SREB

SREB Readiness Courses
Transitioning to college and careers

Literacy Ready

Science Unit 2 . DNA and Biotechnology
Version 2a

Southern Regional Education Board

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Unit 2
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Unit 2
Course Overview

Overview:

In this unit, students will extend their understanding of reading and writing in the sciences. They will read research articles, textbook material, take notes from lecture videos and make predictions using scientific models. The text material in this second science unit, DNA and Biotechnology, is more complex in both content and composition than the material from unit one. Students will investigate the impact of biotechnology and select a relevant area for independent study. Additionally, students will be asked to write in more depth as they prepare to write and present an evidence-based scientific poster in a research symposium.

How to Use This Unit:

We have designed this unit to be somewhat flexible. The pacing guide is based on 250 minutes of instruction per week. Lessons are not based on specific instructional minutes; they are designed conceptually. Thus, one lesson may run for 50 minutes and another 250 minutes. For each lesson, you will find a list of objectives and goals as well as a listing of activities and resources needed.

Students will use the Academic Notebook during each lesson. This notebook will provide a means to record notes, vocabulary and complete lesson activities. Thus, it will serve as a way to assess student learning. Students should be encouraged to add to their vocabulary collection each week. Additionally, students should complete the weekly reflections in the Academic Notebook to think about both the science and the literacy skills they are learning.

The anchor text for this unit will be an on-line biology text, simply named, Biology (Ital.), available through OpenStax College, (Rice University, Houston, TX – download for free at: http://cnx.org/content/col11448/latest/). Chapters 3.5, 14, and 17 will serve as text material an part of the total readings for this unit. You may download these chapters from the SREB website (www.sreb.org/Ready) or from the openstax site listed above.

Unit Objectives:

1. Students will learn strategies for approaching both general and discipline specific vocabulary.
2. Students will be able to explain the processes involved in reading in the sciences.
3. Students will develop skills to critically examine current science topics.
4. Students will evaluate perspectives from multiple stakeholders using multiple sources of information.
5. Students will understand the functions and importance of modeling in the sciences.
6. Students will be able to explain the processes involved in critical reasoning in science.

7. Students will develop skills to analyze information from a variety of sources.
8. Students will integrate ideas to develop a larger understanding of scientific contributions made by researchers.
9. Students will be able to read, analyze and critique scientific peer-reviewed research studies.
10. Student will apply their knowledge by analyzing science-based arguments.
11. Students will be able to write and present evidence-based arguments citing specific examples, using data-driven and peer-reviewed materials and drawing conclusions from the research.

Week 1

Lesson 1: Gateway Activity (175 minutes)

1. Students will be provided with an overview of the course and introduction to the Academic Notebook.
2. Students will think about how scientists do research by comparing and contrasting two views of the scientific method using a charting strategy.
3. Students will participate in a gateway activity on biotechnology and health: Would you want to be screened for disease?
   - Discussion of ethics in science
   - Discussion of reading scientific articles
   - Applying principles

4. Students will review and understand the final writing project.

Lesson 2: Close Reading in Science: DNA and Biotechnology (105 minutes)

1. Students will be introduced to the biology text.
2. Students will learn to annotate this text using a close reading approach.
3. Students will read, annotate and respond to text dependent questions.
4. Students will complete a weekly reflection on learning.

Week 2

Lesson 3: Discovery of DNA Structure (100 minutes)

1. Students will understand the characteristics of DNA.
2. Students will read historical scientific, popular press and textbook articles regarding the discovery of the structure of DNA.
3. Students will create a diagram of DNA based on multiple sources, adding to and editing their model with each new source.

Lesson 4: Close Reading and Annotating for Concepts (100 minutes)

1. Students will read and annotate the text describing the function of DNA, and the flow of information from gene to expression.
2. Students will build their understanding of the concepts through vocabulary learning.
3. Students will create a concept map connecting key scientific terminology in this complex process of genetic expression.

Week 3

LESSON 5: Taking Notes Part 1 (100 minutes)

1. Students will read and annotate text.
2. Students will learn strategies for effective note taking.
3. Students will use the Cornell method of note taking over the biotechnology video.
4. Students will compare notes with peers and reflect on the note taking process.
5. Students will complete a weekly reflection on learning.

Lesson 5: Taking Notes Part 2 (50 minutes)

1. Students will use the Cornell method of note taking over the biotechnology video.
2. Students will compare notes with peers and reflect on the note taking process.

Week 4

Lesson 6: Taking Science Exams (50 minutes)

1. Students will organize information for the exam by creating concept maps in small groups.
2. Students will predict exam questions using higher-level questioning strategies.
3. Students will conduct their exam review by explaining their maps and quizzing each other using the predicted questions.
4. Students will take the exam.
5. Students will reflect on the exam.

Lesson 7: Analyzing Science Arguments (75 minutes)

1. Students will learn about analyzing arguments from research articles.
2. Students will complete a weekly reflection on learning.
3. Students will apply the principles of analyzing arguments to a research article on biotechnology and crops.
4. Students will use a pro/con chart to delineate their arguments.

Week 5

Lesson 8: Critiquing Science Research (200 minutes)

1. Student will select a research topic.
2. Students will create a project plan timeline.
3. Students will review strategies for reading scientific articles.
4. Students will find sources for their project in the library.
5. Students will take notes on their articles.
6. Students will complete a weekly reflection on learning.

Week 6

Lesson 9: Research Poster Symposium (250 minutes)

1. Students will examine research poster examples to help them understand the task.
2. Students will work on drafting the poster presentations.
3. Students will work in pairs to edit and revise their posters.
4. Students will present their poster presentations.

Lesson 1
Gateway Activity

Overview and Rationale:

This is the second science unit in Literacy Ready, which will build on the skills and strategies from the nutrition unit and will introduce new strategies as well. Students will continue to learn about science literacy, the ways scientists think when reading and writing and the literacy conventions that are specific to the sciences. Students will also learn a more complex view of the scientific method that is used by scientists. These ideas will be reinforced throughout the unit as instructors model literacy processes and as students have an opportunity to try new ways to read, write and learn in science.

Students will be introduced to the content of the unit as they engage in thinking about the role of ethics in science. Students will watch videos on the BRCA1 gene, read a fact sheet from a government website, read scientific articles about screening for specific diseases and engage in a classroom discussion about being screened for disease from both scientific and ethical stances. These activities are designed to pique students' interest as well as introduce the topics of DNA and biotechnology. Students will use a decision-making framework for critical reasoning that examines what is currently known, who the stakeholders are, what questions still remain and what possible conclusions/solutions/outcomes may be. This way of viewing science allows students to use a solid understanding of science to grapple with ethical concerns about new biotechnology.

Tasks/Expected Outcomes:

1. Students will add to their understanding of the two levels of thinking required in this course: thinking like a scientist and thinking about learning in the sciences.
2. Students will add to their understanding of the components of science literacy.
3. Students will develop skills to critically examine current science topics.
4. Students will evaluate perspectives from multiple stakeholders using multiple sources of information.
5. Students will apply their knowledge by analyzing science-based arguments.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes or information presented in a text by paraphrasing them in simpler but still accurate terms.

6 Analyze the author's purpose in providing an explanation, describing a procedure or discussing an experiment in a text, identifying important issues that remain unresolved.

7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

English Language Arts History/Social Sciences; Science/Technical Subjects Standards: Writing

5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

9 Draw evidence from informational texts to support analysis, reflection and research.

10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 1: Task Engagement

1. Bridging Conversation

Ability to connect the task and new content to existing scientific knowledge, skills, experiences, interests and concerns.

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings through constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Scientific Information

Ability to select and read appropriate research and understand the elements of scientific processes.

3. Scientific Terminology

Ability to locate and understand scientific words and phrases that identify key concepts and facts, processes or information.

4. Close Reading

Ability to interpret text with particular questions in mind that reflect scientific inquiry, and to use self-regulation to understand scientific processes presented in the text.

5. Scientific Processes

Ability to understand and use scientific processes as a way to answer questions and evaluate text information.

6. Annotation and Note-taking

Ability to read purposefully, select and use relevant information; to summarize and/or paraphrase; to use and understand multiple representations of science processes.

Skills Cluster 3: Writing Process

1. Writing for a Purpose

Ability to write routinely for different tasks and purposes.

2. Reflective Writing

Ability to write reflectively based on synthesis of information and texts.

3. Writing for a Specific Audience

Ability to construct a writing task to address a specific audience.

(www.literacydesigncollaborative.org)

Materials:

Websites

- How to read a scientific paper — http://www.lib.purdue.edu/help/tutorials/scientific-paper

Videos

- Scientific Explanation of BRCA-1 — http://www.youtube.com/watch?v=-GwdZIqJf8g (one minute).
- Twins with BRCA-1 — https://www.youtube.com/watch?v=SIUPa57hIE8 (five minutes).
- Commercial website — www.23andme.com
- Video explanation of gene mutation — http://www.youtube.com/watch?v=C503LJrUGKc&feature=results_video&playnext=1&list=PLD85B1680C865C024 (two minutes).

Readings

Whole class articles:

- "BRCA1 and BRCA2: Cancer Risk and Genetic Testing." National Cancer Institute — http://www.cancer.gov/cancertopics/factsheet/Risk/BRCA
- "Genetic Testing for a BRCA 1 mutation." *American Journal of Medical Genetics* — http://onlinelibrary.wiley.com/doi/10.1002/ajmg.a.10102/abstract
- *New York Times* Angelina Jolie editorial — http://www.nytimes.com/2013/05/14/opinion/my-medical-choice.html

Small group articles:

- "Diagnosing Down Syndrome, Cystic Fibrosis, Tay-Sachs Disease and Other Genetic Disorders." *Nature Education* — http://www.nature.com/scitable/topicpage/diagnosing-down-syndrome-cystic-fibrosis-tay-sachs-646
- "Ethics of Genetic Testing: Medical Insurance and Genetic Discrimination." *Nature Education* — http://www.nature.com/scitable/topicpage/ethics-of-genetic-testing-medical-insurance-and-651
- "Normal Breast-Cancer Gene Keeps Cancer at Bay by Blocking DNA Replication." *Scientific American* — http://www.scientificamerican.com/article.cfm?id=normal-breast-cancer-gene
- "Breast Cancer: Knocking Out a Killer." *Scientific American* — http://www.scientificamerican.com/article.cfm?id=breast-cancer-knocking-ou
- "Facing Your Genetic Destiny." *Scientific American* — http://www.scientificamerican.com/article.cfm?id=facing-your-genetic-desti-2002-02-18
- "Facing Life With a Lethal Gene." *New York Times* — http://www.nytimes.com/2007/03/18/health/18huntington.html?pagewanted=all.

Timeframe:

175 minutes

Targeted Vocabulary:

General Academic Vocabulary

- authoritativeness
- bias
- critical reasoning
- timeliness
- risk assessment

Discipline Specific Vocabulary

- genetic mutation
- genetic testing
- prophylactic surgery

Activity One — Discussing Science Thinking (Approx. 10 minutes)

NOTE: If students are starting Unit Two without doing the lessons from Science Unit One: Nutrition, it would be beneficial to teach them Lesson One: Activity One from that unit.

Explain in this unit, students will learn science content but also reading and writing strategies to help them learn the content. Students will also learn about disciplinary literacy, which are the specialized skills and strategies that scientists use. This means that there are certain reading, writing and listening strategies for learning in science that are different than those used in other contents. There are also some strategies that are used across contents, but need to be used in a way that makes sense in the sciences. Students will learn both the discipline-specific and general strategies adapted for science in this unit. The goal of this unit is to help students prepare for college and career-readiness in science.

Ask students to discuss the ways scientists think as a think-pair-share activity. They will discuss their parts in pairs and then in small groups:

- What are scientists looking for when reading?
- What are scientists' goals when conducting an experiment?
- What are their goals when writing up results?
- What does this mean for the ways students should approach reading, writing, and thinking in the sciences?

Discuss the responses as a class. Ask students to discuss how their knowledge about these issues has increased since completing the nutrition unit.

Activity Two	Understanding How Science Works (Approx. 40 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 8; Writing– 10

NOTE: If students did not complete Unit One, go over the features of the academic notebook with students.

Ask students to take a look at the Academic Notebook to help familiarize them with how they will use it in this unit.

Ask students to turn to the table of contents page 2. There are 9 overall lessons in this unit, but know that some are longer than others. The entire unit will span six weeks.

Students will have an exam during Lesson 6. It is important to note that this will be a science exam, not a strategies exam. That means that even though students are learning reading and writing strategies for learning sciences, the exam will assess how well they learned the science—there will not be any questions about the strategies themselves.

Students will also have a final project at the end of the unit. This will be discussed more about this as it gets closer, but basically students will research a topic related to DNA and biotechnology and create a research poster about it.

Ask students to turn to the section about the purpose of the notebook page 3: Ask, "What is the purpose?"

1. Tools and information for learning.
2. Place to record work.
3. Assessment tool—it will be collected periodically for grading.

Ask students to examine the "Overview of the Scientific Method" and the "How Science Works" diagrams in their Academic Notebooks pages 6-7.

Discuss how scientists use diagrams as a visual way to depict information. Discuss the following steps in reading a science diagram:

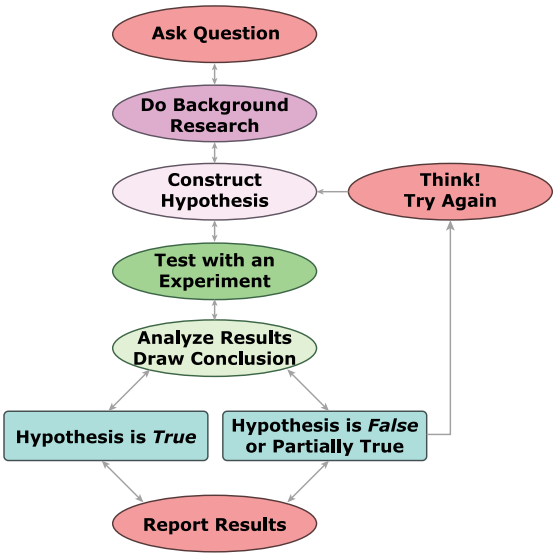
1. Read the title and the information on where the diagram comes from (what is the source).
2. Read the labels (often these will be vocabulary terms that you need to know when the diagram is depicting a science process).
3. Examine the directionality of the arrows or lines. This will help you understand the ways that the ideas are connected.

Ask students to work in small groups comparing and contrasting the two diagrams using the chart in the Academic Notebook page 8. Remind students about the strategies learned in Unit 1: Nutrition on annotating diagrams.

Discuss how the traditional view of the scientific method as a step-by-step process may not get at the iterative, complex way that scientific inquiry is conducted in reality.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 6-8

Overview of the Scientific Method



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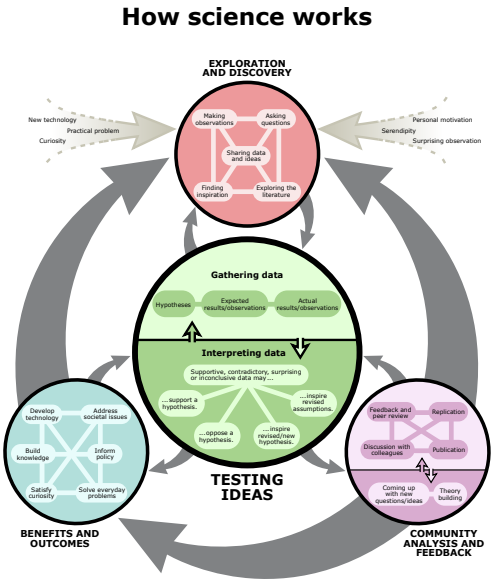


http://undsci.berkeley.edu/lessons/pdfs/complex_flow_handout.pdf

	Overview of the scientific method	How science works
Main premises of the diagram.		
How are science outcomes described?		
How is science conducted?		
Who are the key players involved in science inquiry?		

Ask students to summarize their conclusions about the two diagrams in their notebooks page 9.

As a whole class, ask students to use their knowledge from the diagrams they read to discuss the ways they differ in terms of how science is viewed. Why are students taught the simple version of the scientific method? What does the more complex version mean for them as students taking a science class?

Remind students about of the disciplinary literacy in conventions that they learned from the last unit on nutrition. Ask them to recall some of the ideas they learned (long noun phrases, transforming information, evaluating information from the media, using prefixes, roots, and suffixes to determine word meaning, etc.). Talk about how this unit will add their knowledge about science learning.

Ask students to think about how knowledge builds in science. First, ask students to think about the scientific method they just examined and the concept of knowledge building. For example, in the nutrition unit students learned about enzymes. They discussed how they work like puzzle pieces for molecules in the active site. In this unit students will need to use that knowledge to understand about the discovery of DNA and how it can be manipulated. Students may notice that in science information builds and an idea that was introduced in an earlier chapter is now being used differently in a later chapter.

In this unit students will be discussing DNA and biotechnology. It will pull together a lot of what you have previously learned in science classes. The class will address ways to recall previously learned information throughout this unit.

Assessments:

Outcome 1: Students will add to their understanding of the two levels of thinking required in this course: thinking like a scientist and thinking about learning in the sciences.

Outcome 2: Students add to their understanding of the components of science literacy.

- Compare/contrast chart

Evaluation Rubric			
• Provides clear differences between the two models.	No	Somewhat	Yes
• Can explain the key players involved.	No	Somewhat	Yes
• Provides insight into the ways science is investigated.	No	Somewhat	Yes
• Provides a complete summary, which clearly identifies the difference between the two diagrams.	No	Somewhat	Yes

Activity Three — Introducing the Topic (Approx. 5 minutes)

Ask students if they have ever heard of BRCA 1. Have they ever heard of gene mutations or genetic screening? Tell them that they will be watching videos and reading several sources to learn about these issues. Their goal is to be able to compare and contrast the ideas they hear as they think about their own stances on genetic screening.

Activity Four — Note taking from Videos (Approx. 10 minutes)

College and Career Readiness Standards: Science/Technical Reading– 2, 7, 9; Writing– 9, 10

Students will view three videos about BRCA1 mutation: one about a patient with a positive BRCA 1 diagnosis and the others presenting a scientific explanation of BRCA 1 mutation. Show the videos in the order below. Ask students to take notes in their Academic Notebook page 10.

- Twins with BRACA — https://www.youtube.com/watch?v=SIUPa57hIE8.
- Scientific Explanation of BRCA1 — http://www.youtube.com/watch?v=-GwdZIqJf8g (one minute).
- Video explanation of gene mutation — http://www.youtube.com/watch?v=C503LJrUGKc&feature=results_video&playnext=1&list=PLD85B1680C865C024 (two minutes).

After viewing these videos, ask students to add to or revise their notes on the BRCA1 mutation. Show them the website from a company selling home genetic screening tests. Discuss their thoughts on this type of testing.

- Commercial website — www.23andme.com.

Ask students to write a personal reflection on genetic screening in their academic notebooks page 11.

Assessments:

Outcome 1: Students will add to their understanding of the two levels of thinking required in this course: thinking like a scientist and thinking about learning in the sciences.

Outcome 2: Students add to their understanding of the components of science literacy.

- Reflection

Evaluation Rubric			
• Reflection references the resources read.	No	Somewhat	Yes
• Reflection uses information from sources to support student's feelings.	No	Somewhat	Yes
• Reflection is written in appropriate prose.	No	Somewhat	Yes

Activity Five — Reading Science Articles (Approx. 85 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 6, 7, 8, 9

Students will read several articles about gene mutation. Ask students to pay careful attention to information about the risks of cancer with a BRCA 1 or 2 gene mutation, the risk factors and genetic discrimination. This information will provide multiple perspectives on screening and treatment of BRCA 1. Take notes on page 12 of the Academic Notebook.

Guide students through the reading:

Talk about the elements of a scientific article using the article from the A*merican Journal of Medical Genetics* (AJMG).

- First show students the following web explanation: http://www.lib.purdue.edu/help/tutorials/scientific-paper.
- Examine the different sections (abstract, introduction, methods, results and discussion) of the AJMG paper. The abstract gives students an overview of the entire study, the introduction discusses previous research in the field, the methods tell the reader about the participants in the study, how the experiment is conducted (the order of events), how data will be collected and how data will be analyzed. This should give the reader enough information that they could replicate the study. The results section tells the reader what happened as a result of the experiment. The discussion section talks about what the results mean—how they should be interpreted.
- Discuss that the purpose for reading this article is to get a glimpse into some of the research being done on BRCA screening. Although students will read entire articles during this unit, right now they should focus on the abstract for this article on BRCA 1 testing. Ask students to read the first column of text.

Ask the following text-dependent guided reading questions:

- What is the purpose for doing the study? What research questions are the researchers trying to answer? Where in the text can you find this information?
- How did the researchers go about answering their questions?
- What did they find out about BRCA1 screening for mutation? Did it change people's behaviors?

Discuss student responses as a class.

Now ask students to turn to the article from the National Cancer Institute and the *New York Times* (NYT) editorial by Angelina Jolie. In pairs, ask students to work through the claims made by Jolie using the data supplied by the National Cancer Institute (NCI). First read the NYT editorial. Circle any science claims made about BRCA 1, genetic testing, cancer, medical choices. Then use the information from the NCI to see if those claims are supported by cancer research. After students have time with both articles ask them to summarize their findings in the Academic Notebook.

Talk about how students should go about reading multiple sources. Students should think about comparing and contrasting ideas across text, thinking about the science methods/processes/ideas presented in each text, the bias and credibility of each source. They should also consider the cause/effect relationships and decision-making processes used by the women in the BRCA 1 video. How is she using the science?

Ask students to think about issues related to science and ethics—how do ethical considerations affect our reading?

Ask students to respond in their Academic Notebook page 13 to the questions: Explain how BRCA1 and 2 gene mutations impact a person's risk of cancer, and how did the woman in the first video interpret her risk?

Ask students to write a short reflection on their thoughts about genetic screening so far. Remind them to use evidence or examples from the articles to support their claim.

As a whole class, discuss the ethical decision-making involved for a patient after genetic testing. They will also discuss the science behind genetic screening.

Ask students to apply their knowledge of genetic screening to other genetic diseases. Tell students that they will be examining, evaluating and presenting science based arguments about genetic screening. Later in this unit, students will go into much more detail about evaluating arguments. For now, students should think about:

FROM THE STUDENT ACADEMIC NOTEBOOK p 14

- **Data:** these are the facts involved in your argument that support your claims. What data does your article contain?
- **Claim:** this is the conclusion that is drawn from the data. What conclusion do the authors have?
- **Warrants:** these are the reasons that justify the connection between the data and the claim. In science, these are often the scientific principles and/or methods. What warrants are present in your article?
- **Backing:** these are the basic assumptions that are commonly agreed upon that provide justification for the warrants. What are the basic assumptions that the authors used as a justification for their stance?

Ask students to work in small groups to read one of the articles on other genetic mutation diseases. They will prepare for a class discussion using the chart in their Academic Notebook.

Small group articles:

- "Diagnosing Down Syndrome, Cystic Fibrosis, Tay-Sachs Disease and Other Genetic Disorders." *Nature Education* — http://www.nature.com/scitable/topicpage/diagnosing-down-syndrome-cystic-fibrosis-tay-sachs-646.
- "Ethics of Genetic Testing: Medical Insurance and Genetic Discrimination." *Nature Education* —http://www.nature.com/scitable/topicpage/ethics-of-genetic-testing-medical-insurance-and-651.
- "Normal Breast-Cancer Gene Keeps Cancer at Bay by Blocking DNA Replication." *Scientific American* — http://www.scientificamerican.com/article.cfm?id=normal-breast-cancer-gene.
- "Breast Cancer: Knocking Out a Killer." *Scientific American* — http://www.scientificamerican.com/article.cfm?id=breast-cancer-knocking-ou.
- "Facing Your Genetic Destiny." *Scientific American* — http://www.scientificamerican.com/article.cfm?id=facing-your-genetic-desti-2002-02-18.
- "Facing Life With a Lethal Gene." *New York Times* — http://www.nytimes.com/2007/03/18/health/18huntington.html?pagewanted=all

FROM THE STUDENT ACADEMIC NOTEBOOK p 14

Article	Genetic disease description	Science argument	Ethical argument

Question: Use the information you have learned so far to come to a group conclusion. Should people be screened for genetic disease? Students should support their argument with text, refute counterarguments with text and discuss both ethical and scientific concerns.

Ask students to briefly share their summaries with the class. Ask the following questions during the whole-class discussion:

- Would I want to be screened? What are the benefits/drawbacks?
- Who should have access to my screening info? (Insurance, job, doctors, etc.?)
- What is the impact of this knowledge?
- What are the science-based arguments and the ethical arguments? How do they differ?
- Are there some diseases that should always/never be screened? Ask students to think about and discuss the genetic disease they read about.
- Should parents get children tested?

Assessments:

Outcome 3: Students will develop skills to critically examine current science topics.

Outcome 4: Students will evaluate perspectives from multiple stakeholders using multiple sources of information.

Summary of articles on screening for genetic disease (in Academic Notebook).

Evaluation Rubric			
• Summaries include relevant information, summarizes and/or paraphrases effectively.	No	Somewhat	Yes
• Uses and understands multiple representations and science processes.	No	Somewhat	Yes
• Reflection is written in appropriate prose.	No	Somewhat	Yes

Outcome 5: Students will apply their knowledge by analyzing science-based arguments.

- Teacher's analysis of discussion quality and participation.
- Quality of group presentations of arguments.

Criteria

	Excellent	Good	Approaching	Not Yet
Content and organization	All content is relevant to presentation topic and organized in a clear and logical sequence.	Most of the content is relevant to the presentation topic; sequence of main ideas is good but could be improved.	Much of the content is not relevant to the presentation topic; some main ideas seem to be out of logical sequence.	Content is confusing or not relevant to the presentation topic; there is no clear plan for the organization of information.
Effectiveness of argument	Argument is identifiable, reasonable, and sound; each point is supported by persuasive evidence and rhetorical analysis.	Either argument is not identifiable OR not all points are sufficiently supported by evidence and rhetorical analysis.	Argument is barely reasonable and identifiable; few points are supported by evidence and rhetorical analysis.	Argument is not identifiable and insufficiently supported.
Collaboration	Each student in the group was highly productive and played a contributive role.	Each student in the group was sufficiently productive and played a fairly contributive role.	Not all students in the group were productive or played a contributive role.	Few students in the group were productive or played a contributive role.

Activity Six	Introduction to the Final Project (Approx. 25 minutes)

Ask students to read the project directions in their Academic Notebook pages 15-16. Students should underline and annotate the important parts of the project so that they are clear on what the project will entail.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 15-16

DNA Final project: Biotechnology Research Symposium

General Instructions

The purpose of the project is to research an issue on how DNA and biotechnology impacts our daily lives by reviewing the current research literature. You can choose a topic relating to biotechnology and health or biotechnology and agriculture. This is not a term paper or book report. It is not merely a report on your sources. Instead, your poster report will synthesize the sources to present a coherent explanation of the topic. A key aspect is that it provides evidence for a particular point of view. Thus, you will need to read multiple research articles on the same topic to be able to draw conclusions on the findings. Use the following prompt to help guide your thinking:

Critical Focus Question: This will help you focus your research and the development of your project: "What are the current trends and future applications of biotechnology?"

After researching peer-reviewed journal articles on a topic related to biotechnology and health or biotechnology and agriculture, write a research report in the form of a scientific poster in which you discuss the science behind the technology and evaluate current and future applications. Be sure to support your position with evidence from your research. Cite at least six to eight sources, pointing out key elements from each source. One of your sources will be a section from Phelan 5.11-5.19.

Use the following websites as a way to start your search for materials:

www.sciencemag.org.

www.scientificamerican.com.

www.nature.com.

www.newscientist.com.

http://learn.genetics.utah.edu/.

You will create a poster presentation on your topic. To complete this assignment you will read research articles, synthesize the information and write an evaluative argument on your topic.

You will present the poster of your project to the class in a research symposium and create a handout for your classmates.

Research symposium.

For this symposium you will create a poster of your work. Your poster must include the following information:

1. **Title** of a presentation; name; school name; teacher's name
2. **Background** and introduction to the topic—this section introduces the topic, describes the questions you are asking, and provides a thesis. In this section you

will also explain the science behind the particular method and connect it to what you have learned in class. (Describe the biotechnology—what is it? How is the process accomplished? The detailed description of your biotechnology application will lead to your hypothesis/position.)

3. **Current advances** and results—this is the major focus of your poster. This section presents the current issues, themes, research goals. Where is this technology being used? You will describe the important results and explain how those results shape our current understanding of the topic. Be sure to mention the types of experiments done and discuss their findings but do not report the experimental procedure step-by-step. Include a figure to help discuss the data. What are the outcomes of this technology?

   Think about the following:

   - Which studies support your hypothesis/thesis/question?
   - Do some studies support alternative hypotheses?
   - Is there controversy in the scientific community over this topic, or is there general agreement?
   - What are the real and potential benefits and dangers of this scientific development?
   - What graphs, figures or tables might be relevant to include?

