working in pairs.

2. You will need the following materials: a pad of post-its, 1 or 2 markers or pens, and a copy of *Student Handout: Scientific Spelling*.

3. With your partner, pull 10 post-its from the pad and write the following letters on them, 1 per post-it (write one of the following letters on each post-it):

A
E
O
T
C
M
H
G
S
D

4. You will receive a verbal challenge from your teacher. When you receive the challenge, complete it with your partner.

5. Record your answer to the challenge in the appropriate place in chart on the *Student Handout: Scientific Spelling*.

6. You will then receive a “shuffle instruction” from your teacher. When you receive this shuffle instruction, complete it with your partner.

7. Record your answer to the shuffle instruction in the appropriate space in the chart on the *Student Handout: Scientific Spelling*.

8. With your partner, answer the questions at the bottom of your handout, based on your experience with this activity.

VIEWING LOG

***Directions**: As you view the film REWRITING LIFE, fill in the blanks to take note of what you've seen.*

1. _____ is the primary source of information in a cell.

2. What is the function of CRISPR?

3. How and in what sort of organism was CRISPR discovered?

4. What are the CRISPR "molecular scissors" called? What do these "scissors" do?

5. What happens to the molecular DNA when it is cut by the CRISPR scissors?

6. What are the names of the 4 base molecules that comprise DNA?

7. CRISPR edits DNA by....

8. CRISPR 2.0 edits DNA by .....

9. Why do scientists "nick" the healthy strand of DNA when they edit it with CRISPR 2.0?

10. List 3 human diseases that are caused by genetic mutations, which could be cured by CRISPR 2.0.

MEASURING MOLECULAR COMPOSITION LAB

***Directions**: Investigate the collection of DNA base molecules you have been given (the "set"). Count the total number of base molecules in the set, as well as the amount of each kind (the "subset"). Sort them out into subsets, and then, using a centigram balance and calculator, weigh and calculate the average mass of each base molecule. Find the percentage of the total for both NUMBER of each base as well as for the MASS of each base. Record your findings in the chart below.*

Total number of base molecules in the set: _____

Total mass of base molecules in the set: _____

Name of base molecule	**Mass of sample subset** (i.e., mass of all the A's)	**Number of sample subset** (i.e., how many A's)	**Percent of total by number** (number of subset / number of set)	**Average mass of each molecules in the subset**	**Percent of total mass** (mass of subset / mass of set)
A_____					
T_____					
G_____					
C_____					

CRISPR BASE EDITING

Directions: *Use the molecular base cutouts from your lab to build out a double stranded model of the mutated DNA sequences on the left. Then, enact CRISPR base editing to edit the sequence and resolve the genetic mutation, to create a healthy sequence. For each sequence, note the difference between the mutated DNA and the healthy DNA.*

1. Huntington's Disease Mutation
C A T T C A C A G C A G C A G G T A A T C

What is the difference?

Healthy Sequence
C A T T C A C A G G T A A T C

2. Sickle Cell Anemia Mutation
A C TC C T G T G G A G A A G

What is the difference?

Healthy Sequence
A C T C C T G A G G A G A A G

3. Cystic Fibrosis Mutation
A T C A T T G G T G T T

What is the difference?

Healthy Sequence
A T C A T C T T T G G T G T T

DNA BASE MOLECULES TO COPY AND CUT

***Directions for the Instructor**: Print the pieces on cardstock rather than regular paper. This will result in better data due to the larger mass. Templates can be printed on all the same color, or 2 different colors (one for A/T and one for G/C), or even on 4 different colors (simply cut out the A's from one page and discard the T's so you can cut them from the other color). Copy and cut enough pieces to create an envelope or baggie for each small group in your class. Once you've copied and cut out a good quantity of templates, divide the pieces into envelopes/baggies according to these rules:*