4. **Discussion**—this section discusses the current advances and results by putting them in context. Highlight any agreements or disagreements in the field and comment on possible reasons for those disagreements. How will the scientific development impact or potentially impact our lives?
5. **Conclusions/future directions**—this section summarizes your major points and points out the significance. It also discusses where the science is headed in the future and questions that remain based upon the current findings.
6. **References** in APA style

   Here are a few websites to help you with APA style —

   http://www.apastyle.org/learn/tutorials/basics-tutorial.aspx.
   http://owl.english.purdue.edu/owl/resource/560/01/.
   http://www.library.cornell.edu/resrch/citmanage/apa.

Symposium

You will present your poster by discussing your work with the class. Be prepared to talk about your work without reading directly from your poster. Remember, you should have a good understanding of your topic and you should be prepared to answer questions about your work.

Handout

Create a handout for your classmates outlining your work. Be sure to include:

- **Title** of a presentation; name; class
- **Background** and introduction
- **Current advances** and results
- **Discussion**
- **Conclusions/future directions**
- **References** in APA style

FROM THE STUDENT ACADEMIC NOTEBOOK p 24

Possible Topics

Biotechnology Topic	Rate your interest	Possible research question
Human Cloning		
Animal Cloning		
Transgenic (GM) Plants		
Transgenic (GM) Animals		
Gene Therapy		
Forensic DNA Data Banks		
Human Genome Project		
Pharmacogenetics		
Xenotransplantation		
Herbicide tolerance		
Engineered crops		
Insect tolerance		
Golden Rice		
Disease detection		
Repair of damaged organs and tissues		
Engineered proteins for treating disease		
Preserving endangered species		

Discuss how this task is similar to writing a paper, but instead of writing the information in a report format, they will need to display and discuss the information to the class.

Go over the template in the Academic Notebook page 18 (shown on the next page) to discuss the general formatting that will be expected. Have students lead the discussion of the template. Students will use the following headings (as this is not a poster using original research) in their poster.

- **Title** of a presentation; name; class
- **Background** and introduction
- **Current advances** and results
- **Discussion**
- **Conclusions/future directions**
- **References** in APA style

Ask students to examine the scoring rubric in Lesson 9 so that they know how their project will be evaluated. Explain how they can use this rubric to guide their work and their revisions.

Ask students to do a quick write of their initial reaction to the project prompt in their Academic Notebook page 17.

Ask students to share out their reactions to the prompt and what they will need to do to be successful. Chart and post the responses so that students can see the items they will need to do and guide their planning for the project.

Direct students to page 18 of the Academic Notebook that displays a template of the poster design. Review the sections and answer any questions students may have.

Tell the students that the subject of biotechnology encompasses many possible areas and topics for research. Explain that there is a partial list of possible topics for their research on page 19 of the Academic Notebook. Have students individually rate their interest in a potential topic on the form as a 5 for high interest to a 1 for no interest. For topics they rate highest (all 5s or at least 2-3 topics of interest per student), ask students to write a possible research question for the topic. Review responses with students and explain that, for the topics that interest them, they should be noting all relevant facts about DNA and DNA manipulation throughout the unit to help with their research.

FROM THE STUDENT ACADEMIC NOTEBOOK p 23

Your poster title goes here. (You can make the text bigger or smaller if needed).

Name

Teacher's Name

Class

Background and Introduction

This section introduces the topic, describes the questions you are asking, and provides a claim. In this section you will explain the science behind the particular method and connect it to what you have learned in class.

Describe the biotechnology—what is it?

How is the process accomplished? (The detailed description of your biotechnology application will lead to your claim.)

Current Advances and Results

This section presents the current issues, themes, and research goals. Where is this technology being used? Describe the important results and explain how those results shape our current understanding of the topic. Mention the types of experiments done and discuss their findings but do not report the experimental procedure step-by-step.

Think about the following:

- Which studies support your hypothesis/claim/question?
- Do some studies support alternative hypotheses?
- Is there controversy in the scientific community over this topic, or is there general agreement?
- What graphs, figures or tables might be relevant to include?

Include a figure to help discuss the data. What are the outcomes of this technology?

Conclusion/future directions

This section summarizes your major points and points out the significance. It also discusses where the science is headed in the future and questions that remain based upon the current findings.

References

List full references in APA style.

After reviewing the directions with students, discuss the project by asking the following questions:

- What is the purpose of the project?
- What will you need to do to complete the project?
- What will you need turn in?
- What are the elements of a scientific poster? What are the goals?

Teacher Checklist	**Use this list to ensure that you have completed all of the lesson components. I . . .**

- ☐ 1. Discussed science learning.
- ☐ 2. Introduced disciplinary literacy (how scientists approach literacy).
- ☐ 3. Provided an overview of the course.
- ☐ 4. Introduced the Academic Notebook.
- ☐ 5. Asked students to compare/contrast and summarize two views of the scientific method.
- ☐ 6. Discussed their findings as a whole class.
- ☐ 7. Discussed how knowledge builds in science.
- ☐ 8. Introduced BRCA.
- ☐ 9. Showed videos and websites about BRCA and asked students to take notes in their Academic Notebooks.
- ☐ 10. Discussed elements of the scientific article.
- ☐ 11. Used the abstract from the AJMG article to examine the specific elements.
- ☐ 12. Asked students to read claims from two articles on BRCA screening.
- ☐ 13. Asked students to work in small groups to apply their knowledge to articles on other genetic diseases.
- ☐ 14. Discussed elements of academic argument.
- ☐ 15. Asked students to summarize the arguments for the class.
- ☐ 16. Introduced the prompt and received its elements for the unit.

Lesson 2
Close Reading in Science: DNA

Overview and Rationale:

Students will continue to learn text annotation as a way to mark the text while they read. Annotations can be used in any field, because what is annotated can be tailored to the specific requirements of the discipline. In science, they should focus on the elements of the text that are important to scientists: processes, systems, models and explanations, diagrams, interactions, descriptions, classifications, evidence and so on. In our main text, an on-line biology text, it is very important to pay attention to diagrams and processes as well as the specific characteristics of DNA and RNA. Paying attention to these elements will help students to understand not only this chapter, but also science text in general.

Tasks/Expected Outcomes:

1. Students will learn about and practice close reading with a college-level science chapter on DNA.
2. Students will learn about how to approach both general and discipline specific vocabulary.
3. Students will be able to explain the processes involved while reading in the sciences.
4. Students will add to their understanding of the two levels of thinking required in this course: thinking like a scientist and thinking about learning in the sciences.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to 11-12th-grade texts and topics.

6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

English Language Arts Science/Technical Subjects Standards: Writing

1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes and audiences.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings though constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Scientific Terminology

Ability to locate and understand scientific words and phrases that identify key concepts and facts, processes or information.

3. Close Reading

Ability to interpret text with particular questions in mind that reflect scientific inquiry, and to use self-regulation to understand scientific processes presented in the text.

4. Science Inquiry

Ability to generate questions and to select appropriate research to advance and challenge explanations, corroborate evidence and evaluate sources and evidence.

5. Annotation and Note-taking

Ability to read purposefully, select and use relevant information; to summarize and/or paraphrase; to use and understand multiple representations of science processes.

Skills Cluster 3: Writing Process

1. Writing for a Purpose

Ability to write routinely for different tasks and purposes.

2. Reflective Writing

Ability to write reflectively based on synthesis of information and texts.

3. Writing for a Specific Audience

Ability to construct a writing to address a specific audience.

(www.literacydesigncollaborative.org)

Materials:

- Academic Notebook
- *Biology* openstax Chapter 14.1
- Annotation example
- "That Wild Streak? Maybe it Runs in the Family" *New York Times* article http://www.nytimes.com/2006/06/15/health/15gene.html?ref=dnaage&pagewanted=all

Timeframe:

100 minutes

Targeted Vocabulary:

Discipline Specific Words

- DNA
- chromosomes
- genome
- genotype
- phenotype
- haploid

General Academic Vocabulary

- paternity
- forensics
- genealogy
- pathogens
- predisposition

Activity One — Setting a Purpose for Reading (Approx. 10 minutes)

College and Career Readiness Standards: Science/Technical Reading– 2, 4, 5

Ask students to read the excerpt from Nist-Olejnik & Holschuh, *College Success Strategies, 4th Ed.*, 2013 in the Academic Notebook page 22. Discuss the strategies contained in the excerpt on what questions to ask when reading and how to approach the textbook. Ask students to also look at the sample text annotation on page 22 in the Academic Notebook. Identify a few items and ask how and why the notations help a student with a term or concept. Point out that there are tips for annotation on page 23 in the Academic Notebook. Review them with the students.

Ask students to examine the biology text, Chapter 14.1, pages 373-375. Begin by guiding students through the chapter examining the way the chapter is structured. They will discuss their expectations based on the format of the text. Ask students to identify which text features are important to pay attention to and which are not:

- Important: Chapter introduction, chapter outline, "By the end of this section, you will be able to science diagrams and figures, bold-faced words, explanations, characteristics, and details on science processes."
- Less important: photos (*Career Connections*, photos).

Guide the reading by first asking students what they know about DNA. Where have they seen/read/heard about it? They will focus on the standard of citing specifics from text sources. They will also learn how to read in multiple passes with different goals (vocabulary, making notes, etc.). Students will learn strategies for annotating their text to pull out the most relevant information. Students will share their annotations with a partner and in a full class discussion.

Activity Two — Text Annotation (Approx. 80 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 6

Ask students to read about text annotations in their Academic Notebooks page 21.

FROM THE STUDENT ACADEMIC NOTEBOOK p 21

What and How to Annotate During Reading

Because of the large amount of new terminology involved in learning science, it is important for you to read your science textbooks before class. In this way, you will be familiar with the terms and concepts discussed in the text and you will be able to build your understanding of the concepts as you listen in class. It is also a good idea to connect the concepts discussed in class with the concepts described in your text by comparing your lecture notes to your text annotations each time you read. This will help you follow the flow of the concepts and will help you understand how the ideas are connected.

When you annotate your science text, you need to match your annotations to the course expectations. For example, if you are expected to think at higher levels, be sure your annotations include more than just the bold-faced terms. If you are expected to be able to explain science processes, be sure your annotations help you learn to do just that. In general, it is a good idea to limit the amount of material you

annotate. Annotate big concepts and save the details for your rehearsal strategies. A big mistake that students make when annotating science is that they tend to annotate too much. It is also essential to focus on putting the ideas into your own words. This will help you monitor your understanding of what you have read and will keep you from copying exactly from the text. In addition, look for experiments and results or conclusions drawn from scientific theories, and seek to make connections between conclusions drawn from scientific theories, and seek to make connections between the experiments and the concepts they generate.

Science texts often contain diagrams or charts to explain concepts. Because science exams usually contain questions about the concepts described in diagrams or charts, you must be able to read and understand each one. As you read your text, annotate the diagrams and take the time to reflect on what they are depicting. A good self-testing strategy to make sure you fully understand the concept is to cover up the words in the diagram and try to talk through the information. If you can explain how the concept works, you've shown that you understand it. If you find that you cannot explain it, reread your annotations or the diagram text to be sure you understand the key points. In the annotation example on the next page, notice how the annotations focus on explaining the concepts rather than just memorizing the terms.

Work through the chapter introduction together together. Ask students to take turns reading the information aloud. Ask students to consider the following questions as you read: Why does the chapter start with a picture of a sheep? Where can DNA be used today?

Ask, what do the words *paternity*, *forensics* and *predisposition* mean in this introduction? These are not science-specific words. If you did not know the words, how could that impact your understanding of this section? What other words might be worth looking up? How can the context surrounding the word help?

Ask students to think about this sentence: "In humans, DNA testing is applied to numerous uses: determining paternity, tracing genealogy, identifying pathogens, archeological research, tracing disease outbreaks, and studying human migration patterns." Ask, **What examples can you think of, from what you have read or seen on TV, that would be examples of the types of DNA testing?**

Ask, what words can help you make sense of the word, gene? (Is defined as, a sequence of DNA.) Often you can define a word using the context of the rest of the sentence or paragraph. In this case, knowing the word deferred can help you figure out exonerate. **Other times you may find a word, that you have seen before, which is not defined in the context of the sentence because it was defined in a previous reading or chapter of the text. You will need to make sure that you understand these words as well, because they will be key to your understanding of the current reading**

Ask students to think about the word DNA. Use the root word chart in your Academic Notebook (pages 24-26) to think about the meaning of "Deoxyribonucleic Acid." (Note: ribo and acid are not contained in the chart. Ask students to think about their previous science knowledge to come up with the meanings of these roots.)

De = To take away from
Oxy = Oxygen
Ribo = A type of sugar
Nuc = Center
Acid = Acid-like molecule—it contains many hydrogen molecules.

Discuss what this means. What is it composed of? How can these roots tell us that? We will learn about the components of DNA in detail as we continue in this Unit.

Ask students to take a second pass at the material in the introduction to think about the vocabulary. Ask them to identify any words they do not know in this section by circling them in the text. They may mention deferred, mitochondrial genome, genotype, phenotype, haploid, etc. Discuss the meanings of the words by using context. Talk about how sometimes context cannot help. For example, "…analysis on a swab of evidence…" may not provide enough information to know exactly what a swab is. Ask students to refer to a dictionary for words that cannot be defined through context.

Ask students to annotate the Introduction to Chapter 14 on page 373). Discuss their annotations in pairs. What did they find important to annotate? How did they phrase their annotations? Were they complete enough or was more detail needed?

Ask students to annotate section 14.1 from page 374 to the top of page 375 including the picture and the explanation of Figure 14.3, and share their annotation with a partner. **In this section, Griffith discovered "bacterial transformation," but really doesn't know how it happened. How did his "experiment" lead to his discovery?** Look for explanations and trace the steps of the experiment (perhaps list them on the board or chart paper) to gives students a chance to understand the text and help struggling students to develop a strategy to map what they read in a text.

Now move to the *New York Times* article —
http://www.nytimes.com/2006/06/15/health/15gene.html?ref=dnaage&pagewanted=all.

Ask a student to read the first paragraph aloud. What is this article going to be about? How do they know?

There may be a good deal of unfamiliar vocabulary in this article. Divide students into groups to examine the vocabulary on one of the pages of text. Have them circle the words in the text. Share out words as a whole class and use the context to figure out word meanings. Many of these words are not science-specific. Ask students to separate science from non-science words as they discuss.

Ask students to read the article with a partner. They will annotate the article as they read. Have the partners discuss their annotations at the end of each page of text. Direct students to the annotation checklist in the Academic Notebook. Ask students to use the checklist to discuss their partner's annotations to this point.

Discuss the article as a whole class by asking the following text dependent questions:

- What does the text say about the role of DNA in terms of human behavior and habits?
- What controversies or ethical issues does the article present?
- How does the author think that increased knowledge about the role of DNA on personality and individual traits will impact society?

Discuss the use of annotations as a class: What did they find important to note in this article? What is similar about annotating a textbook versus annotating a popular press

science article? What is different? What did they learn from the article about how DNA technology has impacted our lives?

Ask students what they liked and did not like about using annotation, both of a textbook and of a media article. Some may say that it takes a long time to annotate or that it is hard to figure out what is important to note. Be sure to let students know that annotation is a strategy that takes a while to master and that they will likely find it worth the effort when they study for the final and realize they remember what they have learned. In fact, close reading of any type is going to take longer but is crucial for understanding and comprehending complex text.

Assessments:

Outcome 1: Students will learn about and practice close reading with a college-level science chapter on DNA.

Outcome 2: Students will learn about how to approach both general and discipline specific vocabulary.

Outcome 3: Students will be able to explain the processes involved while reading in the sciences.

- Text annotation (see Annotation Checklist).

Annotation Checklist

- ☐ Your annotations are perfect! Keep up the good work.
- ☐ You have missed many key ideas. Go back and annotate them.
- ☐ You need to put your annotations in your own words—do not copy from the book!
- ☐ Be briefer in your annotations. You do not need to write in full sentences.
- ☐ You have ignored the graphic aids. Annotate them.
- ☐ You need to note the specific examples—they could reappear on the exam.
- ☐ You need to enumerate the specific facts, characteristics, causes, events, etc., in the margin or in the text. Get the details, too!
- ☐ Your annotations need to focus on the key ideas more and less on details.
- ☐ You are underlining too much—work more on writing your summaries in the margin.
- ☐ You are annotating too much! It will take you forever to do a chapter.
- ☐ You are annotating too little! You do not have enough information annotated to use as a study aid.
- ☐ You need to develop some symbols of your own and use them.
- ☐ You need to develop a method for organizing your annotations.
- ☐ Please annotate these sections or pages again.

p. _____ p. _____

p. _____ p. _____

Activity Three	Weekly Reflection (Approx. 10 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 9, 10; Writing– 9

Students will write a reflection on learning at two levels in their Academic Notebook: what they learned about science and what they learned about literacy.

FROM THE STUDENT ACADEMIC NOTEBOOK p 27

Weekly Reflection: Week 1

1. Think about the science. What would scientists pay attention to in terms of genetic testing? How does this differ from what patients would pay attention to? Why?

2. Think about your learning. How will this experience change the way you approach reading in the sciences? What strategies did you use that helped you understand what you were reading?

Assessment:

Outcome 4: Students will add to their understanding of the two levels of thinking required in this course: thinking like a scientist and thinking about learning in the sciences.

- Weekly Reflection

Evaluation Rubric			
• Reflection references the resources read.	No	Somewhat	Yes
• Reflects on the learning of science.	No	Somewhat	Yes
• Shows a deep understanding of both the science and the learning.	No	Somewhat	Yes

Teacher Checklist	**Use this list to ensure that you have completed all of the lesson components. I . . .**

- ☐ 1. Discussed the text features of a biology text.
- ☐ 2. Presented the text annotation strategy.
- ☐ 3. Began the discussion of the biology text by reading as a class.
- ☐ 4. Discussed learning vocabulary through context.
- ☐ 5. Asked students to read and annotate Chapter 14 introduction and 14.1 of the biology text.
- ☐ 6. Asked students to read and annotate *New York Times* article on DNA.
- ☐ 7. Asked students to identify science and non-science vocabulary terms in the article.
- ☐ 8. Discussed the article as a class.
- ☐ 9. Debriefed on student experiences using text annotation.
- ☐ 10. Provided annotation feedback to students using the annotation checklist.
- ☐ 11. Asked students to complete the weekly reflection in their Academic Notebook.

Lesson 3
Discovery of DNA Structure

Overview and Rationale:

Students will build their understanding of the structure of DNA through reading multiple sources. Students will also build on their close reading strategies by reading different types of text. The class will begin with the famous Watson and Crick article, debuting their discovery of DNA structure. Based on this article, students will create a rough model of the structure of DNA, drawing and labeling as much as they can based on the article. They will also write a paragraph that explains why the structure of DNA is so important. Students will then read the article from *Popular Science* that reports on this important discovery. Using information from this article, students will revise their diagram of the structure of DNA and their explanation as to why the structure of DNA is so important. Finally, students will read Chapter 3.5 of the biology text to add to or edit their diagram of DNA and explanation of the importance of the structure of DNA. In this lesson, students will build understanding of the structure of DNA by first consulting historical scientific texts to create a diagram of DNA, and then corroborating this information across multiple sources.

Tasks/Expected Outcomes:

1. Students will understand the characteristics of DNA.
2. Students will read historical scientific articles regarding the discovery of the structure of DNA.
3. Students will create a diagram of DNA based on multiple sources, adding to and editing their model with each new source.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes or information presented in a text by paraphrasing them in simpler but still accurate terms.

4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to 11-12th-grade texts and topics.

6 Analyze the author's purpose in providing an explanation, describing a procedure or discussing an experiment in a text, identifying important issues that remain unresolved.

8 Evaluate the hypotheses, data analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

English Language Arts: Writing

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.

9 Draw evidence from literary or informational texts to support analysis, reflection and research.

10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes and audiences.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings though constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Scientific Terminology

Ability to locate and understand scientific words and phrases that identify key concepts and facts, processes or information.

3. Close Reading

Ability to interpret text with particular questions in mind that reflect scientific inquiry, and to use self-regulation to understand scientific processes presented in the text.

4. Science Inquiry

Ability to generate questions and to select appropriate research to advance and challenge explanations, corroborate evidence and evaluate sources and evidence.

5. Annotation and Note-taking

Ability to read purposefully, select and use relevant information; to summarize and/or paraphrase; to use and understand multiple representations of science processes.

Skills Cluster 3: Writing Process

1. Writing Explanatory Texts

Ability to write an explanatory text that demonstrates understanding of a concept, procedure or structure.

1. Writing for a Purpose

Ability to write routinely for different tasks and purposes.

2. Reflective Writing

Ability to write reflectively based on synthesis of information and texts.

(www.literacydesigncollaborative.org)

Materials:

- Watson and Crick article
- *Popular Science* article
  http://www.popsci.com/archive-viewer?id=uSADAAAAMBAJ&pg=66.
- Section 3.5 of the biology text
- Academic Notebook

Video clips

- Watson and Crick DNA Story
  http://www.youtube.com/watch?v=OiiFVSvLfGE.
- James Watson explains base pairing
  http://www.youtube.com/watch?v=PDeaLxoL75M.

Timeframe:

100 minutes

Targeted Vocabulary:

Discipline Specific Vocabulary

- nucleic acids
- ribonucleic acid
- genome
- nucleotides

General Academic Vocabulary

- helix
- dyad

General Vocabulary Used in a Disciplinary Way

- base

Activity One — Reading Scientific Articles (Approx. 30 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 6, 8, 9; Writing– 2, 10

Remind students about the components of scientific articles discussed during Lesson One. The first article the students will be reading is from the scientific journal *Nature*, which is written by scientists for scientists. Explain to students that scientists have field-specific scientific journals that they use to publish their work for other scientists. These journals are peer-reviewed, highly formulaic and are full of scientific jargon. As teachers, we understand that students will not understand every word of these types of articles, but it is important that students are exposed to this type of writing, as they will be expected to use these articles in their research. There are a few words, however, that will impact student understanding of the article if they do not know what they mean:

- Phosphate—a salt of phosphoric acid.
- Helix (helical)—something spiral in form.
- Dyad—pair of two.

Discuss the meaning of these words by asking students what they know about them. Ask if they have ever heard the terms. Ask where they may have seen them in the past (Chemistry, math, etc.). Ask them to be on the lookout for these words and other unfamiliar terms as they read. Remind them to use the annotation and close reading strategies as they begin to read.

Ask students to read the first paragraph of the Watson and Crick article in their Academic Notebooks page 29. What is the purpose of the article (to suggest a structure for DNA)?

Ask students to read paragraphs two and three in pairs. Then, discuss the paragraphs as a class. What is the main point of this paragraph (to discuss why previous theories on DNA structure are incorrect)? What was wrong with those previous attempts at explaining DNA structure?

Ask students to finish reading the Watson and Crick article in pairs, discussing the ideas after each paragraph with their partner.

No. 4356 April 25, 1953 NATURE

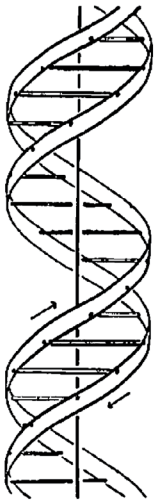
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey[1]. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.



This figure is purely diagrammatic. The two ribbons symbolize the two phosphate–sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's[2] model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each chain every 3·4 A. in the *z*-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.

The structure is an open one, and its water content is rather high. At lower water contents we would expect the bases to tilt so that the structure could become more compact.

The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical *z*-co-ordinates. One of the pair must be a purine and the other a pyrimidine for bonding to occur. The hydrogen bonds are made as follows: purine position 1 to pyrimidine position 1; purine position 6 to pyrimidine position 6.

If it is assumed that the bases only occur in the structure in the most plausible tautomeric forms (that is, with the keto rather than the enol configurations) it is found that only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally[3,4] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data[5,6] on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the conditions assumed in building it, together with a set of co-ordinates for the atoms, will be published elsewhere.

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at King's College, London. One of us (J. D. W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis.

J. D. WATSON
F. H. C. CRICK
Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems,
Cavendish Laboratory, Cambridge.
April 2.

[1] Pauling, L., and Corey, R. B., *Nature*, 171, 346 (1953); *Proc. U.S. Nat. Acad. Sci.*, 39, 84 (1953).
[2] Furberg, S., *Acta Chem. Scand.*, 6, 634 (1952).
[3] Chargaff, E., for references see Zamenhof, S., Brawerman, G., and Chargaff, E., *Biochim. et Biophys. Acta*, 9, 402 (1952).
[4] Wyatt, G. R., *J. Gen. Physiol.*, 36, 201 (1952).
[5] Astbury, W. T., Symp. Soc. Exp. Biol. 1, Nucleic Acid, 66 (Camb. Univ. Press, 1947).
[6] Wilkins, M. H. F., and Randall, J. T., *Biochim. et Biophys. Acta*, 10, 192 (1953).

After reading, ask students to complete the questions in part I of the "Building Your Understanding of the Structure of DNA" prompt in their Academic Notebooks pages 30-31.

FROM THE STUDENT ACADEMIC NOTEBOOK p 30 and p 31

Building your Understanding of DNA Structure

Part 1:

After reading the Watson and Crick's article in Nature on their discovery of the structure of DNA, draw a diagram of DNA below, labeling all components of your diagram.

Explain the importance of the structure of DNA in understanding how our genetic material functions to make us who we are.

As part of a whole-class discussion, ask students the following text-dependent questions:

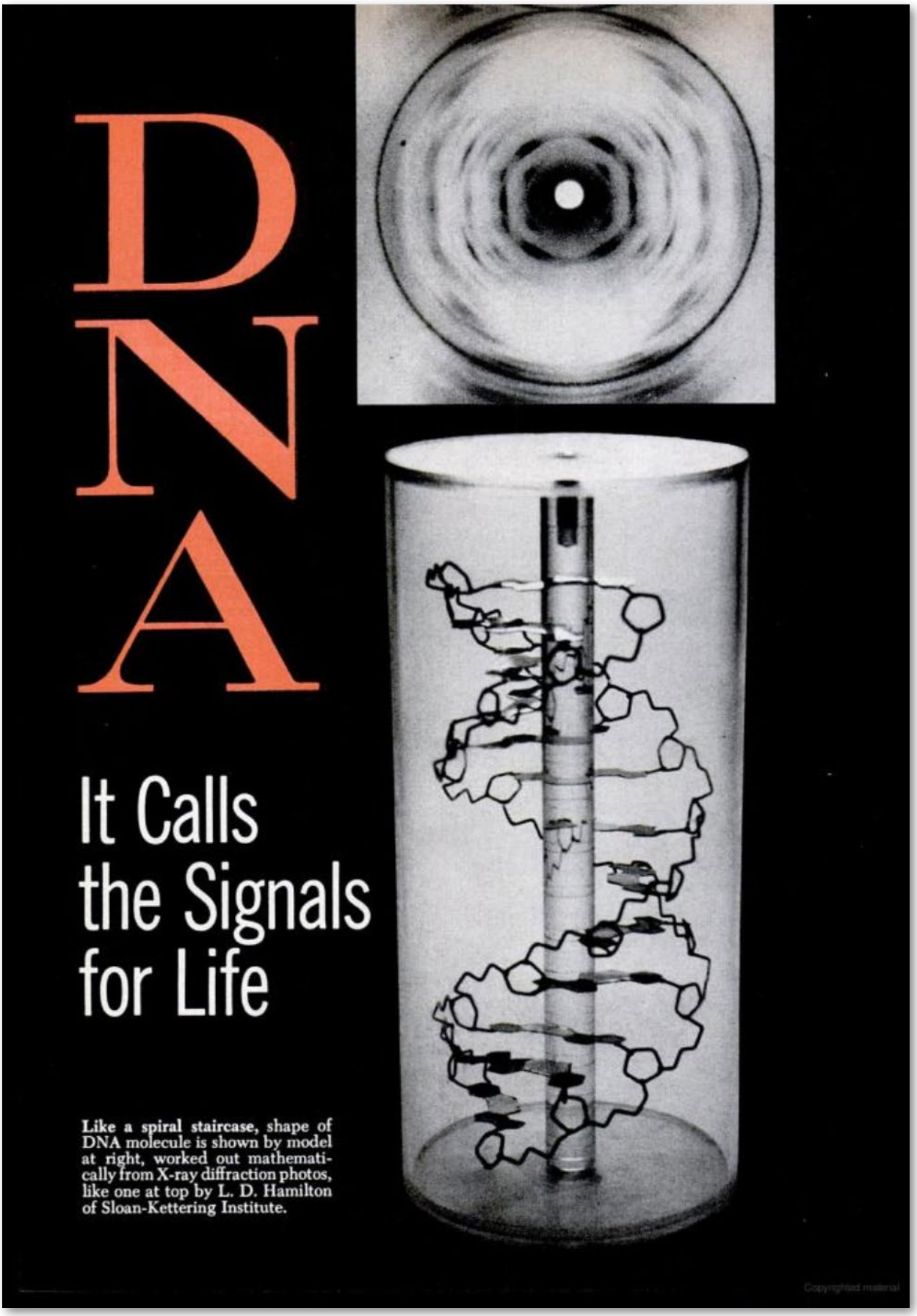
1. How did Linus Pauling's model differ from Watson and Crick's model for DNA?
2. What type of bond holds the bases together?
3. A very important observation is made about base pairing in this article. What is the significance of how bases pair up?