1. The number of A's must match the number of T's, and G's must match the number of C's.

2. Each set can be identical, or some sets can have more A/T or G/C.

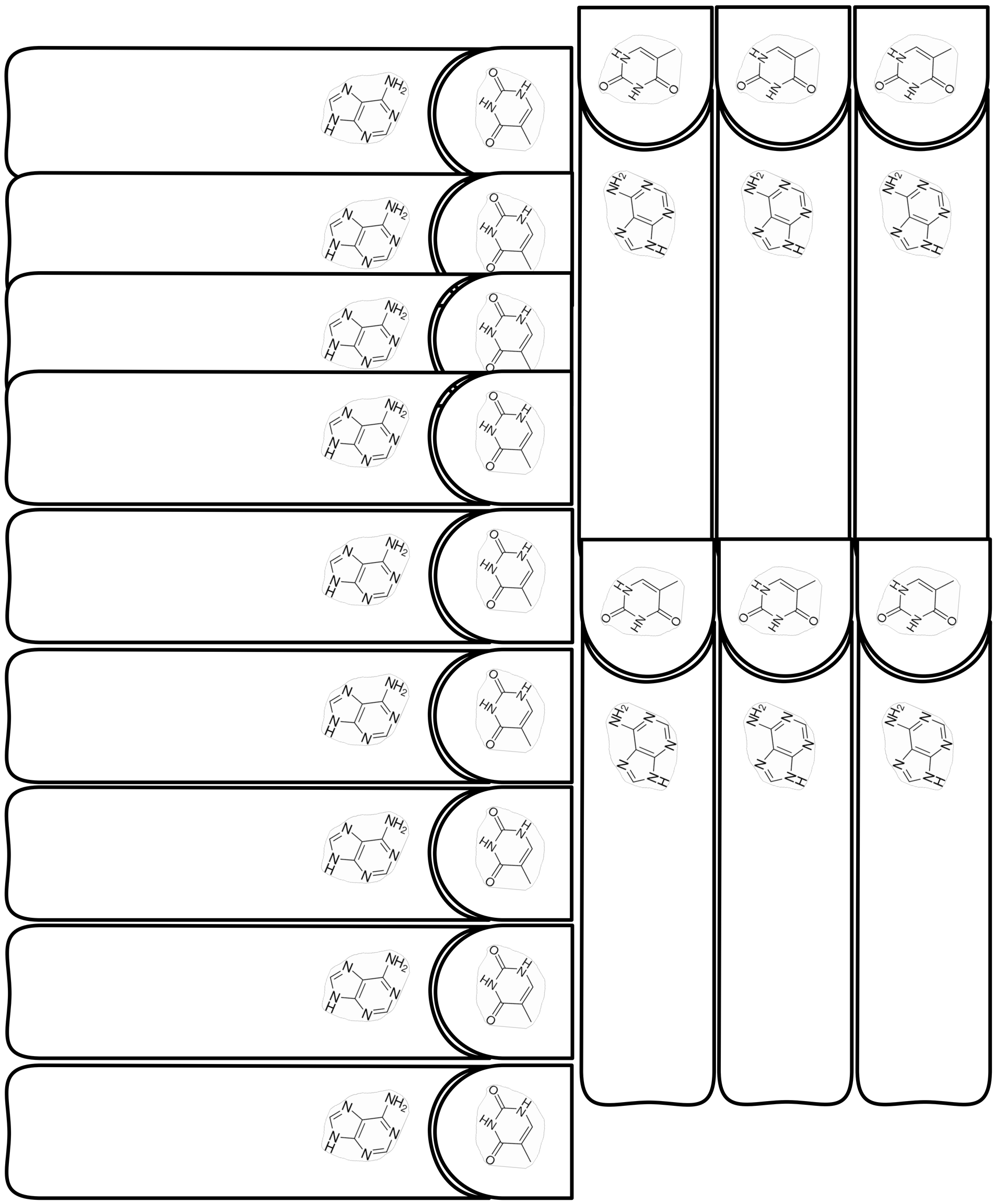
3. There is no exact number of pieces that must be in a set. Even numbers only, but anywhere from 16-30 of each molecule will work

Note: Retain some extra pieces to have handy for the editing activity at the end. 14 of each piece is required for the editing, but groups can trade around if needed.