Ask students to locate and share where in the article they find evidence to support their answers to these questions.

Activity Two — Reading Popular Articles (Approx. 30 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 6, 8, 9; Writing– 2, 10

Ask students to read paragraphs one through three of the article from *Popular Science Magazine* (pages 33-38 in the Academic Notebook). Discuss how these articles are often written in more layman's terms and are easier to understand. These articles allow people to gain a general understanding of the scientific principles, but may lack in some detail or depth. The article students will be reading was written for *Popular Science Magazine* in 1963 after the Nobel prize was awarded to Watson and Crick for the discovery of the structure of DNA. This article reviews their findings and discusses the importance of this discovery. (http://www.popsci.com/archive-viewer?id=uSADAAAAMBAJ&pg=66).


DNA
It Calls the Signals for Life
Like a spiral staircase, shape of DNA molecule is shown by model at right, worked out mathematically from X-ray diffraction photos, like one at top by L. D. Hamilton of Sloan-Kettering Institute.
Copyrighted material

How three men got the Nobel Prize for solving a jigsaw puzzle: assembling the pieces of a molecule that made you what you are—and keeps you ticking

By Wallace Cloud

LAST December an American biologist and two English physicists received formal recognition, in the shape of a Nobel Prize, for a discovery made 10 years ago—a discovery that started a chain reaction in biology.

They determined the structure of a molecule that provides answers to questions scientists have been asking for over a century:

- How does a heart muscle "know" how to beat?
- How does a brain cell "know" how to play its role in thinking and feeling?
- How do the cells of the body "know" how to grow, to reproduce, to heal wounds, to fight off disease?
- How do infectious bacteria "know" what diseases to cause?
- How do single fertilized egg cells, from which most of nature's creatures begin, "know" how to become plants, animals, people?
- If one such cell is to multiply and form a human being, how does it "know" how to produce a potential Einstein or a Marilyn Monroe?

The stuff that genes are made of. Sounds like a lot to expect of a molecule—even one with a jaw-breaking name like deoxyribonucleic acid (known more familiarly as DNA). But it's scientific fact that DNA is what genes are made of. DNA molecules supply the basic instructions that direct the life processes of all living things (except a few viruses). The DNA molecule contains information in a chemical code—the code of life.

The effects of discovery of the structure of DNA have been called "a revolution far greater in its potential significance than the atomic or hydrogen bomb." Professor Arne Tiselius, President of the Nobel Foundation, has said that it "will lead to methods of tampering with life, of creating new diseases, of controlling minds, of influencing heredity—even, perhaps, in certain desired directions."

I asked the American member of the Nobel Prize trio, Dr. James D. Watson, about these speculations in his laboratory at Harvard. It was a few weeks before he flew to Stockholm to receive the award

CONTINUED

Three Nobelmen

Dr. James D. Watson, now at Harvard, worked on DNA in 1953 while in England.

Dr. Francis H. C. Crick of Cambridge was Watson's partner in the research.

Dr. Maurice H. F. Wilkins, King's College, London, made essential X-ray photos.

along with Dr. Francis H. C. Crick of Cambridge University and Dr. Maurice H. F. Wilkins of King's College, London.

The boyish 34-year-old Nobelman, who did the prize-winning research in England when he was only 25 (he entered college at 15, had been a Quiz Kid before that, in the days of radio), refused to endorse the wilder predictions about the future of DNA research. He said, "The average scientist busy with research looks ahead anywhere from an hour to two years, not more."

Conceding that discovery of the structure of DNA was as important as the working out of atomic structure that led to the atom bomb, he added, "It will have a very profound effect, slowly, on medicine. Doctors will stop doing silly things. Our knowledge of DNA won't cure disease, but it gives you a new approach—tells you how to look at a disease."

Dr. Watson went on to explain just what he and his co-workers discovered during those days of inspired brainwork in England, back in 1953, and how they did it.

The discovery was not the work of an institute-full of technicians, he said, but the product of four minds: He and Crick did the theoretical work, interpreting cryptic X-ray diffraction photos made by Wilkins, who had as collaborator an English woman scientist, Dr. Rosalind Franklin. She died in 1958. She "should have shared" the Nobel Prize, said Dr. Watson.

Picking up the thread. DNA was not a newly discovered substance. It had been isolated in 1869, and by 1944 geneticists were sure it was the substance of the genes—the sites of hereditary information in the chromosomes. Then they started asking, "How does it work?" That's the question Watson and his co-Nobelists answered.

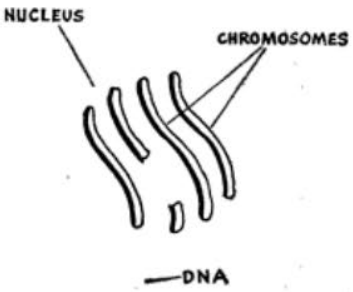
They knew DNA as one of the most complex of the "giant molecules" known to man. It was believed to have a long, chainlike structure consisting of repeating groups of atoms, with side groups sticking out at regular intervals.

The shape of the DNA molecule was important. In the cell, many of the larger molecules work together like machine parts, and their mechanical properties are as important as their chemical activity. However, even the electron microscope, through which it is possible to see some of the biggest giant molecules, shows DNA only as a thread, without detail.

One way of "looking" at molecules is to take them apart by chemical treatments that make

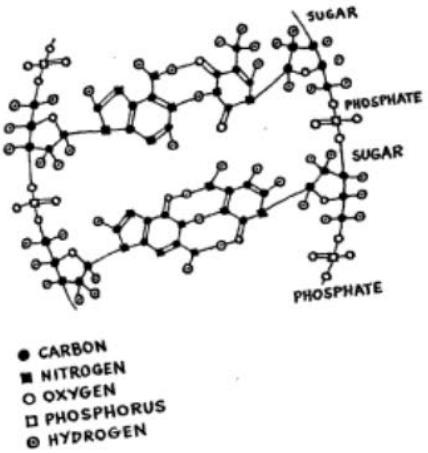
[*Continued on page 186*]

How DNA molecules



A miniature chemical factory, the living cell (diagramed above) is controlled by "executive molecules" of DNA—deoxyribonucleic acid. In all plant and animal cells, DNA is located in chromosomes, threadlike bodies in the nucleus. Bacteria have simpler structures, but are also directed by DNA.

Control depends on the ability of DNA molecules to store and transmit information. Long, twisted strands of DNA are archives of instructions for



all processes of the cell.

Information is recorded in a molecular code made possible by the structure of the DNA molecule, detailed above.

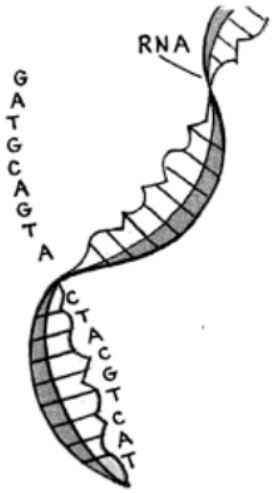
Twin backbones are repeating chains of submolecular units, called deoxyribose sug-

supply instructions to direct life processes of living things

ars, linked together by phosphate bonds. Bridging across are pairs of subunits named adenine, thymine, cytosine, and guanine—usually called A, T, C, and G.

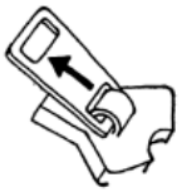
These units serve as a four-letter alphabet. As shown below, their sequence spells "words" that are meaningful to the cell.

Instructions are read by means of another kind of molecule, RNA (ribonucleic acid), a single twisted chain with side groups that correspond to the subunits of DNA. RNA molecules are built by the chemical machinery of the cell, using one strand of a DNA molecule as a template. Then the RNA molecule peels off, acts as a messenger to deliver instructions elsewhere in the cell.



Two-stranded structure of DNA makes possible use of the same information-transfer mechanism for copying DNA molecules, so that hereditary instructions can be passed from generation to generation.

Pairing of subunits follows a rule: A can pair only with T, C pairs only with G. (Note that this rule is followed throughout illustration.) Thus, the strands are not identical, but are complementary, and each can serve as a template for the reconstruction of the other.



When a DNA molecule is to be copied, the molecule "unzips," as shown symbolically above. Then the machinery of the cell uses the same zipper-like action to reconstruct each missing half, as shown below, from subunits freely available in the nucleus of the cell. Now there are two DNA molecules identical with the original one.

Every DNA molecule in the chromosomes of a cell is copied prior to cell division, the basis of all reproduction. When the cell divides, the chromosomes split in half and a full complement of half-chromosomes goes into each new cell.

Since all the information-bearing DNA molecules have doubled, each cell now contains exactly the same stored instructions as the original parent cell, and can carry out the same life processes.

That's how you got those big brown eyes. (The family secret for manufacturing the pigment in your eyes was handed down by means of your ancestral DNA.)

DNA: It Calls the Signals for Life

[Continued from page 68]

small molecules out of big ones. In the case of DNA, the pieces—six kinds of submolecular units—had been identified. Now it was necessary to figure out how the jigsaw puzzle fitted together.

Another way is to use X rays, but in a special manner. A technique called X-ray diffraction lets physicists take a peculiar kind of look inside certain kinds of molecules—those that form crystals.

DNA extracted from cells and purified is a jelly-like material. Not much resemblance to a crystal, you might think. But when it's pulled like taffy and dried under the right tension, it forms fibers that do have a complicated crystalline structure.

One of the Nobel Prize winners, Dr. Wilkins, is a physicist who worked in this country on the Manhattan Project. After World War II, back in England, he got interested in biological problems and became a biophysicist. During the early 1950s he perfected a method of making X-ray diffraction photos of DNA fibers.

Such photos are taken by shooting a very narrow beam of X rays through the sample. Some of the X rays are bent by interaction with atoms. The emerging X-ray waves interfere with each other to form a pattern that registers on the film.

X-ray diffraction photos do not show the outlines of the molecules they represent. They are in "reciprocal space"—small distances on a photograph stand for large spaces in the molecule, and vice versa. The pictures must be interpreted by mathematical analysis; and the more complex the molecule, the more difficult that is.

Drs. Crick and Watson began to work on methods of interpreting the X-ray diffraction photos of DNA. They met at Cambridge, where Watson had gone to do research a couple of years after getting a Ph. D. from Indiana University.

Working backwards. Crick had worked out a theory for predicting what X-ray pictures of various molecular models would look like. That is, the pictures were so hard to interpret they had to work backwards: devise a model, then determine mathematically what its X-ray diffraction equivalent should be. Then the prediction was compared with actual distances and angles on the X-ray photos.

The two experimenters shared with Wilkins the idea that a twisted, helical molecular structure might fit the X-ray data (it had been discovered that such twists exist in other molecules produced by the cell). They built a model of rods, clamps, and sheet-metal cutouts (representing the various known pieces of the jigsaw puzzle), and evaluated it mathematically.

This first model didn't prove out, and they temporarily dropped the problem, going on to other research. Some months later, in February, 1953, they learned of a structure proposed for DNA by Linus Pauling, Caltech's Nobel-Prize-winning chemist. From their previous work, they knew that Pauling had to be wrong. This stimulated them to try another model, incorporating new information about the exact shapes of some of the subunits of DNA.

A month later they had a model that fitted the X-ray data closely. From it, they worked out the profound "Watson-Crick hypothesis," which explains how the DNA molecule does its work in the cell. That hypothesis has been tested through ingenious experiments in numerous laboratories, and is accepted as gospel in the new world of molecular biology.

The key to life. The DNA molecule stands revealed as a double helix shaped roughly like a twisted ladder.

The two legs of the ladder are identical, but the rungs are not, and this is the key to the molecule's ability to store information. The order of the four different subunits that make up the rungs is the code of life.

The way the subunits link across the rungs is the key to DNA's ability to transmit information. Each rung actually consists of two units, but the pairing of the units follows definite rules; the molecule can "unzip," and each half serves as a template for rebuilding the missing half, producing two new molecules identical to the original one.

The Watson-Crick hypothesis has made possible a new view of the "molecular basis of life": In the cell—really a miniature chemical factory—DNA molecules contain the instructions that tell the molecular machinery of the factory what new molecules to build. The product molecules in turn determine the function of the cell—whether it's a blood cell, a nerve cell, a sperm cell, or (if not part of a many-celled organism) perhaps a harmful bacterium.

DNA: It Calls the Signals for Life

In this way, the information stored in DNA molecules specifies an entire community of cells, such as those that add up to a human being—the color of his hair and eyes, his basic aptitudes, his built-in sensitivity or resistance to disease.

Programing a man. An individual DNA molecule is about 10,000 subunits long (that is, there are that many rungs on the ladder), and the list of instructions necessary to specify a human being is about 10 billion DNA units long. If the DNA molecules containing that message were placed end to end, they would make a strand 10 feet long, but only one twelve-millionth of an inch thick. Actually the strands are bundled in the microscopic bodies called chromosomes, in the nucleus of each cell, which hold the machinery of heredity.

The specifications must be passed on from generation to generation. This takes place during the cell division, when the chromosomes divide. Preparatory to cell division, the DNA molecules in the chromosomes have unzipped and have been copied by the machinery of the cell.

Work in the cell, controlled by DNA, is important not only to healthy life, but also to disease. Viruses, for example, take over cells and turn them into virus factories by interfering with the normal flow of instructions and substituting new instructions. Hereditary diseases are the result of "errors" that have crept into the coded instructions during copying of DNA molecules. Such changes also transform normal cells into cancer cells, which have "forgotten" their usual roles and "learned" new functions.

Those facts explain why DNA has created such excitement among biologists. If a way can be found to send man-made chemical messages into cells and alter the instructions stored there by DNA molecules, almost anything is possible.

But that isn't likely to come about this year or next. First the code must be deciphered. That's where most of the research on DNA is concentrated today.

Another unsolved problem, perhaps even more mysterious, is how cells "decide" to use particular instructions stored in their DNA archives. Discoveries on this frontier will explain how cells respond to outside stimuli—and how a single fertilized cell can multiply selectively to produce the many different kinds of specialized cells that make up a human being. ■■

Ask students to look at the following "juicy sentences" from the second paragraph of the article:

The discovery of DNA structure is **"a revolution far greater in its potential significance than the atomic or hydrogen bomb."**

Professor Arne Tiselius, President of the Nobel Foundation, has said that it **"will lead to methods of tampering with life, of creating new diseases, of controlling minds, of influencing heredity—even, perhaps, in certain desired directions."**

What do these sentences tell you about the impact of the discovery of DNA structure on the world in 1963? What were the hopes and fears?

Ask students to read the rest of the article with a partner. As they read, they should focus on expanding their understanding of the structure of DNA and the implications of understanding that structure on the sciences.

After reading, ask students to complete Part II of the "Building Your Understanding of the Structure of DNA" prompt in their Academic Notebooks page 32.

FROM THE STUDENT ACADEMIC NOTEBOOK p 32 and p 39

Part II:

After reading the Popular Science article describing the Nobel Prize-winning scientists' discovery of DNA, go back to your original diagram of DNA. Make changes or add to your diagram based on additional understanding gained from this article. You can also re-draw your diagram.

Add to your explanation of the importance of the structure of DNA in understanding how our genetic material functions to make us who we are.

Activity Three — Reading Textbook Explanations (Approx. 30 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 6, 8, 9; Writing– 2, 9, 10

Ask students to read and annotate Section 14.2 in the biology text, pages 377-379. After reading two scientific articles on the structure of DNA and developing a conceptual diagram of the structure of DNA based on their understanding, students will then read and annotate Section 14.2 that describes the structure of DNA in detail. Students should pay special attention to the diagrams in this section as they illustrate the details about the structure of DNA. Students should read and annotate Section 14.2 individually.

Ask students to complete Part III of the "Building Your Understanding of the Structure of DNA" prompt in their Academic Notebooks pages 40-41 after reading the section.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 40-41

Part III:

After reading and annotating Section 14.1 in the biology text, paying special attention to the diagrams and figures, go back to your original diagram of DNA. Make changes or add to your diagram based on additional understanding gained from this article. You can also re-draw your diagram.

Add to your explanation of the importance of the structure of DNA in understanding how our genetic material functions to make us who we are.

Activity Four — Reflection (Approx. 10 minutes)

Show the following videos on the discovery of DNA. Show a two-minute video clip of Watson and Crick discussing their roles in the discovery and a two-minute clip of Watson explaining base pairing:

- http://www.youtube.com/watch?v=OiiFVSvLfGE
- http://www.youtube.com/watch?v=PDeaLxoL75M

The discovery of the structure of DNA was a profound finding based on the use of models. **Ask students to reflect on the importance of models, such as their diagram of DNA, in helping scientists gain understanding of complex concepts by asking the following questions:**

- How did drawing the structure of DNA aid in your understanding of the concept? (Ask several students to share their diagrams.)
- How did using multiple sources add to your model?
- How do models help to explain science concepts?

Discuss how scientists use models in a variety of ways that can help them illustrate an abstract concept and make predictions of how something may function. Students will learn more about using models for prediction later in this unit.

Assessments:

Outcome 1: Students will understand the characteristics of DNA.

Outcome 2: Students will read historical scientific articles regarding the discovery of the structure of DNA.

Outcome 3: Students will create a diagram of DNA based on multiple sources, adding to and editing their model with each new source.

Evaluation Rubric			
• Student responses to questions reflect an understanding of the concepts presented in each source.	No	Somewhat	Yes
• Student model of DNA reflects an understanding of the structure of DNA.	No	Somewhat	Yes
• Student explanation in the Academic Notebook is based on information presented in the text.	No	Somewhat	Yes

Teacher Checklist	**Use this list to ensure that you have completed all of the lesson components. I . . .**

- [ ] 1. Reviewed the components of scientific articles.
- [ ] 2. Discussed the vocabulary in the Watson and Crick article.
- [ ] 3. Guided student reading of the academic article.
- [ ] 4. Asked students to respond to the Part I questions in their Academic Notebook.
- [ ] 5. Discussed the Watson and Crick article as a class.
- [ ] 6. Guided student reading of *Popular Science* article.
- [ ] 7. Asked students complete the Part II questions in their Academic Notebook.
- [ ] 8. Guided student reading of Section 3.5 in the biology text.
- [ ] 9. Asked students complete the Part III questions in their Academic Notebook.
- [ ] 10. Reflected on diagramming DNA using multiple sources.
- [ ] 11. Introduced the role of models in science.

Lesson 4

Close Reading and Annotating for Concepts

Overview and Rationale:

Students will read an overview of the complex process by which a person's DNA can determine their traits. This process can be confusing to many students and includes terminology of many related words. Students will learn the strategy of concept mapping to show relationships between key terms. This process will help students gain a deeper understanding of the process of genetic manipulation as well as to learn a strategy for studying difficult concepts.

Tasks/Expected Outcomes:

1. Students will read and annotate the text describing the function of DNA.
2. Students will build their understanding of the concepts through vocabulary learning.
3. Students will create a concept map connecting key scientific terminology in this complex process of genetic manipulation.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes or information presented in a text by paraphrasing them in simpler but still accurate terms.

3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

4 Determine the meaning of symbols, key terms and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

5 Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

10 By the end of grade 12, read and comprehend science/technical texts in the grades 11-12 text complexity band independently and proficiently.

English Language Arts Standards: Writing

9 Draw evidence from informational texts to support analysis, reflection and research.

10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a day or two) for a range of discipline-specific tasks, purposes and audiences.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings through constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Close Reading

Ability to interpret text with particular questions in mind that reflect scientific inquiry, and to use self-regulation to understand scientific processes presented in the text.

3. Science Inquiry

Ability to generate questions and to select appropriate research to advance and challenge explanations, corroborate evidence and evaluate sources and evidence.

4. Scientific Processes

Ability to understand and use scientific processes as a way to answer questions and evaluate text information.

5. Annotation and Note-taking

Ability to read purposefully, select and use relevant information; to summarize and/or paraphrase; to use and understand multiple representations of science processes.

6. Organizing Notes

Ability to organize and synthesize information.

Skills Cluster 4: Writing Process

1. Writing for a Purpose

Ability to write routinely for different tasks and purposes.

2. Reflective Writing

Ability to write reflectively based on synthesis of information and tasks.

(www.literacydesigncollaborative.org)

Materials:

- Academic Notebook
- Constructing your first concept map directions
- 3x5 cards for each group

Timeframe:

100 minutes

Targeted Vocabulary:

- genome
- genomics
- biotechnology
- cloning
- donor
- haploid
- diploid

Activity One — Close Reading of Science Processes (Approx. 40 minutes)

Common Core Standards: Science/Technical Reading– 1, 2

Students will read and annotate Sections 14.3 – 14.5 (pages 384-391) in the biology text. This section can be very difficult for struggling students. Please read and understand the content thoroughly in order to help students to map the content carefully and to remove frustration. Students should read with the purpose of trying to determine HOW DNA replicates in smaller as well as more complex organisms in order to stand how current trends in biotechnology affect the structure of genes. There is a good deal of terminology involved in these sections, which can make them a challenge. Ask students to circle the terms they need to remember as they read. They will be using these terms in the next two activities.

Read and annotate the first two paragraphs of Section 14.1 (pp. 384- the bottom of 385) together, including Figure2 14.12 and 14.13. Conduct the reading as a think aloud in which you or a student reads a segment aloud and then you annotate according to your observation of the text. Such a sequence might look like this:

1. Read the first sentence.
2. "Elucidation?" What does that mean? circle the word to be looked up.
3. "Double helix" Draw a line to the margin and draw a double helix in the margin based on the work already done in this unit.
4. Read the second sentence.
5. Circle "template" and "complementary." Need to check definitions. I think a template is like a pattern to follow. draw a line from the circled word to the margin and write, "pattern." Write "complementary" and "complimentary" on the board or chart paper and ask how the meaning of these words are different. As where students have seen these words before. Complement – matching or going together; Compliment – to praise. So, this sentence means that each strand of the double helix is a pattern for a new, matching strand. Draw a line from "complimentary" to the margin and write, "matching."
6. Read the next two sentences.
7. This means that scientists didn't know how the process of replicating these strands happened, but they thought of three ways: conservative, semi-conservative, and dispersive. Put a bracket around these three words in the text.

Ask students to turn to page 385 in the biology text and examine Figure 14.12 and the caption.

1. Ask, **Identify where the "parent DNA" is on the diagram and label it. What color is it? Identify the "daughter DNA" on the diagram and label it. What color is it?**
2. Ask students to locate the words "Conservative, Semi-conservative and Dispersive" on the diagram and circle each one. Ask the students to explain the conservative model using just the colored figures in the diagram (The parent DNA strands stay together and produces a different daughter DNA). Ask students to explain the semi-conservative model (each parent produces it's own new daughter DNA strand). Ask students to explain the dispersive model (the DNA of the parent and daughter

strands contain elements of both the old ad new). Ask how many of you think that the correct model is "conservative?" "semi-conservative?" "dispersive?"

3. Ask students to check their explanations of the three models to what the text says in the next paragraph. As students to add anything new or to change their annotations based on the text explanation.

Next, model a reading of Figure 14.13 and its explanation (page 385 of the text).

1. Read aloud the first paragraph and then explain in your own words what Meselson and Stahl did (The grew several generation of the *E. coli* bacteria in a "heavy" isotope of nitrogen. Underline "heavy" isotope of nitrogen" and draw a line to the red beaker in the diagram. Underline the last part of the sentence in this paragraph that notes that eventually the nitrogen isotope gets into the DNA of the *E. coli*.
2. Now read the caption to Figure 14.13 at the bottom of the page. Note that, here, after boiling the *E. coli* in the heavier isotope, the scientists grew the bacteria in a "lighter" isotope of nitrogen, and, after spinning in a centrifuge, noticed that almost half of the *E.coli* had the DNA of the lighter isotope. Additional generations showed increasing DNA with the lighter isotope. Meselson and Stahl concluded that this experiment proved the semi-conservative process was correct. Draw lines from the explanation to the diagram that represents what was said.

Ask the students to now read and annotate the next two paragraphs at the top of page 386 in the biology text. Ask students if the text was easier to understand after the discussion and annotation of Figure 14.13. Remind students that diagrams and charts in texts are often there to clarify, in a visual way, what is explained in the text, and, often, the visual is easier to understand than the text. In disciplinary literacy for science, the blend of visual data and written explanations are used to improve understanding of science concepts. Remind students not to skip over the details in a chart or a diagram. They can also read and digest the details in a diagram first before reading the text if it helps to understand the content.

Ask students to read and annotate 14.4 in pairs. This section provides an explanation of DNA replication in prokaryotes, single-celled organisms such as bacteria. Students should work on their annotation skills and work closely with the annotation checklist to make sure they are getting all of the details.

Assign the reading and annotation of section 14.5, pages 389 - 391 in the biology text as a homework assignment to be turned in an assessed using the annotation checklist. Assess a reasonable number of points for the students' work. Future text readings and annotations will be important to the students' research in biotechnology.

Assessment:

Outcome 1: Students will read and annotate the text describing the function of DNA.

Annotation Checklist

- ☐ Your annotations are perfect! Keep up the good work.
- ☐ You have missed many key ideas. Go back and annotate them.
- ☐ You need to put your annotations in your own words—do not copy from the book!
- ☐ Be briefer in your annotations. You do not need to write in full sentences.
- ☐ You have ignored the graphic aids. Annotate them.
- ☐ You need to note the specific examples—they could reappear on the exam.
- ☐ You need to enumerate the specific facts, characteristics, causes, events, etc., in the margin or in the text. Get the details, too!
- ☐ Your annotations need to focus on the key ideas more and less on details.
- ☐ You are underlining too much—work more on writing your summaries in the margin.
- ☐ You are annotating too much! It will take you forever to do a chapter.
- ☐ You are annotating too little! You do not have enough information annotated to use as a study aid.
- ☐ You need to develop some symbols of your own and use them.
- ☐ You need to develop a method for organizing your annotations.
- ☐ Please annotate these sections or pages again.

p. _____ p. _____

p. _____ p. _____

Activity Two — Close Reading and Concept Formation (Approx. 50 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 3, 4, 5, 10

Students will now read and annotate sections from Chapter 17 of the biology text on biotechnology and genomics. Using the close reading and annotating strategies developed thus far, ask students to read and annotate in pairs pages 451-459 (up to the section on genetic engineering). Ask students to pay particular attention to vocabulary and any processes or procedures that are discussed in the text. Allow one class period for students to work in pairs and then complete the remainder of the reading for homework. Check for completion of the reading as needed.

Activity Three — Creating a Concept Map (Approx. 30 minutes)

College and Career Readiness Standards: Science/Technical Reading– 2, 7

Discuss the components of a concept map using the information in the Academic Notebook pages 42-44.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 42-44

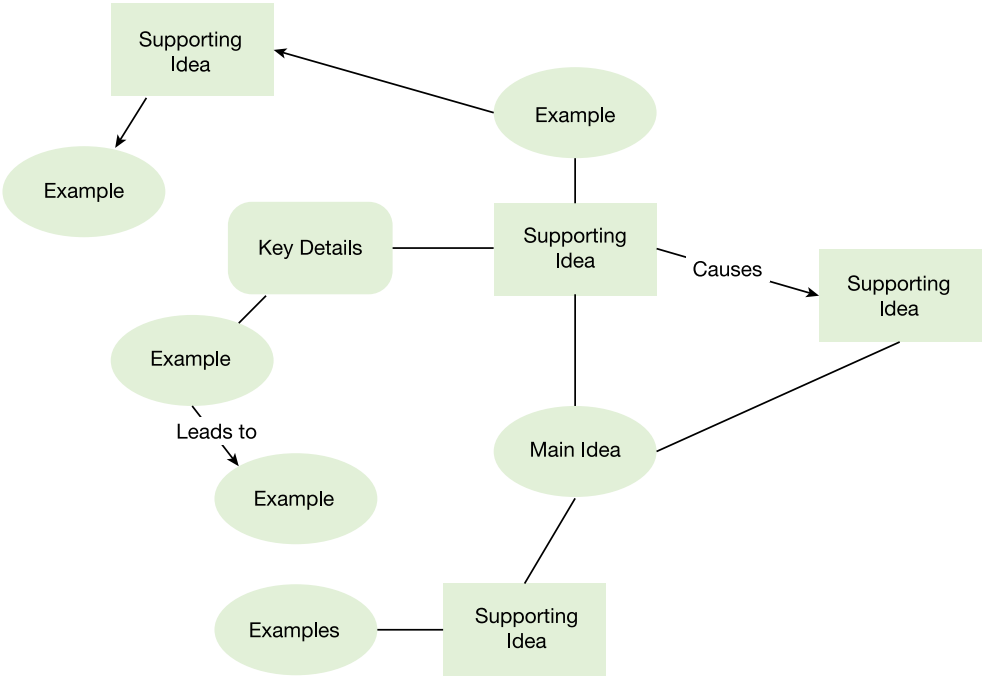
Concept Maps

Concept maps are visual representations of information, so using this strategy is very useful for students who tend to learn visually. A concept map is organized in such a way that it is easy to see the major concept that is being mapped, related concepts, and how everything is related.