[Base molecule templates for duplication appear on the following pages]

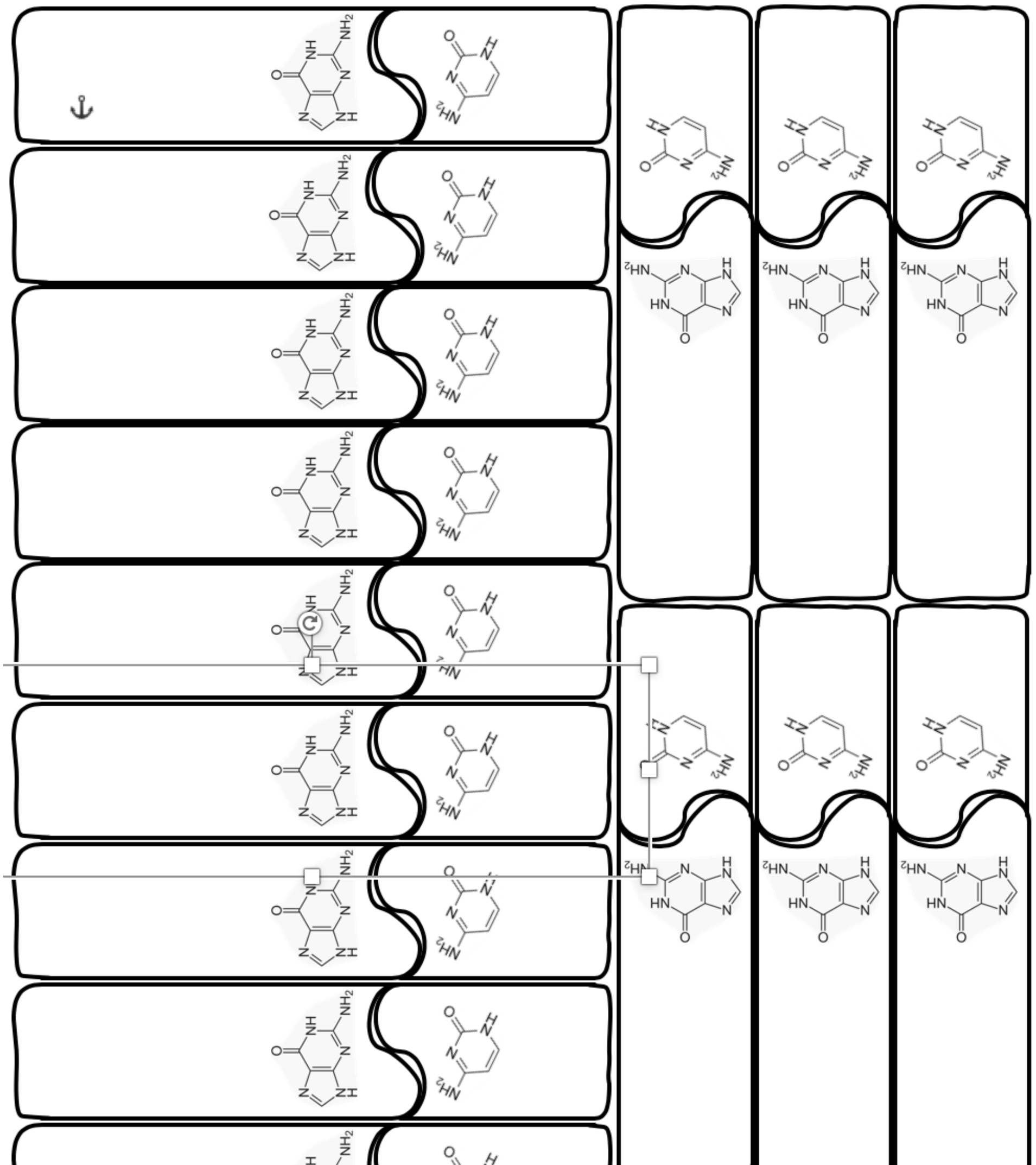
DNA BASE MOLECULES TO COPY AND CUT

Base Molecule Template



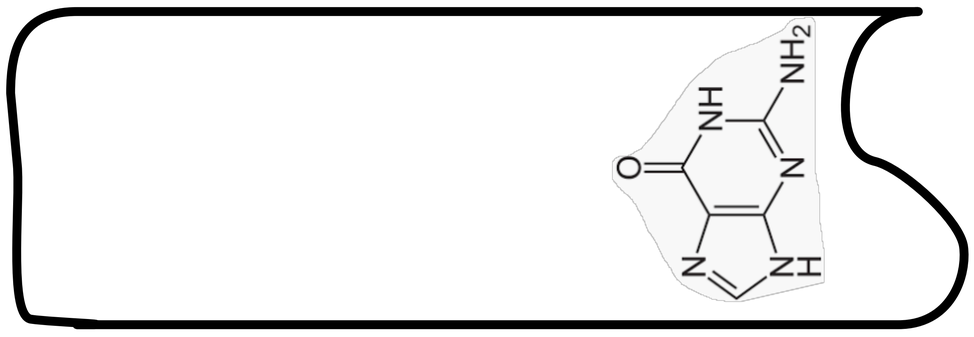
DNA BASE MOLECULES TO COPY AND CUT

Base Molecule Template

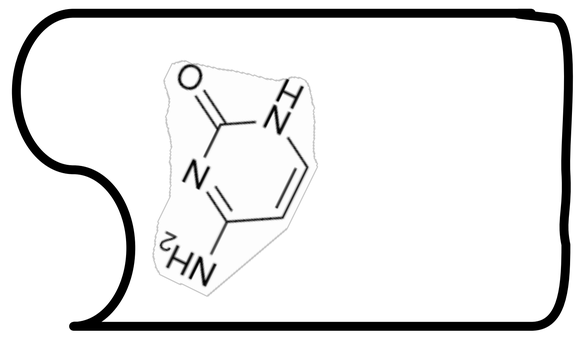


DNA BASE MOLECULES TO COPY AND CUT

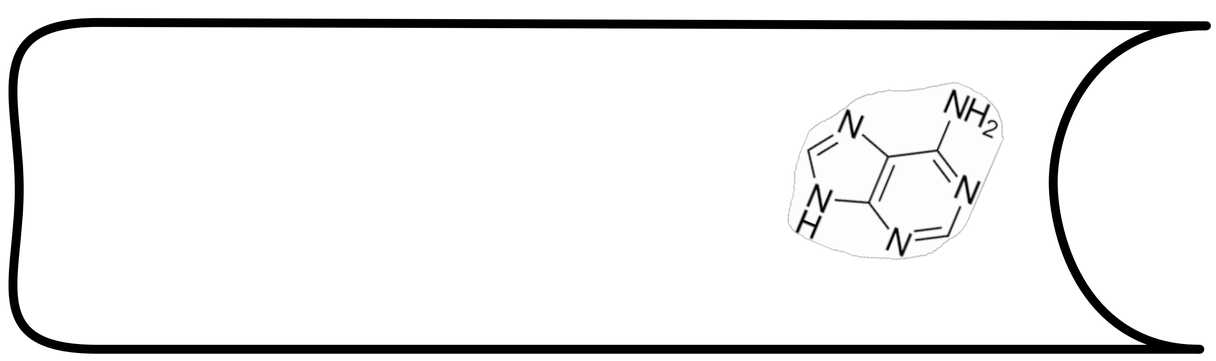
Key for DNA Pieces



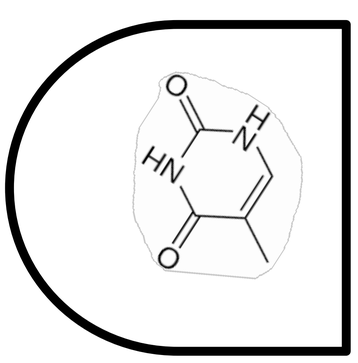
Guanine



Cytosine



Adenine



Thymine

Chemistry Shorts™ is a film series that communicates the breadth and depth of chemistry's impact on humankind in an approachable manner, sponsored by the Camille and Henry Dreyfus Foundation. These films will celebrate the science and the people who share a passion for the vital role chemistry plays in the biggest issues, including human health, renewable energy, the nature of life, sustainability, new materials, and climate change. Each film incorporates a lesson plan that offers ideas for ways they may be incorporated into the classroom. We welcome your feedback at: **chemistryshorts.org.**

SHORT FILMS ABOUT CHEMISTRY