Concept mapping works well when it is important to see the relationship between complex concepts, and it works particularly well in courses where many ideas are related or interconnected. For example, mapping might work well to see the relationship between hormones of the endocrine system or the stages of meisis. Mapping is especially useful for students who like to personalize strategies because there is no right or wrong way to map. The important thing is to clearly show the way ideas are linked together in your concept map.

How Do You Use Maps to Study? When you study your map, you can begin by rehearsing one concept at a time. Then cover up everything except the main concept, and begin to talk the information through. Say the related material and then check your accuracy. Focus on how the concepts are related to each other because that is the major strength of mapping. Rather than viewing ideas one at a time, as you would with CARDS, mapping enables you to understand how these ideas fit together. (Adapted from Nist-Olejnik, S. L. & Holschuh, J. P. (2013). *College Success Strategies 4th ed.*)

General Structure of a Concept Map



You can see in this example that the map includes both main and supporting ideas as well as details and examples.

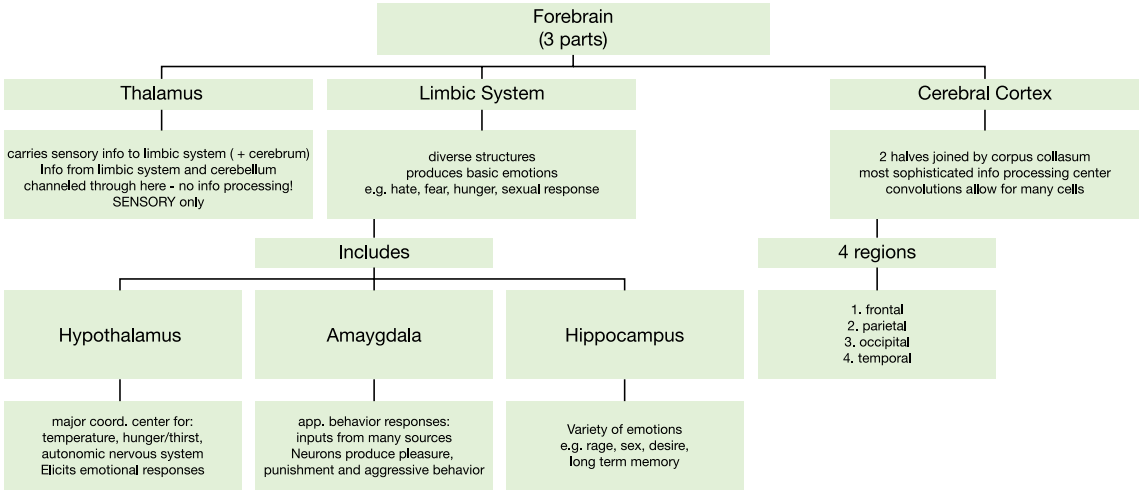
Components of a concept map:

1. Enclosed space (circle, box, etc.) to represent the concepts.
2. Lines to represent the relationship between the concepts.
3. Labels on the line to describe the relationship, such as:

- causes,
- composed of,
- depends on,
- affects (increases, decreases, inhibits, generates, etc.),
- includes,
- leads to.

4. Arrows indicate the direction(s) of the relationship.

It also can show how one concept leads to another or how concepts are interrelated. In the example below, a student has depicted the parts of the forebrain.



Ask students to work though Their notes from Chapter 17, introduction and 17.1 in small groups to create a concept map of molecular cloning.

Ask them to make a jot list of the ideas and terms that should be incorporated into the map by writing each term on a 3x5 index card. Then have them start to think about how those ideas are related by laying the 3x5 cards out on the table and moving them around until the concepts are placed in such a way that makes the most sense to the group. They are trying to map both the concept an the process of how genes are manipulated to create a clone. **Once students feel that they have captured the ideas into a well-represented and organized way, they can draw their concept map (page 45).** Tell students that they will be adding to their map as they work through the next few sections (so they may want to look ahead and leave themselves some space

in the appropriate areas). They will also be using the cards again as a way to help them remember the terminology.

Circulate among the groups as students work to respond to questions and to help students work through the relationships between the concepts and processes they are depicting.

Activity Four	Extending Concept Map for Vocabulary and Concept Learning (Approx. 20 minutes)

College and Career Readiness Standards: Science/Technical Reading– 2, 4

Ask students to go back to the 3x5 cards where they listed the concepts before they created their concept map (they can add to them to make them a complete representation of the ideas they charted). Students should shuffle the cards and, as a group, sort the cards into smaller piles according to the ideas/process related to each term. For example, nucleic acides, polymerase enzyme and messenger RNA could be grouped together.

Students should start to see that some terms, like cloning, would be placed in several groupings. Discuss how these overlaps are a good way to see the relationships between the concepts they are learning. Ask students to manipulate the cards to show all possible combinations of terms for the concepts they have learned thus far.

Then ask students to shuffle the cards again. This time they will pair up with a partner and quiz each other on the terms. The student must define the term and identify at least one science process (or larger concept) the term belongs with. Discuss how in science, it is important to understand both a definition of a concept and be able to place that concept within the larger ideas.

Assessments:

Outcome 2: Students will build their understanding of the concepts through vocabulary learning.

Outcome 3: Students will create a concept map connecting key scientific terminology in this complex process of reproductive cloning.

- Concept Map
- Adapted from NCSEC Concept Map Rubric[6]

	Excellent	Good	Below Average	Poor
Organization	Well organized. Logical format. Contains main concepts. Contains an appropriate number of concepts.	Thoughtfully organized. Easy to follow most of the time. Contains most of the main concepts. Contains an adequate number of concepts.	Somewhat organized. Somewhat incoherent. Contains only a few of the main concepts.	Choppy and confusing. Contains a limited number of concepts.
Content	Linking words demonstrate superior conceptual understanding. Links are precisely labeled.	Linking words easy to follow but at times ideas unclear. Links are not precisely labeled.	Linking words are clear but present a flawed rationale. Links are not labeled.	Difficult to follow. No links.
Cooperation	Worked extremely well with each. Respected and complemented each others ideas.	Worked very well with each other. Worked to get everyone involved.	Attempted to work well with others. At times "off task" and not everyone was actively involved.	Little or no teamwork.

[6]National Computation Science Education Consortium Louisiana Team11. (2000). Rubric4: ConceptMap. Retrieved on December 20, 2007, from http://www.ncsec.org/team11/RubricConceptMap.doc.

Activity Five — Weekly Reflection (Approx. 10 minutes)

College and Career Readiness Standards: Science/Technical Writing– 2, 9, 10

Students will write a reflection on learning at two levels in their Academic Notebook page 46: what they learned about science and what they learned about literacy.

FROM THE STUDENT ACADEMIC NOTEBOOK p 46

Week 2

1. Think about the science. What did you learn about the discovery, structure, and function of DNA?

2. Think about your learning. How will your experiences change the way you approach reading in the sciences?

Teacher Checklist	**Use this list to ensure that you have completed all of the lesson components. I . . .**

- [ ] 1. Asked students to read and annotate sections 14.3 - 14.5 in the biology text.
- [ ] 2. Discussed each section of the text using text dependent questions.
- [ ] 3. Discussed how to create concept maps in science.
- [ ] 4. Asked students to list concepts from biology text Chapter 17, introduction and 17.1 on 3x5 cards.
- [ ] 5. Modeled how to use the concepts on the cards to show how they function in each science process.
- [ ] 6. Asked students to create a concept map.
- [ ] 7. Asked students to sort the cards to extend their vocabulary and concept learning.
- [ ] 8. Asked students to complete the weekly reflection in their Academic Notebook.

Lesson 5
Taking Notes

Overview and Rationale:

Students will take notes over a full-length documentary. This will advance the note-taking skills introduced in previous units. Students will also continue to read from the biology text to learn more about the role of DNA in biotechnology.

Tasks/Expected Outcomes:

1. Students will understand the steps involved in biotechnology.
2. Students will learn note-taking strategies for science documentaries.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.

7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

English Language Arts Standards: Writing

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.

8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

10 Write routinely over extended time frames (time for research, reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes and audiences.

English Language Arts Standards: Speaking and Listening

3 Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings through constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Scientific Terminology

Ability to locate and understand scientific words and phrases that identify key concepts and facts, processes, or information.

3. Science Constructs

Ability to understand, create, and use science models and explanations, evidence, and representations with an understanding of their limitations.

4. Close Reading

Ability to interpret text with particular questions in mind that reflect scientific inquiry, and to use self-regulation to understand scientific processes presented in the text.

5. Scientific Processes

Ability to understand and use scientific processes as a way to answer questions and evaluate text information.

6. Annotation and Note-taking

Ability to read purposefully, select and use relevant information; to summarize and/or paraphrase; to use and understand multiple representations of science processes.

7. Multiple Representations

Ability to read texts using multiple representations including diagrams, charts, tables, models, oral and written text.

Skills Cluster 3: Transition to Writing

1. Bridging Conversation

Ability to connect the task and new content to existing scientific knowledge, skills, experiences, interests and concerns.

2. Examining Informational Text and Notes in a New Medium

Ability to annotate information from a lecture format and apply information to a teaching task.

Skills Cluster 4: Writing Process

1. Writing for a Purpose

Ability to write routinely for different tasks and purposes.

(www.literacydesigncollaborative.org)

Materials:

- Academic notebook
- Cornell notes PPT
- The biotech revolution (59 minutes) https://www.youtube.com/watch?v=teYl5lVN-BrE&nohtml5=False

Timeframe:

150 minutes

Targeted Vocabulary:

Discipline Specific Vocabulary

- genome
- genomics
- biotechnology
- cloning
- transgenic

Activity One — Annotating Multi-step Processes (Approx. 40 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 7, 8

Ask students to read and annotate the following sections of the biology text: 17.1 (pages 459 - 462), 17.4 - 17.5 (pages 469 - 473). These are the last sections students will read in this text (other than using one of the remaining sections in their final project) and, at this point, we want them to recognize their ability to pull out the information that is important to learn. We want students to use the knowledge and skills they have learned thus far to determine the key ideas in this section.

Ask students to preview this section and discuss what will be important to note (diverse fields of study). What guided them to this knowledge of what to mark? What will they need to note about each step (why it occurs, when it occurs, what happens, what are the outcomes)?

This is a very important section for understanding the various fields of biotechnology.

Place students into five working groups (Genetic Engineering - p. 459, Biotechnology in Medicine and Agriculture - p. 460, Production of Vaccines, Antibiotics and Hormones - pp. 46--461, Transgenic Animals - p. 461 and Transgenic Plants - pp. 461- 462. In their teams, students will review their notes for their assigned section and write a summary of the information in their academic notebooks. Each group will then share their summary with the whole class. Students should enter a summary for each section in the Academic Notebook on pages 48-49.

Assessments:

Outcome 1: Students will understand the various fields of biotechnology.

- Summary

Evaluation Rubric			
• Summaries include relevant information, summarizes and/or paraphrases effectively.	No	Somewhat	Yes
• IIndicates understanding of the various fields of biotechnology.	No	Somewhat	Yes
• Includes correct terminology.	No	Somewhat	Yes

- Annotations

Annotation Checklist

- ☐ Your annotations are perfect! Keep up the good work.
- ☐ You have missed many key ideas. Go back and annotate them.
- ☐ You need to put your annotations in your own words—do not copy from the book!
- ☐ Be briefer in your annotations. You do not need to write in full sentences.
- ☐ You have ignored the graphic aids. Annotate them.
- ☐ You need to note the specific examples—they could reappear on the exam.
- ☐ You need to enumerate the specific facts, characteristics, causes, events, etc., in the margin or in the text. Get the details, too!
- ☐ Your annotations need to focus on the key ideas more and less on details.
- ☐ You are underlining too much—work more on writing your summaries in the margin.
- ☐ You are annotating too much! It will take you forever to do a chapter.
- ☐ You are annotating too little! You do not have enough information annotated to use as a study aid.
- ☐ You need to develop some symbols of your own and use them.
- ☐ You need to develop a method for organizing your annotations.
- ☐ Please annotate these sections or pages again.

p. _____ p. _____

p. _____ p. _____

Activity Two	Review of Note-Taking (Approx. 10 minutes)

Review the Cornell Notes PPT from Unit 1: Nutrition. Discuss the importance of noting the key points during the lecture—including examples, diagrams, etc. Then, after the lecture, students will use the margins to write question for self-testing over the material.

Activity Three	Taking Notes from Video (Approx. 100 minutes)

College and Career Readiness Standards: Science/Technical Writing– 2; Speaking and Listening– 3

Students will watch the biotech revolution video and will take notes using the Cornell Method of note taking. Ask students to take notes in their academic notebook pages 51-53. Review the following note-taking tips from Unit 1: Nutrition.

FROM THE STUDENT ACADEMIC NOTEBOOK p 50

- *Read ahead of time:* Most college instructors provide outlines in their syllabi of what materials will be read and when. Read these closely before attending class. A close reading of the assigned materials beforehand will alleviate the need to take tons of notes because lectures often repeat material covered in the textbooks.
- *Take reading notes:* Again, in preparation for the lecture, find a system that works for you and take reading notes. You may read a small section of the text, then review it, and then take notes.
- *Listen closely:* This may seem simple but during a long lecture it is easy to drift away and not listen. Stay focused during class and try to identify aspects of the lecture that are not covered in the assigned readings. These new components are perfect note taking opportunities. Keep your mind actively engaged.
- *Be organized in your note taking:* Date each lecture. Leave a space at the top of the page so that you can come back later and outline the major topics covered in the lecture. This mini-outline creates a kind of running table of contents for you that you can review on a day-to-day basis. Use a note-taking tool, like a graphic organizer, that helps you identify the key science processes, terms and ideas.
- *Deal with diagrams:* An important component in most science lectures is diagrams, tables, and illustrations. When this information is discussed, it is sometimes difficult to take notes on both the diagrams and what the instructor is saying. One way to deal with this problem is to write down the title of the diagram (e.g. the Fluid Mosaic Model) but focus your note taking on the instructor's explanation. Then, refer to your textbook after class to connect the visual with your notes.

Show the biotech revolution video — https://www.youtube.com/watch?v=teYl5lVN-BrE&nohtml5=False.

Stop the video periodically (every 15-20 minutes) and ask students to share their notes with a partner, ask questions and fill in gaps. The video runs about 60 minutes. With the breaks, viewing the entire video should take approximately 90 minutes.

After viewing the video, ask students to review their notes and add self-testing questions in the margins. Ask students to circle the vocabulary and concepts they

have questions about. Discuss the questions as a whole class. Be sure to review the following vocabulary terms and ideas.

- Biomolecular (ask students to use their prefix-suffix chart to help them make meaning of this term)
- Gene mapping
- Three stages of medicine
- Transhumans

Sample notes from the biotech revolution video:

TEACHER RESOURCE

The Biotech Revolution	
	"We are currently witnessing a revolution: From an age of scientific discovery to an age of scientific mastery, an age in which we will be able to discovery the destiny of life itself."
Explain the biomolecular revolution.	Biomolecular revolution promises a strong ability to manipulate life at the most fundamental levels: • Enable us to grow human organs in labs. • Change genetic heritage. • Enhance our abilities. • Even shape the evolution of mankind. We are changing from passive observers to active choreographers of nature. We have unparalleled possibilities, enabling us to rethink who we are and how we will live. We currently hold the future of humanity in our hands. Narrator is on his way to the doctors to diagnose his medical future. In the past, scientific advances gave us a great way of checking our future and health, but the biotech revolution will give us greater control of our health.
Explain the reasons and impacts of running genetic tests for an individual.	**First stage of mastery of life:** • Allow us to eliminate many diseases. • Perhaps prolong lives by decades. The future will bring us owners' manuals for ourselves. • Mapping genes—using personal history and use of medications to determine health future, in this case, future of the narrator's: - Blood test for heart disease, Alzheimer's, diabetes, and such, including all major diseases. - This practice of genome mapping will soon be very common—like checking blood pressure.
Describe the ethical and social results of knowing genetic risks.	- It is very interesting to be able to read genomes and predict health future, but it is also a "Pandora's box" if discovering something "screwed up" or "lethal"—and, most people have some genes like this.

- Doctors run a genome-wide genetic analysis, but will also be respectful of individual's privacy based on the results.
- This testing procedure would have been impossible without the Human Genome project (HGP).

• Took ten years, billions of "pounds," thousands of researchers over six nations.

• (First draft of human genetic code, 90% of it completed in 18 months, containing nearly 3 billion letters of genetic code). A milestone in human history, because it could potentially eliminate many diseases.

- 1990s scientists did not think that human genome project could be done in only 15 years without advanced technology. This breakthrough of human endeavor changed everything.

History of medicine:

• BG – Before genome.

• AG – After genome.

• Move from age of discovery to age of mastery (biomolecular revolution).

Describe the three stages of medicine. How is the third stage currently impacting our society?

Now in the age of mastery, we can manipulate our biological codes.

• Medicine (three stages):

- Stage 1: Germ theory, better sanitation, modern sewer system.
- Stage 2: Antibiotics, vaccination, modern surgery.
- Stage 3: Genetic medicine (most profound).

• Story of boy with no immune system; his story offers a glimpse of the future; "Bubble boy" condition (SCID = Severe Combined Immunodeficiency); immune system comes from bone marrow, so try to replace marrow with transplanted marrow from a health match; came up with gene therapy by combining healthy bone marrow with stem cells with working copy of chain.

• Gene therapy may eventually eradicate other diseases that threaten our lives.

• SCID easy to treat through therapy because it only has a single rouge cell.

• Cancer, Alzheimer's, and heart disease harder to treat because they have multiple rouge genes and a lot more difficult to sequence.

Explain the HGP. What is the goal of the CGP?

Cancer:

• 200,500 die of cancer every day.

• Cancer death every 30 seconds.

• HGP succeeded by an attempt to map a cancer-free future.

• Caused by mutations in DNA; To study cancer: need to figure out how it is functioning within the tumors; want to look at the 50 most common cancers and sample hundreds of tumors to try to sequence all that DNA (roughly 12,500 HGPs).

Explain the secret weapon to preventing cancer in the future.	Cancer Genome project (CGP): • Goal: to compile an encyclopedia of all known cancers, marking down every single genetic mutation in all cancers. • Francis Collins believes it's doable and that cancer is preventable. - Secret weapon to figuring this out: the merger between the computer and the biotech revolutions. - Biology, with use of digital tools, can now become quantitative, and get more at the heart of illnesses.
What exactly is the biotech revolution?	Biotech Revolution • Promises to reprogram our biology— - Turning genes on and off. - Turn on or off enzymes, proteins, and other gene expressions. - Possible reprogram biology away from cancer, heart disease, major diseases. - Ability to do this is increasing exponentially (and doubling) every year. What if our medical history will be irrelevant compared to the medical future ridden in our genes?
How might genetic tests and knowledge of an individual's DNA work against an individual?	Genetic test (Narrator's results): • At risk for heart disease (however; it's low in Japanese people in general). • He had to ask himself: If at risk for Alzheimer's, what about financial stability for his future to cover illness expenses, how will he be taken care of, what measures should they (his family) take when/if he gets sick? • Results, he says, forces one to think about social and ethical questions. • Knowing genome health future may revolutionize health care. • Health future might cause us to want us to know everything that's possible to know. • DNA could work against us (insurance example).
Provide and elaborate on examples of current biotech revolutionary projects.	Biotech revolution ("Human body shop"): • Might enable us to repair and regrow the tissues and organs that our bodies are made out of. • Regenerate human organs. • Skin, cartilage, blood vessels, windpipes, small kidneys, etc. • Lab grown bladders actually used in 7 patients in 2006 research study. • This gives us power to make us better, lengthen life, make us healthier, or perhaps even immortal. If we can suddenly regenerate our body parts, what will that mean for our future? Would life be less interesting if we no longer had pain or physical issues, and so on?

Describe the difference between humans today and humans continuously being given regenerated body parts, longer lifespans, and ability to feel no pain.	Due to modern medicine, we can now double the lifespan of humans. We are now uncovering the molecular secret of the aging process. A lab in Massachusetts discovered section of sequence that causes aging. If they can determine that sequence, then it would hold the answer to all aging issues. Molecular secret to the aging process: calorie restriction, which is a diet that was discovered nearly 75 years ago and slowed down the aging process in rats and other animals that it was tested on. It has a genetic basis and can impact on the aging process. Researcher feels that if the aging process can be affected, then the result will also be favorable on diseases that come with age: could be healthier longer and live longer. The nature of life is not mortality, but immortality. DNA is an immortal molecule. This molecule was on earth, probably more than 3.5 billion years ago. It's a self-made molecule, which even after duplication and duplication and in variations, is still around today. This is as close to immortality on earth as we can get. Our life is dictated by sense of self, sense of when we will continue to live, and then when we will die. We have to consider the implications of manipulating our genes. Also, we need to consider why we might want to live longer and what we would do with technology and it's advances in that time.
Explain the second stage in the mastery of life.	**Second stage of mastery of life—** • Control own biology. • Control biology of future generations. • Tamper with human evolution itself. • 1996 – first cloned mammal (Dolly the sheep); made illegal in several countries. • Tampering with new strains of crops, new varieties of farm animals.
How is the power of cloning currently being used?	How will we use this power of cloning? Marquis Ranch in Texas— • Ranch has all cloned cattle. • Four cloned families. • Cloning allows for the breeding of almost perfect animals. • Enable him to breed animals of assured strength and extreme pedigree (cloning prize bulls). • Cloning allows him to know exactly what kind of animal he'll get.
Explain and interpret potential ethical and social implications of cloning.	We need to think about what cloning should be used for or not used for. • Can we put embryos in near infertile people? • Can cloning happen on a case-by-case basis? • Should cloning be allowed for rich people to maintain wealth in family? • We might have to accept that human cloning will eventually happen. • Human cloning can change human nature itself, which is power to genetically enhance ourselves to give us abilities beyond our biology heritage.

Argue on the role humans should have with cloning.	• Look at the mouse example with enhanced brain protein; "regular" mouse can't find platform under cloudy water, even after shown it, but genetically designed mouse can find it almost immediately. • Memory enhancement happens in mice, which are very similar to humans, and thus very possible for memory enhancement to be performed on humans (a possibility at least). • Might be able to enhance mental as well as physical abilities. Will we do the same as we do on animals and use this power to enhance ourselves?
Discuss the world with all genetically enhance individuals.	• Society built on being better than others. • Maximized performance in sports. • What about allowing people a "better go at a better life," if they've been given a "short straw"? • Raises question as to who decides what's an improvement and enhancement… • Key question: What happens to society if everyone is clamoring to have their status and their capabilities boosted? A race of super-beings? Haves and haves-not? • What if our individual modified genes affects our children's genetic makeup? • Will we have a generation of designer children?
Describe the debate that genetically modified genes will have and how they will impact our future.	Genetically modified genes can cause us to tremendously enhance or improve humans—but we need to consider the impacts on our future. • Should humans be allowed to take control of their own genetic evolutionary futures? • We seek to extend ourselves through our knowledge. • It's up to us to figure out how our future will be. • Potential genetic divide. • It's our first chance in life to have the potential to be many different things and to be many different things. • Pace of science is increases. Future may bring even more possibilities. • One day we can length life span, human abilities, and cure diseases. • Transhumans? • Key is to engage in reason, democratic debate.

Activity Four	Reflection (Homework)

College and Career Readiness Standards: Science/Technical Writing– 8, 10

Ask students to complete the following homework activity:

Students will respond to the questions in their Academic Notebook page 54. Explain to students that they will be selecting a topic to research in the field of biotechnology within the next week. These questions will be used to help them decide on a topic for research.

FROM THE STUDENT ACADEMIC NOTEBOOK p 54

Based on the video you watched and the text you read, respond to the following questions:

- Why might a scientist want to modify organisms?
- What are the current concerns and advancements in biotechnology?
- What interests you about biotechnology?

Assessments:

Outcome 3: Students will learn note-taking strategies for science documentaries.

Cornell notes from video—Use lecture note checklist for assessing the notes.

- Assessment using the lecture note checklist

Lecture Note Checklist *Please circle the appropriate number*	**5** Always	**4**	**3** Sometimes	**2**	**1** Never
1. The lecture notes are titled and dated.	**5**	**4**	**3**	**2**	**1**
2. The notes are easy to read.	**5**	**4**	**3**	**2**	**1**
3. The notes are organized.	**5**	**4**	**3**	**2**	**1**
4. You underline or star key ideas.	**5**	**4**	**3**	**2**	**1**
5. You utilize abbreviations of longer words.	**5**	**4**	**3**	**2**	**1**
6. You skip spaces between ideas/ concepts.	**5**	**4**	**3**	**2**	**1**
7. You indent minor points.	**5**	**4**	**3**	**2**	**1**
8. You note all the important concepts	**5**	**4**	**3**	**2**	**1**
9. You paraphrase what the instructor says.	**5**	**4**	**3**	**2**	**1**
10. Your notes incorporate examples.	**5**	**4**	**3**	**2**	**1**
11. Your notes are accurate.	**5**	**4**	**3**	**2**	**1**
12. Your notes are complete.	**5**	**4**	**3**	**2**	**1**
13. Your notes include self-test questions.	**5**	**4**	**3**	**2**	**1**

Lecture Note Checklist (continued)					
14. Your notes include self-test questions.	**5**	**4**	**3**	**2**	**1**
15. Your self-test questions:	**5**	**4**	**3**	**2**	**1**
a. Are complete.	**5**	**4**	**3**	**2**	**1**
b. Will prepare you for the instructor's tests.	**5**	**4**	**3**	**2**	**1**
c. Cover all the material from that day's lecture.	**5**	**4**	**3**	**2**	**1**
d. Use short-answer format.	**5**	**4**	**3**	**2**	**1**
e. Are appropriate for the type of tests in the class.	**5**	**4**	**3**	**2**	**1**
f. Combine material from multiple lecture topics into a single question.	**5**	**4**	**3**	**2**	**1**

- Biotechnology homework questions

Evaluation Rubric			
• Student responses include relevant information, and indicate an ability to summarize and/or paraphrase effectively, and use understand the current concerns in biotechnology.	No	Somewhat	Yes
• Responses includes reference to both the video and text annotations	No	Somewhat	Yes
• There is a clear response to each of of the 3 posed questions	No	Somewhat	Yes
• Writes in reasonable prose	No	Somewhat	Yes

Teacher Checklist	**Use this list to ensure that you have completed all of the lesson components. I . . .**

- ☐ 1. Asked students to annotate portions of Chapter 17 of the biology text.
- ☐ 2. Asked working groups to create a summary of one of the fields of in biotechnology.
- ☐ 3. Asked working groups to share their sections with their learning group.
- ☐ 4. Reviewed the Cornell Method of note taking.
- ☐ 5. Asked students to take notes over the biotechnology video.
- ☐ 6. Paused the video periodically to allow time for reflections/questions/discussion.
- ☐ 7. Discussed student questions about vocabulary and concepts about the video.
- ☐ 8. Assigned biotechnology homework questions.

Lesson 6
Preparing for Science Exams

Overview and Rationale:

Students will learn to prepare for and take a science exam. Students will generate their own exam review by organizing the concepts they learned, thinking about the types of questions teachers ask, rehearsing material they need to know, and reflecting on the strategies that will help them master the material. By creating their own review, rather than relying on the teacher to supply a review, students must be able to select the information to be learned and create a way to learn it. In this lesson they will use three strategies to help them generate effective reviews: jot lists, concept maps, and question prediction.

Teacher Note: If you want students to continue to focus on the development of their final project, you can move this lesson on test taking to the end of the unit or allow the students to be also dong outside research for the projects while you use class time for Lesson Seven. Because this lesson is not directly connected to the project, but encompasses a valuable study skill for students, you can move the lesson and still keep its benefits for the unit.

Tasks/Expected Outcomes:

1. Students will utilize strategies to generate their own exam reviews.
2. Students will learn to organize concepts as a way to comprehend science processes.
3. Students will learn to ask and answer higher-level questions.
4. Students will demonstrate their knowledge on a multiple-choice and short essay exam.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

5 Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

10 By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.

English Language Arts History/Social Studies, Science/Technical Subjects Standards: Writing

2d Use precise language, domain-specific vocabulary and techniques, such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

English Language Arts Speaking and Listening Standards

1a Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well reasoned exchange of ideas.

1c Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.

2 Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

4 Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings through constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Scientific Terminology

Ability to locate and understand scientific words and phrases that identify key concepts and facts, processes, or information.

3. Science Constructs

Ability to understand, create, and use science models and explanations, evidence, and representations with an understanding of their limitations.

4. Organizing Notes

Ability to organize and synthesize information.

5. Multiple Representations

Ability to read texts using multiple representations including diagrams, charts, tables, models, oral and written text.

6. Using Multiple Texts

Ability to engage in the interpretation of multiple texts, requiring converging (corroboration) of information, integrating across sources, and evaluating sources and evidence.

Skills Cluster 4: Writing Process

1. Writing for Assessments

Ability to prepare for writing short essays as part of a science assessment.

Ability to write short explanatory essays in response questions on science assessments.

2. Writing for a Purpose

Ability to write routinely for different tasks and purposes.

3. Writing for a Specific Audience

Ability to construct a writing task to address specific audience.

(www.literacydesigncollaborative.org)

Materials:

- Academic notebook
- Biology Textbook

Timeframe:

150 minutes

Targeted Vocabulary:

The terms and concepts on the concept map

Activity One — Discussing the Exam Format. (Approx. 5 minutes)

Discuss the format of the exam with the class. The exam will contain multiple-choice (25 items) and short essay (three items) questions. The questions will ask students to apply what they have learned so they need to fully understand the concepts—it is more than a memorization task. Spend a few minutes discussing what this means by presenting the following questions:

For example, the question "What is the shape of DNA called?" is a memory level question. This exam will ask very few memorization items. Instead, students should prepare for items that ask them to synthesize ideas such as "Which of the following proteins cut into DNA sequences and create "sticky ends?."

To prepare for the exam, students will generate their own review using jot lists, concept maps and reciprocal questioning.

Activity Two — Organizing Concepts (Approx. 10 minutes)

Remind students that when they are preparing for an exam, they need to organize all of the concepts they need to know. To organize for this exam, students will make a jot list of the concepts that they will need to add to their concept map. Ask students to think about all of the material that will be covered on the exam. Remember to ask them to think beyond the textbook alone (Chapters 14 and 17 in the biology text; DNA models and animations, biotechnology video). What other materials? (Students will make a list in their Academic Notebooks page 56) of questions for self-testing on the material.

Remind students that their goal is to go beyond memorizing individual vocabulary words. If they only know the definition of the term, but do not understand how the term fits into the larger science concept, they are missing the most important part of vocabulary learning in science (and they will not do well on the exam).

Activity Three	Expanding Concept Map (Approx. 25 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 5, 9

Ask students to examine the concept map they began in Lesson Four to see which concepts need to be added. Then students will work in groups to expand their concept map to include important items generated in their jot list, especially when connecting the information about biotechnology to their concept map on cloning. As students are working, they should ask each other questions and review their annotations if they find a concept that they do not understand. Have students expand their maps in a way that indicates what additions/changes they made (different color, sticky notes, etc.)

Once students have expanded their maps, discuss how students can use them to study for an exam. To study the map, students will try to explain the broad concept (for example, transgenic plants) by explaining all of the ideas connected to it in detail.

FROM THE STUDENT ACADEMIC NOTEBOOK p 57

Concept Maps

(Adapted from Nist & Holschuh, *2012 College Success Strategies*, 4th edition).

How Do You Use Maps to Study?

When you study your map, you can begin by rehearsing one concept at a time. Then cover up everything except the main concept, and begin to talk the information through. Say the related material and then check your accuracy. Focus on how the concepts are related to each other because that is the major strength of mapping.

Assessments:

Outcome 1: Students will utilize strategies to generate their own exam reviews.

Outcome 2: Students will learn to organize concepts as a way to comprehend science processes.

- Concept Map

Evaluation Rubric			
• Show relationships between concepts.	No	Somewhat	Yes
• Accurately depicts the science processes.	No	Somewhat	Yes
• Is complete.	No	Somewhat	Yes

Activity Four — Predicting Test Questions (Approx. 25 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 5, 10

In small groups, ask students to predict one question over the content they have learned so far using the concepts from their jot lists and their concept maps. They can use any material—chapter, notes, etc., to formulate one question. (Note: Many students will predict "what" questions. Use this as an opportunity to help them hone their question prediction skills—"Instead of asking what is DNA, how can you word that question so that it gets at a deeper understanding of the concept?") Have students rework their questions so that they are written in ways that encourage higher-level thinking and deeper understandings of the concepts.

Discuss the following guidelines for creating questions:

- Avoid "what" questions. Ask higher-level questions using words such as *why*, *how*, *explain*, or *compare*. For example, it is much better to ask a question such as *Explain the role of tRNA in protein building* than to ask *What is tRNA?*
- Predict short answer items (even when you are taking multiple-choice tests) because they will help you check your knowledge of an entire concept, rather than one small part.
- Ask questions that require application, analysis, or interpretation of ideas. These are the types of questions you will be asked.
- Get at the "big picture."
- Ask questions that make people really think about the concepts.
- General hint: if it takes more words to ask the question than to answer it, ask a tougher question.

Present the following two questions to students:

1. List the steps in translation.

2. Describe the process of translation.

Ask students to explain why the second question is a better one to predict. Ask students to use their concept maps to predict 10 higher-level questions. They should sketch out an answer as well—they don't need full sentences—just enough information to know if their classmate is on the right track when responding to the question during the exam review.

FROM THE STUDENT ACADEMIC NOTEBOOK p 58

Question		Answer
1		
2		
3		
3		
4		
6		
7		
8		
9		
10		

Assessments:

Outcome 1: Students will utilize strategies to generate their own exam reviews.

Outcome 3: Students will learn to ask and answer higher-level questions

- Predicted Test Questions

Evaluation Rubric			
• Contains appropriate question and answers.	No	Somewhat	Yes
• Questions come from all of the sources used thus far.	No	Somewhat	Yes
• Answers are complete enough to tell that the student understands the entire concept.	No	Somewhat	Yes

Activity Five — Test Review (Approx. 35 minutes)

College and Career Readiness Standards: Speaking and Listening– 1a, 1c, 2, 4

Divide students into small groups for the review. First students will take turns to explain a part of their concept map to the group. They should be sure to include all of the important information about the science process they are describing. Each student in the group should present a different concept so that all major ideas are discussed. For example, one student might discuss the process of cloning, another might discuss DNA structure, a third might discuss a field in biotechnology, and so on.

Then, students will work in pairs to ask each other the questions they had predicted. Students will take turns asking and answering questions. Tell students to respond to the questions without looking at the text or the concept map to be sure they really understand the science concepts and processes.

Activity Six — Exam (Approx. 50 minutes)

College and Career Readiness Standards: Science/Technical Writing– 2, 2d

Hand out the science exam to students. Let them know that they have the entire class period to work on the exam. Remind them to write in full sentences when responding to the short essay items.

Activity Seven — Science Exam Reflection (Homework)

College and Career Readiness Standards: Science/Technical Writing– 2, 2d

After the exams are returned, ask students to complete the exam reflection in their Academic Notebooks pages 59-60. Ask them to think about what went well and what they would need to change for the next time they take a science exam.

Note: Proceed to Lesson Seven as the next activity while exams are being scored. When exams are returned, this reflection will be a homework assignment that happens concurrently with the work on the final project.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 59-60

Exam Reflection

The purpose of this evaluation is to help you learn from your experience preparing for and taking the exam. Think about how you felt about your level of preparation before the exam, where you focused your effort, and how you felt taking the exam.

1. What went right? Analyze the exam to discuss what you did well and what helped your thinking about these concepts.
2. What went wrong? Analyze the exam to discuss areas you might want to work on. In this analysis:

Think about the errors you made and diagnose the nature of your difficulties as they relate to the DNA and biotechnology concepts learned, problem solving expected, or your beliefs about science and/or science learning. Note: don't just describe a difficulty; you need to analyze your thinking. (For example, a poor diagnosis would be "I was confused" or "I picked the wrong answer." A good diagnosis would provide a reason for the errors "I thought that a person's tRNA was the same as mRNA.")

3. What will I do differently next time? Conduct an overall assessment of your performance. This is where you will look for patterns to your errors, think about particular aspects of the exam that may have been difficult for you, types of questions you missed, general concepts that were difficult, etc. In your assessment write about how understanding these issues will impact your science test taking in the future.

Assessments:

Outcome 4: Students will demonstrate their knowledge on a multiple-choice and short essay exam.

The exam and answer key is on the SREB website for test security.

Teacher Checklist | **Use this list to ensure that you have completed all of the lesson components. I . . .**

- [ ] 1. Discussed the exam format with the students.
- [ ] 2. Asked students to create a jot list of important concepts.
- [ ] 3. Reminded students that they are doing more than memorizing unit vocabulary–they are using vocabulary as a way to understand larger concepts.
- [ ] 4. Asked students to work in small groups to expand their concept maps.
- [ ] 5. Discussed how to use concept maps to study.
- [ ] 6. Reviewed the guidelines for predicting exam questions.
- [ ] 7. Asked students to predict 10 higher-level questions and answers about the concepts.
- [ ] 8. Asked students to work in small groups to explain a part of the concept map during the test review.
- [ ] 9. Asked students to work in pairs to ask each other the questions they predicted.
- [ ] 10. Asked students to complete the exam.
- [ ] 11. Asked students to complete the exam reflection once the exams had been returned.

Lesson 7
Analyzing Science Arguments

Overview and Rationale:

Understanding argument provides students with a more authentic understanding of what is really involved in scientific inquiry. Students will discuss the idea that science goes beyond observation and experiment to an understanding that science is contested, that scientists often disagree on many ideas, and that there is generally more than one correct answer to a science problem. Additionally, engaging in scientific discourse will help students develop a deeper conceptual understanding of the issue of biotechnology.

Tasks/Expected Outcomes:

1. Students will learn to analyze scientific arguments.
2. Students will learn strategies to construct and represent arguments.
3. Students will evaluate the arguments and counterarguments based on evidence and warrants.
4. Students will learn that science argumentation is based on evidence to support claims and science principles used as warrants.
5. Students will select a topic and create a purpose statement for the final project.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

5 Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

10 By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.

English Language Arts History/Social Studies, Science/Technical Subjects Standards: Writing

1 Write arguments focused on discipline-specific content.

1a Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

4 Produce clear and coherent writing in which the development, organization and style are appropriate to task, purpose and audience.

9 Draw evidence from informational texts to support analysis, reflection, and research.

10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

English Language Arts Speaking and Listening Standards

2 Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

3 Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

4 Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 1: Preparing for the Task

1. Task Engagement

Ability to connect the task and new content to existing scientific knowledge, skills, experiences, interests, and concerns

2. Planning

Ability to select a topic and develop a purpose statement based on a series of guiding questions.

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings through constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Scientific Terminology

Ability to locate and understand scientific words and phrases that identify key concepts and facts, processes, or information.

3. Close Reading

Ability to interpret text with particular questions in mind that reflect scientific inquiry, and to use self-regulation to understand scientific processes presented in the text.

4. Science Inquiry

Ability to generate questions and select appropriate research to advance and challenge explanations, corroborate evidence, and evaluate sources and evidence

5. Annotation and Note-taking

Ability to read purposefully, select and use relevant information; to summarize and/or paraphrase; to use and understand multiple representations and science processes.

6. Organizing Notes

Ability to organize and synthesize information.

Skills Cluster 3: Transition to Writing

1. Argumentative Writing

Ability to recognize the format used in scientific texts to advance an argument and provide evidence.

2. Elements of an Argument

Ability to recognize the elements of a scientific argument: data, claim, warrants and backing.

3. Counterclaims

Ability to recognize counterclaims in an argument and how they are supported/refuted.

4. Diagramming an Argument

Ability to map out the development of an argument from a scientific journal.

Skills Cluster 4: Writing Process

1. Writing for a Purpose

Ability to write routinely for different tasks and purposes.

2. Reflective Writing

Ability to write reflectively based on synthesis of information and tasks.

(www.literacydesigncollaborative.org)

Materials:

- Phillips, T. (2008). Genetically modified organisms (GMOs): Transgenic crops and recombinant DNA technology. *Nature Education* 1(1)

  http://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-nbsp-732
- Final Project Directions
- Poster examples
- Biology text

Timeframe:

100 minutes

Targeted Vocabulary:

Discipline-Specific Words

- enrichment
- enterotoxigenic
- fortified
- garner
- monoculture
- transgenic
- propagated

General Academic Vocabulary

- subsequent
- susceptible
- tolerance

Activity One — Reviewing the Prompt (10 minutes)

Review the prompt and the project requirements that were introduced in Lesson 1.

Ask students to reread their thoughts after taking notes on the biotechnology video (at the end of Lesson Five) **on what they find interesting about biotechnology and what topics they might want to know more about.**

Activity Two — Understanding Science Arguments (Approx. 60 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 5, 6, 8, 9, 10; Writing– 1, 1a, 9, 10

Explain to students that in order to prepare for the poster symposium, they must first add to their understanding of reading science research. Students will examine science arguments in research.

Ask Students to turn to page 61 in their Academic Notebooks.Discuss the following ideas with students:

In textbooks, science is often presented as a series of experiments and observations. Reading these books can make it seem like all scientists agree on every idea. Actually, the majority of scientific concepts are continually contested and modified in the scientific community. Scientists can agree on one thing: arguing science creates better understandings. Once students learn to spot scientific arguments, they will find them in most science writing.

Students will examine an article on GMOs from the journal *Nature Education* to examine the ways arguments are structured.

> Phillips, T. (2008). Genetically modified organisms (GMOs): Transgenic crops and recombinant DNA technology. *Nature Education* 1(1) —
>
> http://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-nbsp-732.

Remind students about the elements of an argument (Academic Notebook page 66):

- **Data:** these are the facts involved in your argument that support your claims.
- **Claim:** this is the conclusion that is drawn from the data.
- **Warrants:** these are the reasons that justify the connection between the data and the claim. In science, these are often the scientific principles and/or methods.
- **Backing:** these are the basic assumptions that are commonly agreed upon that provide justification for the warrants.

Ask students to read the title of the GMO article and the guiding questions below the title.

If you could save lives by producing vaccines in transgenic bananas, would you?
In the debate over large-scale commercialization and use of GMOs, where should we draw the line?

Ask students to discuss what these questions tell us about the author's argument.

Ask students to read the first paragraph of the article. Ask, "What is the author discussing?" (Students should mention something about how plants have been bred for certain traits for years, but that now scientists can control these genetic changes more precisely and can even introduce new genes from one species to another.)

Ask, "Which part of the argument is being delineated here?" Note: it is OK for students not to know at this point. Basically, they should understand that author is presenting the grounding for the claim (which has not yet been discussed). These are parts of the warrant for the argument.

Ask students to read the section on current use of GMOs (including Table one). In pairs, ask them to mark up the section to show which part(s) of the argument is being described in this paragraph. Ask, which part of the argument is the author presenting in this section? (Students should mention data, backing, warrant). Ask students to point to the specific sections of the paragraph that indicate the different parts of the argument.

Ask students to work in pairs to read up to, but not including, the section on the History of International Regulations. Students should be looking for the parts of the argument already discussed as well as these two additional aspects of complex arguments.

- **Qualifiers:** These are the special conditions under which the claim can be true. They are the limitations on the claim
- **Rebuttals:** These are the conditions when the claim will not be true.

Ask students to discuss the concerns about GMOs. What are the risks? What are the controversies surrounding GMOs?

Ask students to work in pairs to figure out the author's complete argument.

The overall goal is to present the argument in a sentence: "The author argues… because *(data*) . . . since (*warrant*) . . . on account of (*backing*) . . . although some believe/are concerned about (*qualifiers*)…however, the data suggests (*rebuttal*)… therefore (conclusion)."

(Adapted from Driver, R., Newton, P., Osborne, J. (1998). Establishing the norms of scientific argumentation in classrooms.)

To help them figure out the argument, ask students to work with a partner to fill out the pro/con chart in their Academic Notebook before they write out the complete argument.

FROM THE STUDENT ACADEMIC NOTEBOOK p 63

Pro/Con – Chart Biotechnology and Crops

Pros	Cons

Assessments:

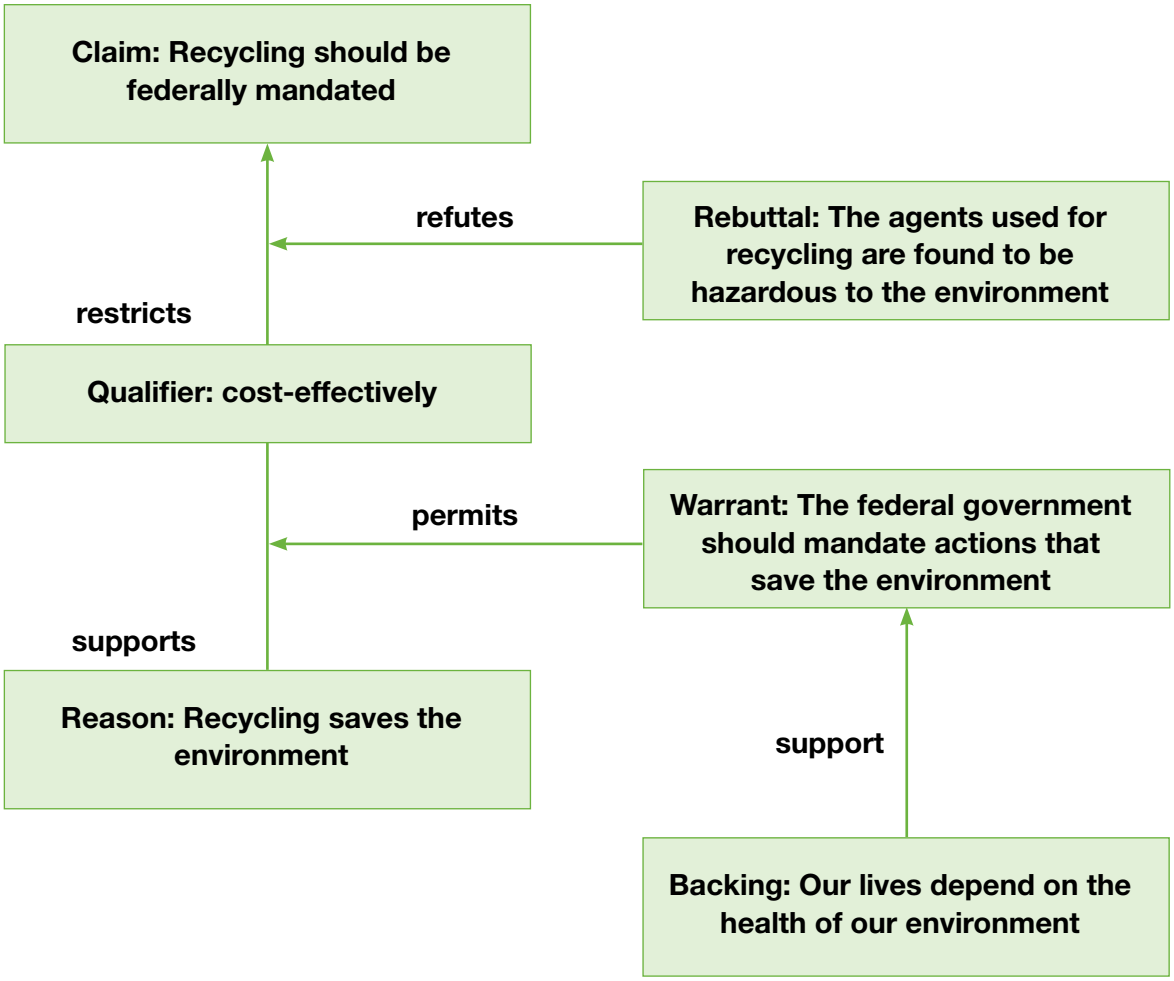
Outcome 1: Students will learn to analyze scientific arguments.

Outcome 3: Students will strategies to construct and represent arguments.

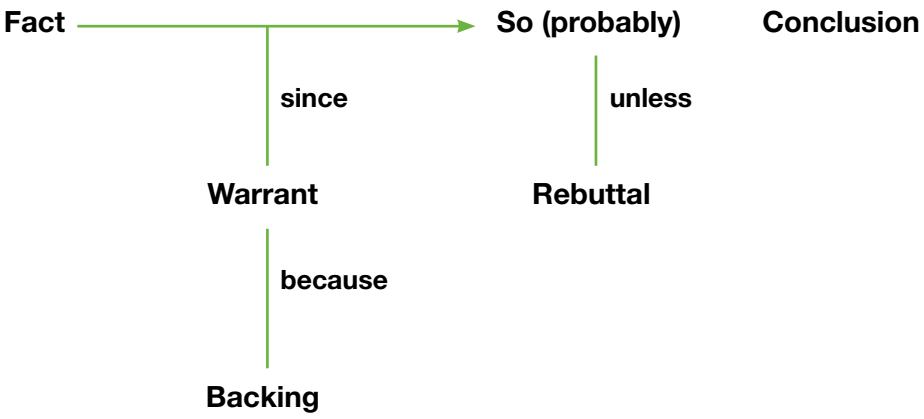
- Pro/con chart

Evaluation Rubric			
• Includes pros and cons of the argument.	No	Somewhat	Yes
• Provides specific references to the article.	No	Somewhat	Yes
• Fully delineates the argument.	No	Somewhat	Yes

Once students have completed their pro/con chart, discuss the examples below to show ways to diagram an argument (Academic Notebook page 64). Then ask students to work in small groups to create their own diagram to show the argument.



From Britt, M. A., & Larson, A. A. (2003) Constructing representations of arguments. *Journal of Memory and Language, 48,* 794-810.



Toulamin's (1958) Argument Frame

Once students complete their diagram, ask them to work in small groups to present the argument as a sentence as shown in the following example (Academic Notebook page 65):

"The author argues…because (*data*)…since (*warrant*)…on account of (*backing*) … although some believe/are concerned about (*qualifiers*)…however, the data suggests (*rebuttal*)…therefore (*conclusion*)."

(Adapted from Driver, R., Newton, P., Osborne, J. (1998). Establishing the norms of scientific argumentation in classrooms.)

Assessments:

Outcome 3: Students will evaluate the arguments and counterarguments based on evidence and warrants.

Outcome 4: Students will learn that science argumentation is based on evidence to support claims and science principles used as warrants.

- Argument Diagrams and Sentences

Evaluation Rubric			
• Includes all of the components of the argument.	No	Somewhat	Yes
• Is able to form into a sentence as well as a diagram.	No	Somewhat	Yes
• Contains the elements of an effective argument.	No	Somewhat	Yes
• Shows a clear understanding of the science while explaining the argument to peers.	No	Somewhat	Yes

Activity Three — Classroom Discussion of Arguments (Approx. 15 minutes)

College and Career Readiness Standards: Speaking and Listening– 2, 3, 4

Students will present their argument sentences to the class. As each group presents, the rest of the class will be looking for and asking questions about the elements of good argument.

Activity Four — Creating a Purpose Statement (Homework)

College and Career Readiness Standards: Speaking and Listening– 2, 3, 4; Writing– 4

DNA Final Project Topic Idea and Purpose Statement

Discuss the differences between creating thesis and purpose statements from the Academic Notebook page 66.

Ask students to write up their topic ideas using the guiding questions in their Academic Notebook page 66-69 before the next class.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 66

Writing a Purpose Statement

From https://writing.wisc.edu/Handbook/Thesis_or_Purpose.html

Thesis and Purpose Statements

Use the guidelines below to learn the differences between thesis and purpose statements.

- In the first stages of writing, thesis or purpose statements are usually rough or ill-formed and are useful primarily as planning tools.
- A thesis statement or purpose statement will emerge as you think and write about a topic. The statement can be restricted or clarified and eventually worked into an introduction.
- As you revise your paper, try to phrase your thesis or purpose statement in a precise way so that it matches the content and organization of your paper.

Thesis statements

- A thesis statement is a sentence that makes an assertion about a topic and predicts how the topic will be developed. It does not simply announce a topic: it says something about the topic.

  Good: X has made a significant impact on the teenage population due to its . . .

  Bad: In this paper, I will discuss X.
- A thesis statement makes a promise to the reader about the scope, purpose, and direction of the paper. It summarizes the conclusions that the writer has reached about the topic.
- A thesis statement is generally located near the end of the introduction. Sometimes in a long paper, the thesis will be expressed in several sentences or an entire paragraph.
- A thesis statement is focused and specific enough to be proven within the boundaries of the paper. Key words (nouns and verbs) should be specific, accurate, and indicative of the range of research, thrust of the argument or analysis, and the organization of supporting information.

Purpose statements

- A purpose statement announces the purpose, scope, and direction of the paper. It tells the reader what to expect in a paper and what the specific focus will be.

  Common beginnings include:

  "This paper examines . . .," "The aim of this paper is to . . .," and "The purpose of this essay is to . . ."
- A purpose statement makes a promise to the reader about the development of the argument but does not preview the particular conclusions that the writer has drawn.
- A purpose statement usually appears toward the end of the introduction. The purpose statement may be expressed in several sentences or even an entire paragraph.

- A purpose statement is specific enough to satisfy the requirements of the assignment. Purpose statements are common in research papers in some academic disciplines, while in other disciplines they are considered too blunt or direct. If you are unsure about using a purpose statement, ask your instructor.

  This paper will examine the ecological destruction of the Sahel preceding the drought and the causes of this disintegration of the land. The focus will be on the economic, political, and social relationships which brought about the environmental problems in the Sahel.

FROM THE STUDENT ACADEMIC NOTEBOOK p 67-68

Critical Focus Question: This will help you focus your research and the development of your project: "What are the current trends and future applications of biotechnology?"

After researching peer-reviewed journal articles on a topic related to biotechnology and health or biotechnology and agriculture, write a research report in the form of a scientific poster in which you discuss the science behind the technology and evaluates current and future applications. Be sure to support your position with evidence from your research. Cite at least ***six to eight*** *sources, pointing out key elements from each source.*

You will create a poster presentation on your topic. To complete this assignment you will read research articles, synthesize the information and write an evaluative argument on your topic.

You will present the poster of your project to the class in a research symposium and create a handout for your classmates.

Select your research topic. Write up a purpose statement outlining the following:

- **What is your topic?** You can choose one of the suggested topics or come up with one of your own.

  Example:

  Topic: Engineered crops

- **What is your question?** This is where you take your topic idea and transform it into a question to ask the literature.

  Example:

  Question: How does genetic engineering of crops impact efforts to fight disease in third world countries?

  This question is tentative at this point, but it will help you enter the research with some kind of focus. Next you need to figure out how to answer this question.

- **What will you need in order to answer this question?**

  Example: First I will need to find out exactly what is being done in the area of engineered crops and disease. I know that there are some studies on "edible vaccinations." I need to find research on how that is being done and what else the field is working on.

- **List the issues that will be addressed** (Note: this is just a starting off point. Your list will expand as you do your research)

  Example:

  - Types of diseases being treated.
  - Types of vaccines available now and types in production.
  - The technology behind creating the edible vaccines.
  - Types of foods being used for vaccines.
  - Benefits.
  - Drawbacks.
  - Future benefits and drawbacks.

Assessments:

Outcome 5: Students will select a topic and create a purpose statement for the final project.

Evaluation Rubric			
• Selects an appropriate topic for the final project.	No	Somewhat	Yes
• Writes a well-thought-out purpose statement.	No	Somewhat	Yes
• Responds thoughtfully to all questions.	No	Somewhat	Yes

Teacher Checklist	Use this list to ensure that you have completed all of the lesson components. I . . .

- [ ] 1. Introduced the final project.
- [ ] 2. Asked students to read and annotate the project directions in their academic notebook.
- [ ] 3. Reviewed the poster template in the Academic Notebook.
- [ ] 4. Asked students to discuss the purpose of the project.
- [ ] 5. Asked students to review the list of possible project topics.
- [ ] 6. Discussed analyzing arguments from science research.
- [ ] 7. Discussed the elements of arguments using the GMO article.
- [ ] 8. Asked students to complete the pro/con chart in their Academic Notebook.
- [ ] 9. Discussed diagramming arguments.
- [ ] 10. Asked students to diagram the argument from the GMO article.
- [ ] 11. Asked students to write the argument as a sentence.
- [ ] 12. Asked students to present their argument to the class.
- [ ] 13. Asked students to create a purpose statement for their project.

Lesson 8
Critiquing Science Research

Overview and Rationale:

In this lesson, students will hone their research topics, gather sources, and create a plan for completing the project. Students will be engaged in evaluating scientific arguments; therefore, students must be able to comprehend and analyze the sources they select. Students will bring in the articles they have selected and will begin to take notes using a template to help guide their reading. By the end of this lesson, students should be ready to draft their poster.

Tasks/Expected Outcomes:

1. Students will be able to explain the science topic they are researching by citing specific evidence from their sources
2. Students will engage in scientific inquiry by forming hypotheses, researching evidence and providing support across text by synthesizing research from multiple sources to support their claims.
3. Students will gather and critically evaluate information.
4. Students will be able to identify important concepts from science articles and use the information to support their ideas.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

10 By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.

English Language Arts Standards: Writing

7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

9 Draw evidence from literary or informational texts to support analysis, reflection and research.

10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes and audiences.

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 1: Preparing for the Task

2. Task Analysis

Ability to understand and explain the task's prompt and rubric.

3. Project Planning

Ability to plan so that the task is accomplished on time.

Skills Cluster 2: Reading Process

1. Science Epistemology

Ability to understand the underlying idea that science is an attempt to build understandings through constructed models and as approximations, findings are subject to revision, and that science knowledge is constructed incrementally using peer critique and public dissemination.

2. Scientific Information

Ability to select and appropriate research and understand the elements of scientific processes.

3. Scientific Terminology

Ability to locate and understand scientific words and phrases that identify key concepts and facts, processes, or information.

4. Science Constructs

Ability to understand, create, and use science models and explanations, evidence, and representations with an understanding of their limitations.

5. Close Reading

Ability to interpret text with particular questions in mind that reflect scientific inquiry, and to use self-regulation to understand scientific processes presented in the text.

6. Science Inquiry

Ability to generate questions and to select appropriate research to advance and challenge explanations, corroborate evidence, and evaluate sources and evidence.

7. Scientific Processes

Ability to understand and use scientific processes as a way to answer questions and evaluate text information.

8. Annotation and Note-taking

Ability to read purposefully, select and use relevant information; to summarize and/or paraphrase; to use and understand multiple representations and science processes.

9. Organizing Notes

Ability to organize and synthesize information.

10. Multiple Representations

Ability to read texts using multiple representations including diagrams, charts, tables, models, oral and written text.

11. Using Multiple Texts

Ability to engage in the interpretation of multiple texts, requiring converging (corroboration) of information, integrating across sources, and evaluating sources and evidence.

(www.literacydesigncollaborative.org)

Materials:

- Academic notebook
- Purugganan & Hewitt (2004) How to read a scientific article (in Academic Notebook)
- Bocquet-Appel, J.P. (2001). When the world's population took off: the springboard of the neolithic demographic transition. *Science*, 333, 560-561.
- Anest, et. al. (2003) A nucleosomal function for I[kappa]B kinase-[alpha] in NF-[kappa]B-dependent gene expression. *Nature*, 423, 559-663.
- How to write a thesis statement — http://www.indiana.edu/~wts/pamphlets/thesis_statement.shtml.

Timeframe:

200 minutes

Targeted Vocabulary:

Student-identified words from articles

Activity One — Preparing for the Final Project (Approx. 35 minutes)

College and Career Readiness Standards: Science/Technical Writing– 4

Ask students to work in small groups to discuss the purpose statements completed for homework. Ask students to discuss the following:

- Is the topic too broad or too narrow?
- Is it manageable and will you be able to find research about the topic within the time frame of the project?
- Is the topic something you are interested in pursuing?
- Will the findings be interesting? Is there a real and debatable issue to research?

Discuss the topics as a class.

Ask students to respond to the prompt in their Academic Notebook about the tasks of the final project.

Discuss any questions they have about the project, key components, etc.

Ask students to complete the project timeline. Students will have some time in class to work on the project but they should be sure they leave time for working outside of class in their plan. The first goal students should set is for the library time they will have next class period.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 75-77

Project Planning Timeline

Make a plan for completing the project by the due date. Be sure to include deadlines for finding and reading your sources, creating a rough draft, and practicing your presentation for the class.

Project Title _____

What will be done?	By when?	What resources will I need?	What goals do I have?
Notes **Library sources** *(space provided)*			

Assessments:

Outcome 1: Students will be able to explain the science topic they are researching by citing specific evidence from their sources.

- Research topic statement

Evaluation Rubric			
• Writes a concise s statement that establishes a controlling idea and identifies key points that support development of information and/or explanation.	No	Somewhat	Yes
• Writes in readable prose.	No	Somewhat	Yes

Outcome 2: Students will engage in scientific inquiry by forming hypotheses, researching evidence, and providing support across text by synthesizing research from multiple sources to support their claims.

- Project timeline

Evaluation Rubric			
• Creates a "doable" timeline that paces reading and writing processes.	No	Somewhat	Yes
• Project planning timeline is complete.	No	Somewhat	Yes
• Sets realistic goals.	No	Somewhat	Yes

Activity Two — Finding Appropriate Sources (Approx. 15 minutes)

College and Career Readiness Standards: Science/Technical Reading– 4

When finding library sources students need to consider:

1. Appropriate level of writing.
2. Credibility of sources.
3. Timeliness.

Appropriate level: show students the two articles for this lesson. If possible, if you can access them from the Internet and display them on a screen, students can answer the questions for this activity without having individual copies of the articles. The purpose for using these articles is to help students figure out how to select articles that will be helpful for them in their research. We want them to read research articles from scientific journals, but they need to take care that those sources are readable for someone who is not an expert in the field.

- Bocquet-Appel, J.P. (2001). When the world's population took off: the springboard of the neolithic demographic transition. *Science*, 333, 560-561. http://mshsapbiology.weebly.com/uploads/1/1/6/4/11645333/springboard_of_neolithic.pdf
- Anest, et al (2003) A nucleosomal function for I[kappa]B kinase-[alpha] in NF-[kappa] B-dependent gene expression. *Nature*, 423, 559-663. http://www.nature.com/nature/journal/v423/n6940/full/nature01648.html

Ask them to determine which article would and would not be appropriate for use in this project.

The article from *Nature* on nucleosomal function as an example of an article that they might come across, but should probably not use, as they would not understand the science. Try to have students come to this conclusion on their own by asking them to explain the abstract or the figures. Because they will not be able to explain the ideas presented in this article, it is probably not a good choice for them at this point.

The article from *Science* is one that would be helpful. It is written about a current topic in a way that is understandable. Students can understand the abstract and figures, so this would be a good article to choose.

Credibility of Sources: Discuss with students that both journals used in the preceding activity are excellent resources. They may just as easily find a difficult read in *Science* and a more appropriate article in *Nature*. To determine the credibility, students need to think about the type of source (peer-reviewed journal is more appropriate than a commercial website. NSA and other government websites are credible) and the author of the article. They should ask themselves, is the author a reporter? A scientist? A professor? Someone working for a business? Knowing who is doing the research and where the work is being published helps us interpret their findings and conclusions.

Timeliness: Discuss the issue of timeliness of sources. Because students are examining new ideas in science, the more current the sources, the better. Therefore, students will rely on research articles, not books which take longer to get into print than a journal, to complete the project.

Activity Three — Library Time (Approx. 50 minutes)

College and Career Readiness Standards: Science/Technical Writing– 7, 8

Students will begin to conduct searches in the library to find sources for their project. Ask students examine the goals they set for the library time on their timeline. What do they want to accomplish?

Remind students to use the starting places listed in the project directions in their Academic Notebooks page 15 as a good way to start their research:

FROM THE STUDENT ACADEMIC NOTEBOOK p 15

www.sciencemag.org
www.scientificamerican.com
www.nature.com
www.newscientist.com
http://learn.genetics.utah.edu/

If your library does not have access to online articles, there are a few good free online depositories:

http://www.ncsu.edu/sciencejunction/terminal/imse/lowres/3/magazines.htm.

http://libguides.fhcrc.org/content.php?pid=155296&sid=1319205.

http://www.sciencedaily.com.

http://www.sciencedirect.com.

Remind students to use the abstract of the article as a way to determine the appropriateness of the sources for this project.

Circulate to answer questions and to help students find appropriate sources.

After about 20 minutes of searching, ask students to share at least one of their sources with a partner. One partner should read an abstract to the other. They will then discuss what the article will be about and how it can contribute to the student's topic. Partners will then reverse the roles to share another abstract. As a whole class, discuss how the searching is going and ask students for questions about finding sources, timeliness, or determining appropriateness.

Students will need to have the majority of their six to eight sources before the next class. Any additional article searches they still need to do should be completed as homework. Remind students that one of their sources will be the section in the biology text that relates to their project topic.

Activity Four — Review of Reading Scientific Articles (Approx. 100 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 4, 6, 8, 9, 10

Review Purugganan & Hewitt (2004) "How to Read a Scientific Article" (in the Academic Notebook pages 74-76). As the class reviews each section, ask students to work in pairs to find the information in one of their articles.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 74-75

How to Read a Scientific Article

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Cain Project in Engineering and Professional Communication

Reading a scientific article is a complex task. The *worst* way to approach this task is to treat it like the reading of a textbook—reading from title to literature cited, digesting every word along the way without any reflection or criticism. Rather, you should begin by skimming the article to identify its structure and features. As you read, look for the author's main points. Generate questions before, during, and after reading. Draw inferences based on your own experiences and knowledge. And to really improve understanding and recall, take notes as you read. This handout discusses each of these strategies in more detail.

1. Skim the article and identify its structure.

Most journals use a conventional IMRD structure: An abstract followed by **I**ntroduction, **M**ethods, **R**esults, and **D**iscussion. Each of these sections normally contains easily recognized conventional features, and if you read with an anticipation of these features, you will read an article more quickly and comprehend more.

Features of Abstracts

Abstracts usually contain four kinds of information:

- purpose or rationale of study (why they did it).
- methodology (how they did it).
- results (what they found).
- conclusion (what it means).

Most scientists read the abstract first. Others—especially experts in the field—skip right from the title to the visuals because the visuals, in many cases, tell the reader what kinds of experiments were done and what results were obtained. You should probably begin reading a paper by reading the abstract carefully and noting the four kinds of information outlined above. Then move first to the visuals and then to the rest of the paper.

Features of Introductions

Introductions serve two purposes: creating readers' interest in the subject and providing them with enough information to understand the article. Generally, introductions accomplish this by leading readers from broad information (what is *known* about the topic) to more specific information (what is *not known*) to a focal point (what *question* the authors asked and answered). Thus, authors describe previous work that led to current understanding of the topic (the broad) and then situate their work (the specific) within the field.

Features of Methods

The Methods section tells the reader what experiments were done to answer the question stated in the Introduction. Methods are often difficult to read, especially for graduate students, because of technical language and a level of detail sufficient for another trained scientist to repeat the experiments. However, you can more fully understand the design of the experiments and evaluate their validity by reading the Methods section carefully.

Features of Results and Discussion

The Results section contains results—statements of what was found, and reference to the data shown in visuals (figures and tables). Normally, authors do not include information that would need to be referenced, such as comparison to others' results. Instead, that material is placed in the Discussion—placing the work in context of the broader field. The Discussion also functions to provide a clear answer to the question posed in the Introduction and to explain how the results support that conclusion.

Atypical Structure

Some articles you read will deviate from the conventional content of IMRD sections. For instance, Letters to *Nature* appear to begin with an abstract, followed by the body of the article. Upon reading, however, you will see that the "abstract" is a summary of the work filled with extensive introduction (for the purpose of catching the attention of a wide audience), and the next paragraph begins a description of the experiments.

Therefore, when you begin to read an article for the first time, skim the article to analyze the document as a whole. Are the sections labeled with headings that identify the structure? If not, note what the structure is. Decide which sections contain the material most essential to your understanding of the article. Then decide the order in which you will read the sections.

STOP: ASK students to use one of the articles they found to think about the structure. Does it follow a typical or atypical structure? Ask them to use the abstract to find the four types of information discussed.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 75-76

2. Distinguish main points.

Because articles contain so much information, it may be difficult to distinguish the main points of an article from the *subordinate points*. Fortunately, there are many indicators of the author's main points:

Document level

Title	visuals (especially figure and table titles)
Abstract	first sentence or the last 1-2 sentences of the Introduction
Keywords	

Paragraph level: words or phrases to look for

surprising	*in contrast with previous work*
unexpected	*has seldom been addressed*
we hypothesize that	*we develop*
we propose	*the data suggest*
we introduce	

3. Generate questions and be aware of your understanding.

Reading is an active task. Before and during your reading, ask yourself these questions:

- Who are these authors? What journal is this? Might I question the credibility of the work?
- Have I taken the time to understand all the terminology?
- Have I gone back to read an article or review that would help me understand this work better?
- Am I spending too much time reading the less important parts of this article?
- Is there someone I can talk to about confusing parts of this article?

After reading, ask yourself these questions:

- What specific problem does this research address? Why is it important?
- Is the method used a good one? The best one?
- What are the specific findings? Am I able to summarize them in one or two sentences?
- Are the findings supported by persuasive evidence?
- Is there an alternative interpretation of the data that the author did not address?
- How are the findings unique/new/unusual or supportive of other work in the field?
- How do these results relate to the work I'm interested in? To other work I've read about?
- What are some of the specific applications of the ideas presented here? What are some further experiments that would answer remaining questions?

STOP: ASK students to skim their article. Ask students to circle any of the words/phrases science readers should look for in academic articles. Then, ask them to read the first section of the article and write down the responses to the questions above that are answered in that section.

FROM THE STUDENT ACADEMIC NOTEBOOK p 76

4. Draw inferences.

Not everything that you learn from an article is stated explicitly. As you read, rely on your prior knowledge and world experience, as well as the background provided in the article, to draw inferences from the material. Research has shown that readers who actively draw inferences are better able to understand and recall information.

As an example, in the box below is an excerpt from the Introduction of an article in the journal *Biochemistry* (Ballestar et al., 2000). The comments in italics are questions and inferences that might be drawn by a student reader.

> Rett Syndrome is a childhood neurodevelopmental disorder and one of the most common causes of mental retardation in females *Comment: Hmmm… must be related to a gene on the X-chromosome*, with an incidence of 1 in 10000-15000. *Comment: How common is that? Not too likely to happen to me, but there must be several such children born in Houston every year.* Rett syndrome patients are characterized by a period of normal growth and development (6-18 months) followed by regression with loss of speech and purposeful hand use. *Comment: What happens? Something must be triggered or activated at late infancy.* Patients also develop seizures, autism, and ataxia. After initial regression, the condition stabilizes and patients survive into adulthood. Studies of familial cases provided evidence that Rett is caused by X-linked dominant mutations in a gene subject to X-chromosome inactivation. Recently, a number of mutations in the gene encoding the methyl-CpG binding transcriptional repressor MeCP2 have been associated with Rett Syndrome. *Comment: MeCP2 mutations probably cause Rett Syndrome. This must be an important master-regulator to affect so many processes in the brain. I wonder what they know about it…*

STOP: Read the inference paragraph out loud as a way to model thinking when reading research in science.

FROM THE STUDENT ACADEMIC NOTEBOOK p 77

5. Take notes as you read.

Effective readers take notes—it improves recall and comprehension. You may think you'll remember everything you read in researching class assignments, professional papers, proposals, or your thesis, but details will slip away. Develop a template for recording notes on articles you read, or adapt the template below for use. As you accumulate a large collection of articles, this template will help you distinguish articles and quickly locate the correct reference for your own writing. The time spent filling out the form will save you hours of rereading when you write a Background, Related Work, or a Literature Review section.

STOP: Ask students to take notes on the article they are reading. Tell them to skip the citation part for now. We will work on APA style after they take notes.

FROM THE STUDENT ACADEMIC NOTEBOOK p77-78

Template for Taking Notes on Research Articles: Easy access for later use

Whenever you read an article, pertinent book chapter, or research on the Web, use the following format (or something similar) to make an electronic record of your notes for later easy access. Put quotation marks around any exact wording you write down so that you can avoid accidental plagiarism when you later cite the article.

Complete citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

General subject:

Specific subject:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

References

Ballestar, E., Yusufzai, T.M., and Wolffe, A.P. (2000) Effects of Rett Syndrome Mutations of the Methyl-CpG Binding Domain of the Transcriptional Repressor MeCP2 on Selectivity for Association with Methylated DNA. *Biochemistry* 31, 7100-7106.

Burnett, R. (2001) *Technical Communication*. 5th ed. San Antonio: Harcourt College

Publishers.

Zeiger, M. (2000) *Essentials of Writing Biomedical Research Papers*. 2nd Ed. St. Louis: McGraw-Hill.

Supported by the Cain Project for Engineering and Professional Communication
Rice University, 2004.

Stop: Discuss this note taking method with students. This is how they will be taking notes on their reading for the final project. Discuss with students that they will use these notes to pull their argument together for the final poster presentation. Therefore, they need to be sure to have enough information in their notes to understand the points that the author was making. Ask students to discuss the benefits and drawbacks that they see in using this method.

Discuss how to use APA citation. Guide students to the following websites for tutorials and examples on how to cite sources both within text and in a reference list:

http://www.apastyle.org/learn/tutorials/basics-tutorial.aspx.

http://owl.english.purdue.edu/owl/resource/560/01/.

http://www.library.cornell.edu/resrch/citmanage/apa.

FROM THE STUDENT ACADEMIC NOTEBOOK p78

Citing Sources: Using APA Style

Within the text cite the author and the year of publication.

According to Jones (2013) biotechnology can benefit poor nations by increasing access to nutritious food.

Jones (2013) stated that biotechnology can benefit poor nations by increasing access to nutritious food.

Jones (2013) suggested that "biotechnology is our greatest tool for addressing the needs of the undernourished poor" (p 207).

http://owl.english.purdue.edu/owl/resource/560/07/

APA Basic Form:

Articles

Author, A. A., Author, B. B., & Author, C. C. (Year). Title of article. *Title of Periodical*, *volume number* (issue number), pages. doi:http://dx.doi.org/xx.xxx/yyyyy.

Books

Author, A. A. (Year of publication). *Title of work: Capital letter also for subtitle.* Location: Publisher. (this type also uses a hanging indention).

Online periodical

Author, A. A., & Author, B. B. (Date of publication). Title of article. *Title of Online Periodical, volume number* (issue number if available). Retrieved from http://www.someaddress.com/full/url/.

Ask students to fill in the citation using APA style for the article they were using in the preceding note taking activity in their Academic Notebook page 79.

Remind students that they will need to think about the project task as the read. Specifically, they should consider how they will construct their evaluation/argument for the poster.

Ask students to discuss any questions they have about where to find information, ways to note the information and what to do when there does not seem to be all

of the information the template asks for. Then, students can continue taking notes on the articles.

For homework, ask students to take notes on the rest of their sources to prepare to write a draft in class.

Assessments:

Outcome 3: Students will gather and critically evaluate information.

Outcome 4: Students will be able to explain the science topic they are researching by citing specific evidence from their sources.

- Article Notes Using Template

Evaluation Rubric			
• Accomplishes task by selecting relevant source material to support controlling idea.	No	Somewhat	Yes
• Answers question about plagiarism correctly and provides appropriate strategies for avoiding it.	No	Somewhat	Yes
• Writes in readable prose.	No	Somewhat	Yes
• Notetaking is accurate.	No	Somewhat	Yes
• Citation style is accurate.	No	Somewhat	Yes

Activity Five — Weekly Reflection (Homework)

College and Career Readiness Standards: Science/Technical Writing– 9, 10

Ask students to reflect on the following questions in their Academic Notebook page 95.

1. Think about the science. What did you learn about critiquing science research?
2. Think about your learning. How will your experiences change the way you approach reading in the sciences?

Teacher Checklist **Use this list to ensure that you have completed all of the lesson components. I . . .**

- [ ] 1. Asked students to discuss project statements with a peer.
- [ ] 2. Asked students to respond to the project prompt in their Academic Notebook.
- [ ] 3. Asked students to create a project planning timeline.
- [ ] 4. Discussed ways to find appropriate library sources:
    a. Appropriate level (using the two article examples).
    b. Credibility.
    c. Timeliness.
- [ ] 5. Provided library time for article searches.
- [ ] 6. Discussed reading scientific articles.
- [ ] 7. Guided students through note taking from research articles using one of their sources.
- [ ] 8. Discussed APA style guidelines.
- [ ] 9. Provided class time for note taking from library sources.
- [ ] 10. Asked students to complete their note taking before the next class period.
- [ ] 11. Asked students to complete their weekly reflection.

Lesson 9
Research Poster Symposium

Overview and Rationale:

Students will prepare for and engage in a research symposium presenting a poster of their research. Students will use their research to present the information in away that would be meaningful to other scientists. In order to be able to write about science in this way, students must deeply understand the concepts. Students will bring in the articles they have selected and will begin to outline their final project.

Students will learn ways to create effective posters that communicate the significance of the research they read including an overview of how the research was conducted, the results, and the implications of those results.

Tasks/Expected Outcomes:

1. Students will be able to identify important concepts from science articles and use the information to support their ideas.
2. Students will be able to explain the science topic they are researching by citing specific evidence from their sources.
3. Students will engage in scientific inquiry creating an evaluative argument about their topic.
4. Students will be able to synthesize research articles to explain science in a research symposium.

College and Career Readiness Standards (CCRS)

English Language Arts Science/Technical Subjects Standards: Reading

1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

10 By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.

English Language Arts History/Social Studies, Science/Technical Subjects Standards: Writing

1 Write arguments focused on discipline-specific content.

1a Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

1b Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.

1c Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

1d Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

1e Provide a concluding statement or section that follows from or supports the argument presented.

4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

9 Draw evidence from informational texts to support analysis, reflection, and research.

10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

English Language Arts Standards: Speaking and Listening

1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

1a Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well reasoned exchange of ideas.

1b Work with peers to promote civil, democratic discussions and decision making, set clear goals and deadlines, and establish individual roles as needed.

1c Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.

1d Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.

2 Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

3 Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

4 Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development,

substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

6 Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. (See grades 11–12 Language standards 1 and 3 on page 54 for specific expectations.)

Throughout this course, only grade 11-12 standards are used.

LDC	Skills and Ability List

Skills Cluster 2: Reading Process

1. Organizing Notes

Ability to organize and synthesize information.

2. Multiple Representations

Ability to read texts using multiple representations including diagrams, charts, tables, models, oral and written text.

3. Using Multiple Texts

Ability to engage in the interpretation of multiple texts, requiring converging (corroboration) of information, integrating across sources, and evaluating sources and evidence.

Skills Cluster 4: Writing Process

1. Initiation of Task

Ability to identify the components of scientific research articles.

2. Planning

Ability to develop a line of thought and text structure appropriate to a scientific informational synthesis.

3. Development

Ability to construct an initial draft with an emerging line of thought and structure.

4. Revision

Ability to apply revision strategies to refine development of information or explanation, including line of thought, language usage, and tone as appropriate to audience and purpose.

5. Editing

Ability to apply editing strategies and presentation applications.

(www.literacydesigncollaborative.org)

Materials:

- Academic notebook
- Research articles

Timeframe:

240 minutes

Targeted Vocabulary:

Vocabulary terms to be explained in the poster session.

Activity One — Constructing Arguments (Approx. 25 minutes)

College and Career Readiness Standards: Science/Technical Reading– 1, 2, 6, 8, 9, 10

Ask students to examine their notes from their research articles to build their argument for the research poster. Remind them that they are trying to discuss their stance by discussing the following:

- **Data:** these are the facts involved in your argument that support your claims.
- **Claim:** this is the conclusion that is drawn from the data.
- **Warrants:** these are the reasons that justify the connection between the data and the claim. In science, these are often the scientific principles and/or methods.
- **Backing:** these are the basic assumptions that are commonly agreed upon that provide justification for the warrants.
- **Qualifiers:** These are the special conditions under which the claim can be true. They are the limitations on the claim.
- **Rebuttals:** These are the conditions when the claim will not be true.

Ask students to go back through their notes to find the elements of their argument (they can mark each instance in the margins of their notes—D for data, C for claim, etc.). They will use these elements as they work on creating a draft of their poster.

Activity Two — Creating an Outline of the Poster (Approx. 50 minutes)

College and Career Readiness Standards: Science/Technical Writing– 1, 5, 7, 8, 9, 10

Using the notes from their sources, ask student to create an outline of their evaluation argument using the following poster format to help guide their thinking:

FROM THE STUDENT ACADEMIC NOTEBOOK pp 15-16

1. Title of a presentation; name; school name; teacher's name
2. Background and introduction to the topic: This section introduces the topic, describes the questions you are asking, and provides the claim. In this section you will explain the science behind the particular method and connect it to what you

have learned in class. Describe the biotechnology—what is it? How is the process accomplished? (The detailed description of your biotechnology application will lead to your **claim**.)

3. Current advances and results: This is the major focus of your poster. This section presents the current issues, themes, and research goals. Where is this technology being used? You will describe the important results and explain how those results shape our current understanding of the topic. You should mention the types of experiments done and discuss their findings but do not report the experimental procedure step-by-step. You might include a figure to help discuss the data. What are the outcomes of this technology? Think about the following:

   Which studies support your hypothesis/claim/question?

   Do some studies support alternative hypotheses?

   Is there controversy in the scientific community over this topic, or is there general agreement?

   What graphs, figures or tables might be relevant to include?

   (This is where you discuss the **data**, **warrants** and **backing**.)

4. Discussion: This section discusses the current advances and results by putting them in context. Highlight any agreements or disagreements in the field and comment on possible reasons for those disagreements.

   (This is where you discuss the **qualifiers** and **rebuttals**.)

5. Conclusions/future directions: This section summarizes your major points and points out the significance. It also discusses where the science is headed in the future and questions that remain based upon the current findings.

6. References in APA style.

Tell students that they do not need to start with item one and move through item six (listed above) as they draft. To that end, we will start with the main focus of the poster.

Ask students to start by writing an outline of item three—current advances. Have them examine their notes and think about what they need to explain in their poster. Remind them that it will be important to define terms and ideas for their audience. They will also need to think about what data they will include and how they will represent that data.

Then ask students to move to items two and one. Have them think about the background that the audience will need to understand to interpret their findings listed in item three. Then ask them to create a title for their presentation that incorporates their stance (e.g., The future potential of X; The negative impact of Y, etc.).

Ask students to write an outline of items four and five. They will need to include the qualifiers and rebuttals as they discuss the current advances.

For homework, ask students to further refine their outline to be ready to create a draft of their poster during the next class.

Assessments:

Outcome 1: Students will be able to identify important concepts from science articles and use the information to support their ideas.

Outcome 2: Students will be able to explain the science topic they are researching by citing specific evidence from their sources.

Outcome 3: Students will engage in scientific inquiry creating an evaluative argument about their topic.

- Outline of poster

Evaluation Rubric			
• Provides an opening to include a controlling idea and an opening strategy relevant to the prompt.	No	Somewhat	Yes
• Provides an initial draft with all elements of the prompt addressed.	No	Somewhat	Yes
• Writes in readable prose.	No	Somewhat	Yes

Activity Three — Drafting the poster (Approx. 75 minutes)

College and Career Readiness Standards: Science/Technical Writing—1, 1a, 1b, 1c, 1d, 1e, 4, 5, 7, 8, 9, 10

Tell students they will have 75 minutes to work on their draft. Ask them to refer to their project timeline and the project directions to adjust their goals as needed to make the most of class time.

Ask students to share their outlines with a partner to be sure that they understand all of the elements and have a good sense of the material. They will use the outline to create a draft of the poster.

Remind students to examine the poster template from lesson eight to remind them of how the final product will look. The headings on their poster will be those used in their outline:

FROM THE STUDENT ACADEMIC NOTEBOOK p 97

1. Title of a presentation; name; school name; teacher's name
2. Background and introduction to the topic: This section introduces the topic, describes the questions you are asking, and provides the claim. In this section you will explain the science behind the particular method and connect it to what you have learned in class. Describe the biotechnology—what is it? How is the process accomplished? (The detailed description of your biotechnology application will lead to your **claim**.)
3. Current advances and results: This is the major focus of your poster. This section presents the current issues, themes, and research goals. Where is this technology being used? You will describe the important results and explain how those results shape our current understanding of the topic. You should mention the types of experiments done and discuss their findings but do not report the experimental

procedure step-by-step. You might include a figure to help discuss the data. What are the outcomes of this technology? Think about the following:

Which studies support your hypothesis/claim/question?

Do some studies support alternative hypotheses?

Is there controversy in the scientific community over this topic, or is there general agreement?

What graphs, figures or tables might be relevant to include?

(This is where you discuss the **data**, **warrants** and **backing**.)

4. Discussion: This section discusses the current advances and results by putting them in context. Highlight any agreements or disagreements in the field and comment on possible reasons for those disagreements.

   (This is where you discuss the **qualifiers** and **rebuttals**.)

5. Conclusions/future directions: This section summarizes your major points and points out the significance. It also discusses where the science is headed in the future and questions that remain based upon the current findings.
6. References in APA style.

Discuss some ways that students can begin their introduction. They will want to grab the audience in some way. As students draft, they might find it useful to use one of the following sentence starters:

- Current theories and research on…indicate…
- Researchers have predicted that …will…
- Current data on…indicates that…
- Although researchers do not agree on…the data suggests…
- There is a good deal of controversy surrounding… this poster will…
- …is currently defined as/used as/conceived of…however, current advances show the potential for…

(Note: these are just suggestions for getting started. Students do not have to use one of the sentence starters—and even if they use one as they draft, it will likely change as they revise.)

Ask students to draft the introduction of their poster using their outline, notes and the articles.

After students have worked for about 15 minutes, ask students to pair up to share what they have accomplished so far. As a whole class, respond to student questions about drafting the poster.

Ask students to think about the data they plan to include from their outline. Discuss the ways that students can represent that data. They should include at least one figure from their research that explains the points they want to make about the biotechnology. As they include the figure, they must be sure it is properly labeled and complete. They will not be able to visually represent all of the data they have gathered.

Ask them to examine their outline with a partner to decide what to summarize in text or chart format and what to represent using a figure.

Ask students to continue to draft each section on paper using their outline, notes, and the articles.

As students work on their discussion and conclusion sections it might be helpful for them to use one of the following sentence starters:

- Current evidence supports the idea/use/innovation…
- (My topic) has the potential to…
- Future advances in…may…
- After a careful examination of … is appears that…
- Based on the current research on…we can conclude that…
- Based on the current research on…scientists predict that…
- The advantages of …outweigh the drawbacks of…because…

(Note: these are just suggestions for getting started. Students do not have to use one of the sentence starters—and even if they use one as they draft, it will likely change as they revise.)

Check in on students as they continue to work on their drafts. Remind them that they will need a full draft before the next class period.

Activity Four — Editing and Revision (Approx. 50 minutes)

College and Career Readiness Standards: Science/Technical Writing—1, 1a, 1b, 1c, 1d, 1e, 4, 5, 7, 8, 9, 10

Ask students to work in pairs or small groups to evaluate the drafts using the checklist found in the Academic Notebook pages 98-100. First, ask students to read each other's papers using the revising—broad structure checklist.

FROM THE STUDENT ACADEMIC NOTEBOOK p 98-99

Revising and Editing Worksheet

Adapted from: J. Cline, (2009) The Writing Program, j-cline@northwestern.edu.

Writing and Speaking About Science

Student's Name _____

Topic _____

Key Message(s): _____

Revising = Checking Finer Structure	R
Does the introduction	
• Introduce topic and significance?	☐
• Describe the research questions?	☐
• Explain the technology?	☐
• Provide a thesis outlining the argument?	☐
Does the Current Advancements and Results Section	
• Present current issues?	☐
• Discuss where the technology is being used?	☐
• Describe important results?	☐
• Provide clear and supported data?	☐
• Illuminate the arguments?	☐
• Are the data persuasive and support the key message?	☐
• Do graphics follow guidelines, including	
- Illustrations self-explanatory?	☐
- Informative titles ABOVE tables?	☐
- Informative captions BELOW figures?	☐
- Integrated explicitly and appropriately in the poster?	☐
Does conclusion and/or discussion	
• Highlight agreements and disagreements in the field?	☐
• Address advantages and limits of methods used?	☐
• Explain implications for current practice or theory?	☐
• Outline research questions that remain?	☐
Does the Conclusions and Future Directions section	
• Summarize major points?	☐
• Discuss future directions?	☐

Is anything missing that a reader in the target audience needs to know?

Is the key message(s) clear?

Other elements as needed:

Ask students to discuss their ratings in pairs, focusing on ways to make the draft more effective.

Discuss some of the issues that students seem to be having in their drafts (unfocused arguments, too many quotes and not enough synthesis of ideas, lack of graphics, etc.) and have students generate ways they can improve these in the final poster.

Then, ask students to read the draft again looking at the finer structure. They will also write at least one compliment and one area for improvement for their partner.

FROM THE STUDENT ACADEMIC NOTEBOOK pp 99-100

Revising = Checking Finer Structure	R
Does the poster present a logical flow of ideas?	☐
Are all quotes used necessary? Do the quotes advance the argument?	☐
Are there empty, inflated, or redundant words? (Circle in the draft)	☐
Are there choppy sentences that could be combined?	☐
Is there a good variety of words to begin sentences? (Circle redundant starters in the draft)	☐
Are there clichés that need to be removed? (Underline in the draft)	☐
Are sentences of varied length used to draw readers in?	☐
Are there grammar and spelling errors that need to be fixed? (Circle the errors in the draft)	☐
Would subheads improve your understanding?	☐
Is APA style used consistently and correctly? (Underline errors in the draft)	☐
Other elements as needed:	
One thing done well in this poster is:	
Comments to help the author improve this poster:	

Ask students to discuss the finer-structure suggestions for the draft with their partner. They will then use the suggestions to make revisions to their draft before creating their poster.

Assessments:

Outcome 1: Ask students to discuss the finer-structure suggestions for the draft with their partner. They will then use the suggestions to make revisions to their draft before creating their poster.

Outcome 2: Students will be able to identify important concepts from science articles and use the information to support their ideas.

Outcome 3: Students will engage in scientific inquiry creating an evaluative argument about their topic.

- Peer Editing Checklist

Evaluation Rubric			
• Provides effective feedback to classmate.	No	Somewhat	Yes
• Discusses all elements in the checklist.	No	Somewhat	Yes
• Both checklists are complete.	No	Somewhat	Yes
• Author addresses suggestions in revision.	No	Somewhat	Yes

Activity Five — Preparing for the Symposium (Approx. 15 minutes)

Discuss the expectations of the research symposium using the guidelines adapted from the University of California Irvine.

Ask students to read the section on preparing effective oral presentations on pages 101-102. Discuss the expectations for the presentation. Students will present their work to small groups in two rounds. They will need to be able to present their ideas in about three minutes.

In round one, half of the class will present to small groups for the first 20 minutes and the other half of the class will walk around to look at the posters. Students will have about three minutes to present their research to the class. Their presentations must be complete and succinct. Students should be prepared to answer questions without reading from the poster.

They will repeat their talk several times as the listeners move through the posters. Then students will switch roles for the last half of class time and those presenting for the first round will now become the listeners and the listeners from round one will become the presenters for round two.

Students will also need to evaluate three to four presentations using the evaluation rubric in their Academic Notebook (page 104) and the forms on pages 105-108.

Ask students to read the section on effective presenting effectively. Discuss the suggestions as a class.

Finally, ask students to read the section on presenting and designing posters in their Academic Notebooks pages 101-103. Discuss these ideas as a class. Ask students to discuss the strategies they plan to use to prepare for their talk.

UCI UNDERGRADUATE RESEARCH SYMPOSIUM PRESENTATION GUIDELINES

Adapted from urop@uci.edu

ORAL PRESENTATIONS

An oral presentation is more than just reading a paper or set of slides to an audience. How you deliver your presentation is at least as important in communicating your message effectively as what you say. Use these Guidelines to learn simple tools that help you prepare and present an effective presentation, and design PowerPoint slides that support and enhance your talk.

PREPARING AN EFFECTIVE PRESENTATION

An effective presentation is more than just standing up and giving information. A presenter must consider how best to communicate their information to the audience. Use these tips to create a presentation that is both informative and interesting.

Organize your thoughts. Start with an outline and develop good transitions between sections. Emphasize the real-world significance of your research.

Have a strong opening. Why should the audience listen to you? One good way to get their attention is to start with a question, whether or not you expect an answer.

Define terms early. If you are using terms that may be new to the audience, introduce them early in your presentation. Once an audience gets lost in unfamiliar terminology, it is extremely difficult to get them back on track.

Finish with a bang. Find one or two sentences that sum up the importance of your research. How is the world better off as a result of what you have done?

Time yourself. Do not wait until the last minute to time your presentation.

Create effective notes for yourself. Have notes that you can read. Do not write out your entire talk; use an outline or other brief reminders of what you want to say. Make sure the text is large enough that you can read it from a distance.

Practice, practice, practice. The more you practice your presentation, the more comfortable you will be in front of an audience. Practice in front of a friend or two and ask for their feedback. Record yourself and listen to it critically. Make it better and do it again.

PRESENTING EFFECTIVELY

When you start your presentation, the audience will be interested in what you say. Use these tips to help keep them interested throughout your presentation.

Be excited. You are talking about something you find exciting. If you remember to be excited, your audience will feel it and automatically become more interested.

Speak with confidence. When you are speaking, you are the authority on your topic, but do not pretend that you know everything. If you do not know the answer to a question, admit it. Consider deferring the question to your mentor or offer to look into the matter further.

Make eye contact with the audience. Your purpose is to communicate with your audience, and people listen more if they feel you are talking directly to them. As you speak, let your eyes settle on one person for several seconds before moving on to somebody else. You do not have to make eye contact with everybody, but make sure you connect with all areas of the audience equally.

Avoid reading from the screen. First, if you are reading from the screen, you are not making eye contact with your audience. Second, if you put it on your slide, it is because you wanted them to read it, not you.

Blank the screen when a slide is unnecessary. A slide that is not related to what you are speaking about can distract the audience. Pressing the letter B or the period key displays a black screen, which lets the audience concentrate solely on your words. Press the same key to restore the display.

Use a pointer only when necessary. If you are using a laser pointer, remember to keep it off unless you need to highlight something on the screen.

Explain your equations and graphs. When you display equations, explain them fully. Point out all constants and dependant and independent variables. With graphs, tell how they support your point. Explain the x- and y-axes and show how the graph progresses from left to right.

Pause. Pauses add audible structure to your presentation. They emphasize important information, make transitions obvious, and give the audience time to catch up between points and to read new slides. Pauses always feel much longer to speakers than to listeners. Practice counting silently to three (slowly) between points.

Avoid filler words. Um, like, you know, and many others. To an audience, these are indications that you do not know what to say; you sound uncomfortable, so they start to feel uncomfortable as well. Speak slowly enough that you can collect your thoughts before moving ahead. If you really do not know what to say, pause silently until you do.

Relax. It is hard to relax when you are nervous, but your audience will be much more comfortable if you are too.

Breathe. It is fine to be nervous. In fact, you should be—all good presenters are nervous every time they are in front of an audience.
The most effective way to keep your nerves in check—aside from a lot of practice beforehand—is to remember to breathe deeply throughout your presentation.

Acknowledge the people who supported your research. Be sure to thank the people who made your research possible, including your mentor, research team, collaborators, and other sources of funding and support.

Keep these Tips in Mind

Establish early a clear and unifying point. Clearly explain the applicability of your research. Be sensitive to those outside your discipline.

Before the Symposium, present to friends and family and invite their feedback. Ask them questions to see if you communicated your points successfully.

Include or discuss the following, if applicable: Introduction, Methods, Results, Discussion, Conclusion, References, and Acknowledgements.

Make sure that your presentation material is readable, grammatically correct, and has been edited and proofread thoroughly.

Cite sources to support your ideas and provide credibility to your findings. Provide credit for text, graphs, etc.

Always acknowledge your sponsors and mentors. Anticipate possible questions and prepare answers.

Be proud of your work, but acknowledge errors. Explain unexpected results and future research that is needed. Always be truthful in presenting your information, and respect your audience. Bring a pen and pad of paper for notes and to record names and addresses of contacts.

Poster Presentations

A poster lets you summarize your research in an engaging visual format. Effective posters communicate the significance of the research, an overview of how the research was conducted, the results, and the implications of those results. These Guidelines help you design a poster to communicate your message clearly.

Prepare and practice a short summary speech—no than 3 minutes—about your project.

DESIGNING YOUR POSTER

Space on a poster is limited, so pick what to present wisely. Your display should be self-explanatory and have a logical flow—viewers should be able to follow the order even if you are not present. Start with a rough draft of your design on paper, using graph paper or Post-it notes to simulate sections. The sample layouts at the end of these Guidelines may give you some layout ideas.

Place your title at the top of the poster and make sure that the text is large and clear. Include your name and major, and the name and department of your faculty mentor, in addition to other co-authors.

Incorporate appropriate graphics in your poster. Label or describe any charts, tables, figures, graphs, or photos that you use. Make sure all edges line up evenly.

Before you attach the pieces to your board, edit and review them and check your spelling. Be sure to attach all materials to your poster board firmly (spray adhesive, found in art supply stores, works best). All posters MUST be complete and ready for presentation upon arrival. Incomplete posters will not be displayed.

DOES YOUR POSTER COMMUNICATE ITS MESSAGE?

Many posters look great but fail to communicate their information clearly. Ask yourself these questions when you are designing your poster.

Is your message clear? Focus on the results and their importance. Avoid overly detailed descriptions of your methods.

Is everything on your poster critical to communicating your message? Remove everything that is not vitally important. Simplify your text by using short bullet points and phrases instead of complete sentences.

Is your organization easy to follow? Most people read from top to bottom, then left to right. Consider numbering your headings to further clarify the flow of information.

Do your headings deliver real information? Good headings by themselves can summarize the main points of your poster if readers are in a hurry.

Is your text easy to read? The poster title should be at least 144 point text, and information about the student(s) and mentor(s) should be 72 points. Headings should be at least 36 point text and easily readable from at least 6 feet. All other text should be at least 18 point and legible from 4 feet.**Is your poster cluttered by too many fonts?** Do not use more than two typefaces. Instead use bold, italic and size to set type differently. Times New Roman, Arial, Garamond, and Verdana are suggested typefaces.

Are your colors distracting? Stick to a simple color scheme (try a couple that complement or contrast with each other, such as black or navy on white). Avoid red/green combinations, as this is the most common form of color blindness.

Are your graphics clear and easy to understand? Avoid elements—such as unnecessary background colors and overly specific labels—that do not add useful information. Explanations should be within or next to figures, not referred to from elsewhere.

Does your poster have a good balance between text, graphics, and white space? Use white space consistently to emphasize separate sections and to keep the poster from becoming too cluttered and difficult to read.

Do readers have to move back and forth to read your poster? Arranging your information in columns makes the poster easy to read in crowded situations, such as the Symposium Poster Session.

Can you talk about your poster without reading directly from it? Be ready to discuss details that questioners cannot read for themselves. People are interested in additional information and your interpretations.

Students should be ready to use the elements of effective presentations to present their poster to the class in about three minutes. They will also need to create handouts for the class.

Activity Six	Research Poster Symposium (Approx. 50 minutes)

College and Career Readiness Standards: Speaking and Listening– 1, 1a, 1b, 1c, 1d, 2, 3, 4, 6

Presenting the Research Symposium: The posters will be presented in two rounds.

Round 1

Half of the class will present for the first 20 minutes and the other half will walk around to listen to the posters. Students will have about three minutes to present their research to the class. Their presentations must be complete and succinct. Students should be prepared to answer questions without reading from the poster.

They will repeat their talk several times as the listeners move through the posters.

Round 2

Students will switch roles so that the students listening during the first half of class will present and the presenters from round one will become the audience. Students will have about three minutes to present their research to the class. Their presentations must be complete and succinct. Students should be prepared to answer questions without reading from the poster. They will repeat their talk several times as the listeners move through the posters.

Poster etiquette: Discuss the following etiquette guidelines with students.

- The teacher will call start and stop times for each round (students should be able to present about six to seven times in the 20 minutes).
- Students should not arrive after a presenter has begun his/her talk.
- Students should stay to hear the entire poster (no leaving early).
- If students notice that students are grouping around one poster, they should go to look at another poster presentation.
- Students should be sure that each presenter has an audience to talk to for each round.

In addition to teacher evaluation, each presentation will be evaluated by at least two-three classmates using the rubric in the Academic Notebook pages 104-108. At the beginning of each poster talk, assign at least one listening student to provide feedback.

Assessments:

Outcome 4: Students will be able to synthesize research articles to explain science in a research symposium.

• Poster

LDC Argumentation Classroom Assessment

Scoring Elements	1 Not Yet	1.5	2 Approaches Expectations	2.5	3 Meets Expectations	3.5	4 Advanced
Focus	Attempts to address prompt, but lacks focus or is off-task.		Addresses prompt appropriately and establishes a position, but focus is uneven.		Addresses prompt appropriately and maintains a clear, steady focus. Provides a generally convincing position.		Addresses all aspects of prompt appropriately with a consistently strong focus and convincing position.
Controlling Idea	Attempts to establish a claim, but lacks a clear purpose. Makes no mention of counter claims.		Establishes a claim Makes note of counter claims.		Establishes a credible claim. Develops claim and counter claims fairly.		Establishes and maintains a substantive and credible claim or proposal. Develops claims and counter claims fairly and thoroughly.
Reading/ Research	Attempts to reference reading materials to develop response, but lacks connections or relevance to the purpose of the prompt.		Presents information from reading materials relevant to the purpose of the prompt with minor lapses in accuracy or completeness.		Accurately presents details from reading materials relevant to the purpose of the prompt to develop argument or claim.		Accurately and effectively presents important details from reading materials to develop argument or claim.
Development	Attempts to provide details in response to the prompt, but lacks sufficient development or relevance to the purpose of the prompt. Makes no connections or a connection that is irrelevant to argument or claim.		Presents appropriate details to support and develop the focus, controlling idea, or claim, with minor lapses in the reasoning, examples, or explanations. Makes a connection with a weak or unclear relationship to argument or claim.		Presents appropriate and sufficient details to support and develop the focus, controlling idea, or claim. Makes a relevant connection to clarify argument or claim.		Presents thorough and detailed information to effectively support and develop the focus, controlling idea, or claim. Makes a clarifying connection(s) that illuminate argument and adds depth to reasoning.
Organization	Attempts to organize ideas, but lacks control of structure.		Uses an appropriate organizational structure for development of reasoning and logic, with minor lapses in structure and/or coherence.		Maintains an appropriate organizational structure to address specific requirements of the prompt. Structure reveals the reasoning and logic of the argument.		Maintains an organizational structure that intentionally and effectively enhances the presentation of information as required by the specific prompt. Structure enhances development of the reasoning and logic of the argument.
Conventions	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics. Sources are used without citation.		Demonstrates an uneven command of standard English conventions and cohesion. Uses language and tone with some inaccurate, inappropriate, or uneven features. Inconsistently cites sources.		Demonstrates a command of standard English conventions and cohesion, with few errors. Response includes language and tone appropriate to the audience, purpose, and specific requirements of the prompt. Cites sources using appropriate format with only minor errors.		Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors. Response includes language and tone consistently appropriate to the audience, purpose, and specific requirements of the prompt. Consistently cites sources using appropriate format.
Content Understanding	Attempts to include disciplinary content in argument, but understanding of content is weak; content is irrelevant, inappropriate, or inaccurate.		Briefly notes disciplinary content relevant to the prompt; shows basic or uneven understanding of content; minor errors in explanation.		Accurately presents disciplinary content relevant to the prompt with sufficient explanations that demonstrate understanding.		Integrates relevant and accurate disciplinary content with thorough explanations that demonstrate in-depth understanding.

• Poster presentation

Presenter:

Reviewer:

Topic:

Notes:

How effectively did the presenter introduce the audience to the topic?	5 4 3 2 1 Excellent Good Poor	Comments:
How clearly and fully was the science evidence presented? Did the speaker use effective and clear examples?	5 4 3 2 1 Excellent Good Poor	
Were the conclusions effective, logical, and complete?	5 4 3 2 1 Excellent Good Poor	

What was the strongest part of the presentation?

What changes would you suggest for improvement?

Activity Seven — Weekly Reflection (Homework)

College and Career Readiness Standards: Science/Technology Writing– 9, 10

Ask students to reflect on the following questions in their Academic Notebook page 109.

1. Think about the science. What did you learn about critiquing science research?
2. Think about your learning. How will your experiences change the way you approach reading in the sciences?

Teacher Checklist — Use this list to ensure that you have completed all of the lesson components. I . . .

- ☐ 1. Asked students review their research notes to build their argument for the poster.
- ☐ 2. Guided students as they created an outline of their poster.
- ☐ 3. Guided students as they created a draft of their poster.
- ☐ 4. Asked students to share their draft with a partner.
- ☐ 5. Asked students to bring a full draft to class for peer editing.
- ☐ 6. Asked students to work in pairs to evaluate the drafts using the checklist in the Academic Notebook.
- ☐ 7. Discussed the expectations for the poster symposium.
- ☐ 8. Discussed the presentation and symposium guidelines.
- ☐ 9. Conducted the poster symposium in two rounds with half the class presenting while the other half listens to the posters in round one and the students switching roles for round two.

Unit 2
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Transitioning to college and careers

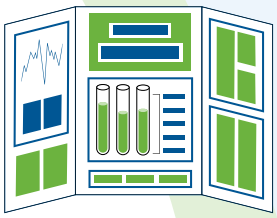
Literacy Ready

Science Unit 2 . DNA and Biotechnology

The Academic Notebook

Version 2a

Name



Unit 2
Table of Contents

Course Overview

Welcome to the second disciplinary literacy science unit of the SREB Readiness Course- Literacy Ready. What does disciplinary literacy in science mean? According to Shanahan & Shanahan (2012), disciplinary literacy refers to the specialized skills and strategies needed to learn at higher levels in each discipline. That means that how people approach reading and writing in the sciences would differ from how they approach it in history, English, mathematics, or other fields. It also means that students need to learn more than the content in any particular discipline—they also need to learn how reading and writing are used within that field. So, disciplinary literacy in science in this unit will introduce you to the knowledge, skills, and tools used by scientists.

You will learn to "make explicit connections among the language of science, how science concepts are rendered in various text forms, and resulting science knowledge" by learning ways to "develop the proficiencies needed to engage in science inquiry, including how to read, write, and reason with the language, texts, and dispositions of science." (Pearson, Moje, Greenleaf, 2010). These ideas are the principal focus of this unit. While certainly the content covered in this course is important, a primary purpose of this unit is to equip you with the tools necessary to be more successful in your college coursework. You will take part in many reading and writing activities aimed at improving your disciplinary literacy in science. To that end, the creators of the course have developed this Academic Notebook.

Purposes of the Academic Notebook

The Academic Notebook plays three roles in this course. First, the notebook provides you with a starter kit of tools aimed to prepare you for college science courses. These tools will assist you in learning and comprehending the information from the scientific text, animations and lectures you receive in the class.

A second role of the notebook is to provide you with a personal space to record your work. The Academic Notebook is where you will take your notes for the class on any materials you are covering. For example, if you are reading an article in class, take notes in this notebook. If you are doing a lab, make your observations and notes here. Likewise, if you are listening to a lecture, take notes here. Use the tools in the resource portion of the notebook to assist you in organizing your notes.

The third and final role of the notebook is that of an assessment tool. Your instructor may periodically collect the notebooks and review your work to ensure that you are remaining on task and to assist you with any material that is causing you difficulty. Your instructor may also assign tasks to be completed in the notebook, such as in-class writing assignments. At the end of this six-week module, your instructor will review the contents of this notebook as part of your overall grade. Thus, it is important that you work seriously as this notebook becomes the record of your activity in this course.

Helpful Hints for Science Literacy Success

About Scientists: How do scientists think?

As you will spend much of your time in class learning this on your own, it is best to be brief. In short, scientists learn by careful observation of the world around them to discover general principles. They do this through careful experimentation that results in data. Scientists use this data to draw conclusions. You likely have heard of the scientific method. Scientists use this method as a structured way to investigate the questions they have. An important use of the scientific method is to be able to replicate previous work. Scientists strive to organize, analyze, and explain things clearly. Scientists believe that science is an attempt to build understandings of the world and that science findings are tentative and subject to revision based on new understandings.

About Scientists: What do scientists ask?

Scientists ask lots of questions about nature and the world around them. These are questions that you will hopefully come to ask upon completing this coursework, and the tools in the resource materials section of the Academic Notebook are intended to aid you in asking these questions.

Scientists are systematic when they ask questions. Scientific inquiry helps scientists answer questions through investigation. They begin by observation. They may start with big, broad questions: “Why? What’s going on? How is this explained?” They then may break a larger question into smaller parts to examine. They examine work that has already been done. They use the scientific method to hypothesize, test, analyze and draw conclusions. This inquiry is often cyclical with experience and observation leading to new hypotheses.

Lesson 1
Gateway Activity

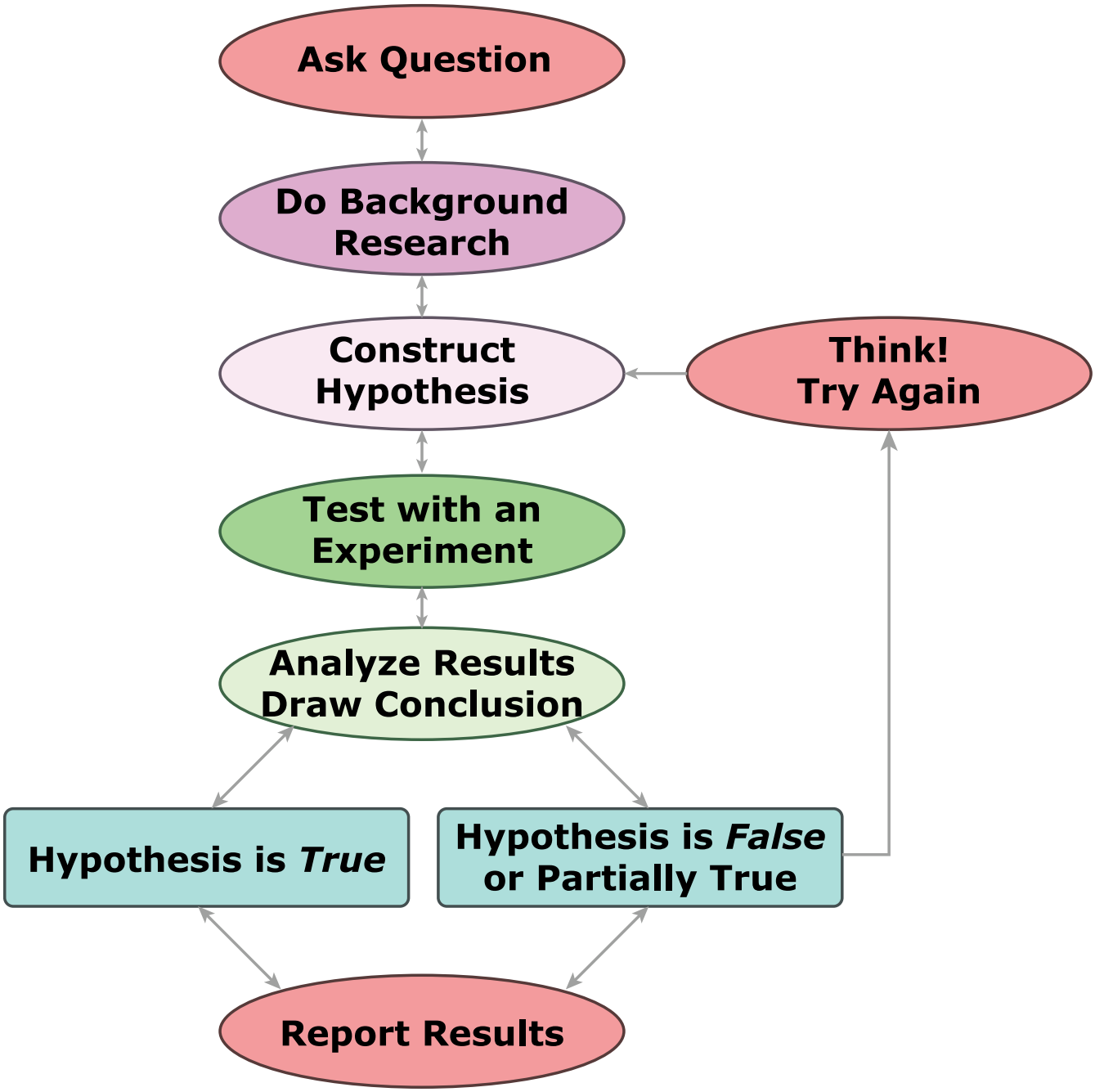
In this lesson, you will . . .

- Add to your understanding of the two levels of thinking required in this course: thinking like a scientist and thinking about learning in the sciences.
- Add to your understanding of the components of science literacy.
- Develop skills to critically examine current science topics.
- Evaluate perspectives from multiple stakeholders using multiple sources of information.
- Apply your knowledge by analyzing science-based arguments.
- Explain the processes involved in critical reasoning in science.

Activity

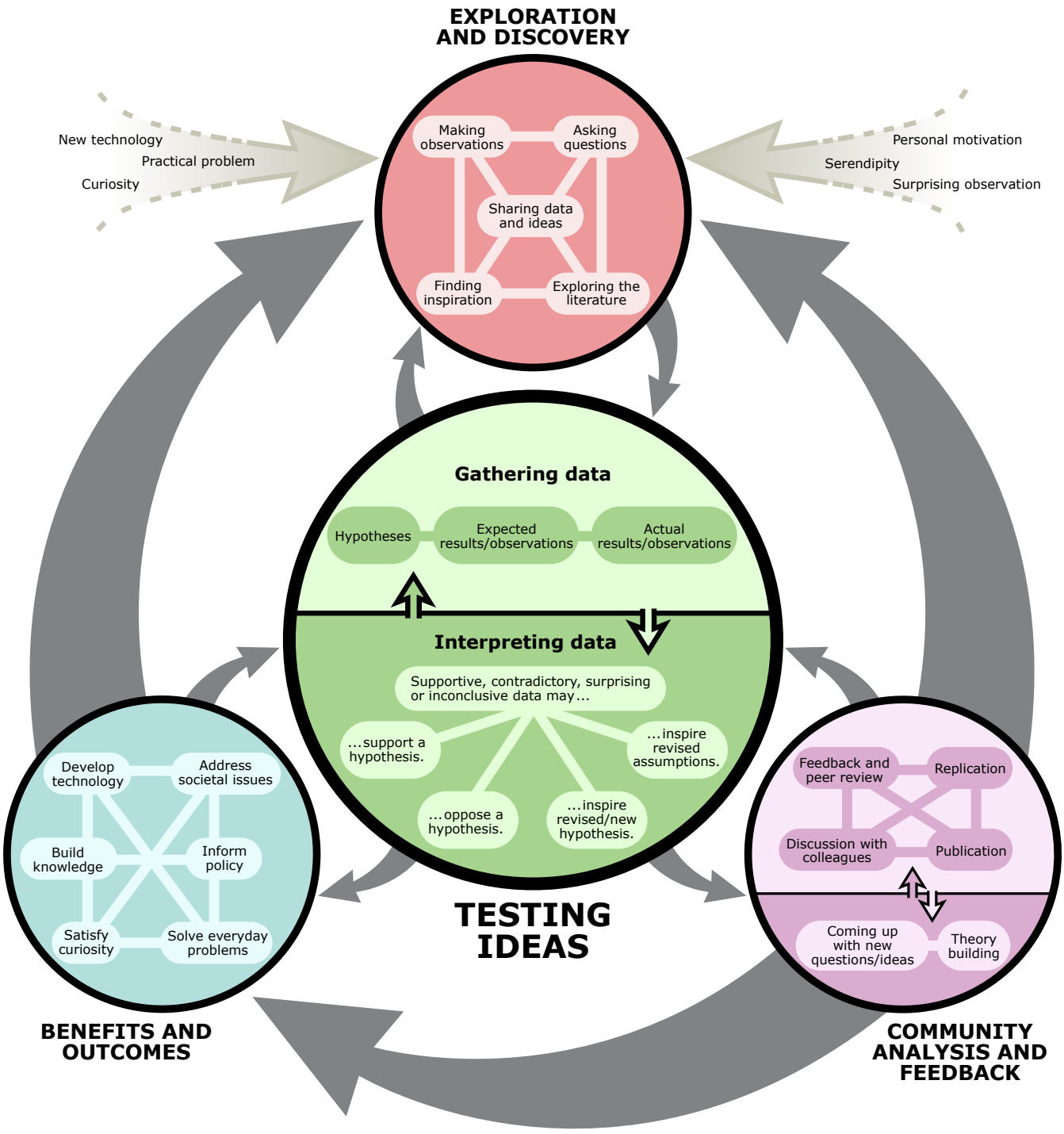
2 Understanding How Science Works

Overview of the Scientific Method



(http://www.sciencebuddies.org)

How science works



www.understandingscience.org

Overview of the Scientific Method

Compare and contrast the overview of the scientific method diagram above with the diagram entitled, "How science works."

	Overview of the scientific method	How science works
Main premises of the diagram.		
How are science outcomes described?		
How is science conducted?		
Who are the key players involved in science inquiry?		

Summarize your conclusions about the two diagrams. How do they differ in terms of the ways science is viewed?

Activity

4 Note Taking from Videos

Gateway Activity

Notes from BRCA video 1:

Notes from BRCA video 2:

Notes from BRCA video 3:

Personal reflection on genetic screening:

Activity

5 Reading Scientific Articles

Notes from *American Journal of Medical Genetics* article on BRCA 1 mutation screening:

Notes on National Cancer Institute article and Angelina Jolie's *New York Times* editorial on genetic testing:

Explain how BRCA1 and 2 gene mutations impact a person's risk of cancer.

How did the women in the video interpret the risk?

Reflection: Should people be screened?

Discussion Preparation

As you read the article assigned to your group, think about the following elements of a scientific argument:

- **Data:** these are the facts involved in your argument that support your claims. What data does your article contain?
- **Claim:** this is the conclusion that is drawn from the data. What conclusion do the authors have?
- **Warrants:** these are the reasons that justify the connection between the data and the claim. In science, these are often the scientific principles and/or methods. What warrants are present in your article?
- **Backing:** these are the basic assumptions that are commonly agreed upon that provide justification for the warrants. What are the basic assumptions that the authors used as a justification for their stance?

Article	Genetic disease description	Science argument	Ethical argument

Question: Use the information you have learned so far to come to a group conclusion. Should people be screened for genetic disease? Students should support their argument with text, refute counterarguments with text and discuss both ethical and scientific concerns.

Activity
6

DNA Final project: Biotechnology Research Symposium

General Instructions

The purpose of the project is to research an issue on how DNA and biotechnology impacts our daily lives by reviewing the current research literature. You can choose a topic relating to biotechnology and health or biotechnology and agriculture. This is not a term paper or book report. It is not merely a report on your sources. Instead, your poster report will synthesize the sources to present a coherent explanation of the topic. A key aspect is that it provides evidence for a particular point of view. Thus, you will need to read multiple research articles on the same topic to be able to draw conclusions on the findings. Use the following prompt to help guide your thinking:

Critical Focus Question: This will help you focus your research and the development of your project: "What are the current trends and future applications of biotechnology?"

After researching peer-reviewed journal articles on a topic related to biotechnology and health or biotechnology and agriculture, write a research report in the form of a scientific poster in which you discuss the science behind the technology and evaluate current and future applications. Be sure to support your position with evidence from your research. Cite at least six to eight (6-8) sources, pointing out key elements from each source. One of your sources will be a section from Phelan 5.11-5.19.

Use the following websites as a way to start your search for materials:

www.sciencemag.org

www.scientificamerican.com

www.nature.com

www.newscientist.com

http://learn.genetics.utah.edu/

You will create a poster presentation on your topic. To complete this assignment you will read research articles, synthesize the information and write an evaluative argument on your topic.

You will present the poster of your project to the class in a research symposium and create a handout for your classmates.

Research symposium

For this symposium you will create a poster of your work. Your poster must include the following information:

1. **Title** of a presentation; name; school name; teacher's name
2. **Background** and introduction to the topic—this section introduces the topic, describes the questions you are asking, and provides a thesis. In this section you will also explain the science behind the particular method and connect it to what you have learned in class. (Describe biotechnology—what is it? How is the process accomplished? The detailed description of your biotechnology application will lead to your hypothesis/position.)

3. **Current advances** and results—this is the major focus of your poster. This section presents the current issues, themes, research goals. Where is this technology being used? You will describe the important results and explain how those results shape our current understanding of the topic. Be sure to mention the types of experiments done and discuss their findings but do not report the experimental procedure step-by-step. Include a figure to help discuss the data. What are the outcomes of this technology?

   Think about the following:

   - Which studies support your hypothesis/thesis/question?
   - Do some studies support alternative hypotheses?
   - Is there controversy in the scientific community over this topic, or is there general agreement?
   - What are the real and potential benefits and dangers of this scientific development?
   - What graphs, figures or tables might be relevant to include?

4. **Discussion**—this section discusses the current advances and results by putting them in context. Highlight any agreements or disagreements in the field and comment on possible reasons for those disagreements. How will the scientific development impact or potentially impact our lives?
5. **Conclusions/future directions**—this section summarizes your major points and points out the significance. It also discusses where the science is headed in the future and questions that remain based upon the current findings.
6. **References** in APA style.

   Here are a few websites to help you with APA style —

   http://www.apastyle.org/learn/tutorials/basics-tutorial.aspx.

   http://owl.english.purdue.edu/owl/resource/560/01/.

   http://www.library.cornell.edu/resrch/citmanage/apa.

Symposium

You will present your poster by discussing your work with the class. Be prepared to talk about your work without reading directly from your poster. Remember, you should have a good understanding of your topic and you should be prepared to answer questions about your work.

Handout

Create a handout for your classmates outlining your work. Be sure to include:

- **Title** of a presentation; name; class.
- **Background** and introduction.
- **Current advances** and results.
- **Discussion.**
- **Conclusions/future directions.**
- **References** in APA style.

DNA Final Project Direction Reflection

Quick Write on the Prompt:

In the space below, write your reaction to this assignment. What will you need to do to prepare for the assignment? What ideas come to mind? What things will you need to learn about in order to be successful?

Your poster title goes here. (You can make the text bigger or smaller if needed).

Name

Teacher's Name

Class

Background and Introduction

This section introduces the topic, describes the questions you are asking, and provides a claim. In this section you will explain the science behind the particular method and connect it to what you have learned in class.

Describe the biotechnology—what is it?

How is the process accomplished? (The detailed description of your biotechnology application will lead to your claim.)

Current Advances and Results

This section presents the current issues, themes, and research goals. Where is this technology being used? Describe the important results and explain how those results shape our current understanding of the topic. Mention the types of experiments done and discuss their findings but do not report the experimental procedure step-by-step.

Think about the following:

- Which studies support your hypothesis/claim/question?
- Do some studies support alternative hypotheses?
- Is there controversy in the scientific community over this topic, or is there general agreement?
- What graphs, figures or tables might be relevant to include?

Include a figure to help discuss the data. What are the outcomes of this technology?

Conclusion/future directions

This section summarizes your major points and points out the significance. It also discusses where the science is headed in the future and questions that remain based upon the current findings.

References

List full references in APA style.

Possible Topics		
Biotechnology Topic	**Rate your interest**	**Possible research question**
Human Cloning		
Animal Cloning		
Transgenic (GM) Plants		
Transgenic (GM) Animals		
Gene Therapy		
Forensic DNA Data Banks		
Human Genome Project		
Pharmacogenetics		
Xenotransplantation		
Herbicide tolerance		
Engineered crops		
Insect tolerance		
Golden Rice		
Disease detection		
Repair of damaged organs and tissues		
Engineered proteins for treating disease		
Preserving endangered species		

Lesson 2
Close Reading in Science: DNA

In this lesson, you will . . .

- Learn about and practice close reading with a college-level science chapter on DNA.
- Learn about how to approach both general and discipline specific vocabulary.
- Explain the processes involved while reading in the sciences.

Activity 1

Setting a Purpose for Reading

(Adapted from Nist-Olejnik & Holschuh, College Success Strategies, 4th Ed., 2013.)

In science textbooks you will find many new terms and definitions. Often, the terms introduced in early chapters will be used later in the text to define other terms. So you need to be sure you understand the new terms as they appear to avoid trouble understanding future reading. Science textbooks also discuss proven principles and theories in terms of their relationship to each other. Therefore, it is important to be aware of and understand how the theories connect and how they explain the science concepts you are learning.

Concepts in science textbooks are usually presented sequentially, which means the concepts build on each other. Your best plan is to test yourself as you read to make sure you fully understand each concept. It is also helpful to create reading goals to monitor what you are learning. This means that rather than focusing on getting through a chapter, focus on learning concepts every time you read. Adopt a scientific approach and ask yourself questions such as:

- What data support this concept or theory?
- What other theories is this concept related to?
- How does this phenomenon work? What is the scientific process involved?
- Why does this phenomenon occur?
- What does it show us?

It is also important to pay attention to the diagrams in each chapter. They are there to help you picture the science process so that you can see what is happening. Understanding diagrams is crucial to doing well in most science courses.

Gearing Up for Reading

To gear up for reading, start by reading the chapter title and thinking about what you already know about that concept. Focus on primary and secondary headings to understand how the chapter is organized and how the ideas are related together. If your text has an outline of topics at the beginning of each chapter, use it to help you think about

the key points. If not, skim through the chapter for key terms and think about how they are related to the appropriate heading or subheading. Pay special attention to diagrams and figures, and think about how they relate to the overall focus of the chapter. Finally, read the chapter objectives and guiding questions if your textbook has these features.

Activity 2

Text Annotation

What and How to Annotate During Reading

Because of the large amount of new terminology involved in learning science, it is important for you to read your science textbooks before class. In this way, you will be familiar with the terms and concepts discussed in the text and you will be able to build your understanding of the concepts as you listen in class. It is also a good idea to connect the concepts discussed in class with the concepts described in your text by comparing your lecture notes to your text annotations each time you read. This will help you follow the flow of the concepts and will help you understand how the ideas are connected.

When you annotate your science text, you need to match your annotations to the course expectations. For example, if you are expected to think at higher levels, be sure your annotations include more than just the bold-faced terms. If you are expected to be able to explain science processes, be sure your annotations help you learn to do just that.

In general, it is a good idea to limit the amount of material you annotate. Annotate big concepts and save the details for your rehearsal strategies. A big mistake that students make when annotating science is that they tend annotate too much. It is also essential to focus on putting the ideas into your own words. This will help you monitor your understanding of what you have read and will keep you from copying exactly from the text. In addition, look for experiments and results or conclusions drawn from scientific theories, and seek to make connections between the experiments and the concepts they generate.

Science texts often contain diagrams or charts to explain concepts. Because science exams usually contain questions about the concepts described in diagrams or charts, you must be able to read and understand each one. As you read your text, annotate the diagrams and take the time to reflect on what they are depicting. A good self-testing strategy to make sure you fully understand the concept is to cover up the words in the diagram and try to talk through the information. If you can explain how the concept works, you've shown that you understand it. If you find that you cannot explain it, reread your annotations or the diagram text to be sure you understand the key points.

In the annotation example on the next page, notice how the annotations focus on explaining the concepts rather than just memorizing the terms.

Introduction: What Is DNA?

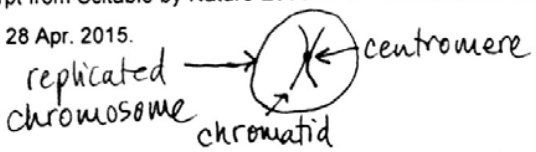
Deoxyribonucleic acid, more commonly known as **DNA**, is a complex molecule that contains all of the information necessary to build and maintain an organism. All living things have DNA within their cells. In fact, nearly every cell in a multicellular organism possesses the full set of DNA required for that organism. However, DNA does more than specify the structure and function of living things — it also serves as the primary unit of heredity in organisms of all types. In other words, whenever organisms reproduce, a portion of their DNA is passed along to their offspring. This transmission of all or part of an organism's DNA helps ensure a certain level of continuity from one generation to the next, while still allowing for slight changes that contribute to the diversity of life.

But what, exactly, is DNA? What smaller elements make up this complex molecule, how are these elements arranged, and how is information extracted from them? This unit answers each of these questions, and it also provides a basic overview of the process of DNA discovery.

Chromosomes

A chromosome is a single, long molecule of DNA. These highly organized structures store genetic information in living organisms. Small sections of the chromosome, called genes, code for the RNA and protein molecules required by an organism. In some organisms, like humans, chromosomes are linear, but in other organisms, like bacteria, chromosomes are typically circular. In prokaryotes, the circular chromosome is contained in the cytoplasm in an area called the nucleoid. In contrast, in eukaryotes, all of the cell's chromosomes are stored inside a structure called the nucleus. Each eukaryotic chromosome is composed of DNA coiled and condensed around nuclear proteins called histones. Humans inherit one set of chromosomes from their mother and a second set from their father. In total, most human cells contain 46 chromosomes with 22 pairs of autosomes, or non-sex chromosomes, and two sex-determining chromosomes. The sex chromosomes in humans are called X and Y. Females carry two X chromosomes, while males carry one X and one Y chromosome. Cells of the body that contain two sets of chromosomes are called diploid. Meanwhile, germ line cells, which go on to produce egg or sperm cells, are called haploid because they contain half the chromosomes of diploid cells. Chromosomes are often observed and depicted as X-shaped structures. DNA takes this form following DNA replication during the process of cell division when the two replicated chromosomes, called chromatids, are highly condensed and still attached to one another at a point called the centromere. Human chromosomes can be differentiated from one another under a microscope by their lengths and by the position of the centromere.

Excerpt from Scitable by Nature Education. "Introduction: What Is DNA?" *Nature.com*. Nature Publishing Group, n.d. Web. 28 Apr. 2015.



The Annotation System of Text Marking

What is Annotation?

- Writing brief summaries in the textbook's margin.
- Enumerating multiple ideas (i.e., causes, effects, reasons characteristics).
- Sketching pictures or charts to explain difficult processes/concepts.
- Writing possible test questions.
- Noting puzzling or confusing ideas that need clarification.
- Underlining key ideas.

Why Should I Annotate?

- It will improve your concentration so you will not become distracted and have to reread.
- It can provide an immediate self-check for your understanding of the textbook's key ideas.
- It will help you remember more.
- It can assist you in test preparation.
- It will negate the need of time spent in rereading the chapters.
- It will help you state ideas in your words.

What should you annotate?

- Definitions.
- Lists, features, causes, effects, reasons, characteristics.
- Diagrams and Processes.
- Examples of main idea.
- Good summaries.
- Possible test questions.
- Something you do not understand.

SCIENTIFIC ROOT WORDS, PREFIXES, AND SUFFIXES

http://www.succeedinscience.com/apbio/assignments/generalinfo/rootwords.pdf

a-; an- ab- -able	not; without; lacking; deficient away from; out from capable of	cente- centi- centr-	pierce; hundredth; center	-err- erythro- -escent	wander; go astray red; becoming
ac-	to; toward	cephal-	head	eso-	inward; within; inner
-aceous	of or pertaining to	cerat-	horn	eu-	well; good; true; normal
acou-; acous -	hear	cerebr-	brain	eury-	widen
ad-	to; toward	cervic-	neck	ex-	out of; away from
aden-	gland	chel-	claw	extra-	beyond; outside
adip-	fat	chem-	dealing with chemicals	-fer-	bear; carry; produce
aero-	air	chir-	hand	ferro-	iron
agri-	field; soil	chlor-	green	fibr-	fiber; thread
-al	having the character of	chondr-	cartilage	-fid; fiss-	split; divided into
alb-	white	chrom-; -chrome	color	-flect; -flex	bend
alg-; -algia	pain	chron-	time	flor-	flower
alto-	high	-chym-	juice	flu-; fluct-; flux	flow
ambi-	both	-cid-; -cis -	cut; kill; fall	foli-	leaf
ameb-	change; alternation	circa-; circum-	around; about	fract-	break
amni-	fetal membrane	cirru-	hairlike curls	-gam-	marriage
amphi-; am-pho-	both	co-	with; together	gastr-	stomach
amyl-	starch	cocc-	seed; berry	geo-	land; earth
ana-	up; back; again	coel-	hollow	-gen; -gine	producer; former
andro-	man; masculine	coll-	glue	-gene-	origin; birth
anemo-	wind	coni-	cone	-gest-	carry; produce; bear
ang-	choke; feel pain	contra-	against	-glen-	eyeball
angi-	blood vessel; duct	corp-	body	-glob-	ball; round
ante-	before; ahead of time	cort-; cortic-	outer layer	gloss-	tongue
anter-	front	cosmo-	world; order; form	gluc-; glyc-	sweet; sugar
antho-	flower	cotyl-	cup	glut-	buttock
anti-	against; opposite	counter-	against	gnath-	jaw
anthropo-	man; human	crani-	skull	-gon	angle; corner
-ap-; -aph-	touch	cresc-; cret-	begin to grow	-grad-	step
apo-; ap-	away from	crypt-	hidden; covered	-gram; graph	record; writing
aqu-	water	-cul-; -cule	small; diminutive	grav-	heavy
archaeo-	primitive; ancient	cumul-	heaped	-gross-	thick
-ary; -arium	place for something	cuti-	skin	gymno-	naked; bare
arteri-	artery	cyan-	blue	gyn-	female
arthr-	joint; articulation	-cycle; cycl-	ring; circle	gyr-	ring; circle; spiral
-ase	forms names of enzymes	-cyst-	sac; pouch; bladder	-hal-; -hale	breathe; breath
aster-; astr-	star	cyt-; -cyte	cell; hollow container	halo-	salt
-ate	verb form - the act of...	dactyl-	finger	hapl-	simple
ather-	fatty deposit	de-	away from; down	hecto-	hundred
-ation	noun form - the act of...	deca-	ten	-helminth-	worm
atmo-	vapor	deci-	tenth	hem-	blood
audi-	hear	deliquesc-	become fluid	hemi-	half
aur-	ear	demi-	half	hepar-; hepat-	liver
auto-	self	dendr-	tree	herb-	grass; plants
bacter-; bactr-	bacterium; stick; club	dent-	tooth	hetero-	different; other
barb-	beard	derm-	skin	hex-	six
baro-	weight	di-; dipl- (Latin)	two; double	hibern-	winter
bath-	depth; height	di-; dia- (Greek)	through; across; apart	hidr-	sweat
bene-	well; good	dia- (Latin)	day	hipp-	horse
bi- (Latin)	two; twice	digit-	finger; toe	hist-	tissue
bi-; bio- (Greek)	life; living	din-	terrible	holo-	entire; whole
-blast-	sprout; germ; bud	dis-	apart; out	homo- (Latin)	man; human

brachi-	arm	dorm-	sleep	homo- (Greek)	same; alike
brachy -	short	dors-	back	hort-	garden
brady-	slow	du-; duo-	two	hydr-	water
branchi-	fin	-duct	lead	hygr-	moist; wet
brev-	short	dynam-	power	hyper-	above; beyond; over
bronch-	windpipe	dys-	bad; abnormal; difficult	hyph-	weaving; web
cac-	bad	ec-	out of; away from	hypno-	sleep
calor-	heat	echin-	spiny; prickly	hypo-	below; under; less
capill-	hair	eco-	house	hyster-	womb; uterus
capit-	head	ecto-	outside of	-iac	person afflicted with disease
carcin-	cancer	-elle	small	-iasis	disease; abnormal condition
cardi-	heart	-emia	blood	-ic	(adjective former)
carn-	meat; flesh	en-; endo-; ent-	in; into; within	ichthy-	fish
carp-	fruit	-en	made of	ign-	fire
carpal-	wrist	encephal-	brain	in-; il-; im-; ir-	not
cata-	breakdown; downward	enter-	intestine; gut	in-; il-; im-; ir-	to; toward; into
caud-	tail	entom-	insects	in-	very; thoroughly
-cell-	chamber; small room	-eous	nature of; like	-ine	of or pertaining to
cen-; -cene	now; recent	epi-	upon; above; over	infra-	below; beneath
inter- intra-	between within; inside	-oma omni-	abnormal condition; tumor; all	sacchar- sapr-	sugar rotten
-ism	a state or condition	onc-	mass; tumor	sarc-	flesh
iso-	equal; same	oo-	egg	saur-	lizard
-ist	person who deals with...	opthalm-	eye	schis -; schiz-	split; divide
-itis	inflammation; disease	opt-	eye	sci-	know
-ium	refers to a part of the body	orb-	circle; round; ring	scler-	hard
-kary-	cell nucleus	-orium; -ory	place for something	-scop-	look; device for seeing
kel-	tumor; swelling	ornith-	bird	-scribe; -script	write
kerat-	horn	orth-	straight; correct; right	semi-	half; partly
kilo-	thousand	oscu-	mouth	sept-	partition; seven
kine-	move	-osis	abnormal condition	-septic	infection; putrefaction
lachry-	tear	oste-	bone	sess-	sit
lact-	milk	oto-	ear	sex-	six
lat-	side	-ous	full of	-sis	condition; state
leio-	smooth	ov-	egg	sol-	sun
-less	without	oxy-	sharp; acid; oxygen	solv-	loosen; free
leuc-; leuk-	white; bright; light	pachy -	thick	som-; somat-; -	body
lign-	wood	paleo-	old; ancient	somn-	sleep
lin-	line	palm-	broad; flat	son-	sound
lingu-	tongue	pan-	all	spec-; spic-	look at
lip-	fat	par-; para-	beside; near; equal	-sperm-	seed
lith-; -lite	stone; petrifying	path-; -pathy	disease; suffering	-spher-	ball; round
loc-	place	-ped-	foot	spir-; -spire	breathe
-log-	word; speech	-ped-	child	-spor-	seed
-logist	one who studies...	pent-	five	stat-; -stasis	standing; placed; staying
-logy	study of...	per-	through	stell-	stars
lumin-	light	peri-	around	sten-	narrow
-lys-; -lyt-; -lyst	decompose; split; dissolve	permea-	pass; go	stern-	chest; breast

macr-	large	phag-	eat	stom-; -stome	mouth
malac-	soft	pheno-	show	strat-	layer
malle-	hammer	-phil-	loving; fond of	stereo-	solid; 3-dimensional
mamm-	breast	phon-; -phone	sound	strict-	drawn tight
marg-	border; edge	-phore; pher-	bear; carry	styl-	pillar
mast-	breast	photo-	light	sub-	under; below
med-	middle	phren-	mind; diaphragm	super-; sur-	over; above; on top
meg-	million; great	phyc-	seaweed; algae	sym-; syn-	together
mela-; melan-	black; dark	phyl-	related group	tachy-	quick; swift
-mer	part	-phyll	leaf	tarso-	ankle
mes-	middle; half; intermediate	physi-	nature; natural qualities	tax-	arrange; put in order
met-; meta-	between; along; after	phyt-; -phyte	plant	tele-	far off; distant
-meter; -metry	measurement	pino-	drink	telo-	end
micro-	small; millionth	pinni-	feather	terr-	earth; land
milli-	thousandth	plan-	roaming; wandering	tetr-	four
mis-	wrong; incorrect	plasm-; -plast-	form; formed into	thall-	young shoot
mito-	thread	platy-	flat	-the-; -thes-	put
mole-	mass	pleur-	lung; rib; side	-thel-	cover a surface
mono-	one; single	pneumo-	lungs; air	-therm-	heat
mort-	death	-pod	foot	-tom-	cut; slice
-mot-	move	poly-	many; several	toxico-	poison
morph-	shape; form	por-	opening	top-	place
multi-	many	port-	carry	trache-	windpipe
mut-	change	post-	after; behind	trans-	across
my-	muscle	pom-	fruit	tri-	three
myc-	fungus	pre-	before; ahead of time	trich-	hair
mycel-	threadlike	prim-	first	-trop-	turn; change
myria-	many	pro-	forward; favoring; before	-troph-	nourishment; one who feeds
moll-	soft	proto-	first; primary	turb-	whirl
nas-	nose	pseudo-	false; deceptive	-ul-; -ule	diminutive; small
necr-	corpse; dead	psych-	mind	ultra-	beyond
nemat-	thread	pter-	having wings or fins	uni-	one
neo-	new; recent	pulmo-	lung	ur-	urine
nephro-	kidney	puls-	drive; push	-ura	tail
-ner-	moist; liquid	pyr-	heat; fire	vas-	vessel
neur-	nerve	quadr-	four	vect-	carry
noct-; nox-	night	quin-	five	ven-; vent-	come
-node	knot	radi-	ray	ventr-	belly; underside
-nom-; -nomy	ordered knowledge; law	re-	again; back	-verge	turn; slant
non-	not	rect-	right; correct	vig-	strong
not-	back	ren-	kidney	vit-; viv-	life
nuc-	center	ret-	net; made like a net	volv-	roll; wander
ob-	against	rhag-; -rrhage	burst forth	-vor-	devour; eat
ocul-	eye	rhe-; -rrhea	flow	xanth-	yellow
oct-	eight	rhin-	nose	xero-	dry
odont-	tooth	rhiz-	root	xyl-	wood
-oid	form; appearance	rhodo-	rose	zo-; -zoa	animal
olf-	smell	roto-	wheel	zyg-	joined together
oligo-	few; little	rubr-	red	zym-	yeast

Activity
3

Week 1
Weekly Reflection

Reflect on your experience:

1. Think about the science. What would scientists pay attention to in terms of genetic testing? How does this differ from what patients would pay attention to?

2. Think about your learning. How will this experience change the way you approach reading in the sciences?

Lesson 3
Discovery of DNA Structure

In this lesson, you will . . .

- Understand the characteristics of DNA.
- Read historical scientific articles regarding the discovery of the structure of DNA.
- Create a diagram of DNA based on multiple sources, adding to and editing their model with each new source.

Activity

1 Reading Scientific Articles

No. 4356 April 25, 1953 NATURE

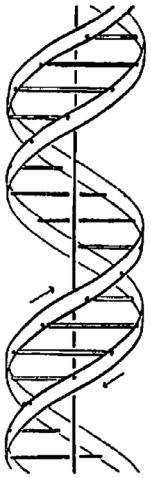
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

We wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey[1]. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.



This figure is purely diagrammatic. The two ribbons symbolize the two phosphate—sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's[2] model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each chain every 3·4 A. in the z-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.

The structure is an open one, and its water content is rather high. At lower water contents we would expect the bases to tilt so that the structure could become more compact.

The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical z-co-ordinates. One of the pair must be a purine and the other a pyrimidine for bonding to occur. The hydrogen bonds are made as follows: purine position 1 to pyrimidine position 1; purine position 6 to pyrimidine position 6.

If it is assumed that the bases only occur in the structure in the most plausible tautomeric forms (that is, with the keto rather than the enol configurations) it is found that only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally[3,4] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data[5,6] on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the conditions assumed in building it, together with a set of co-ordinates for the atoms, will be published elsewhere.

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at King's College, London. One of us (J. D. W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis.

J. D. WATSON
F. H. C. CRICK
Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems,
Cavendish Laboratory, Cambridge.
April 2.

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Building your Understanding of DNA Structure

Part 1: After reading the Watson and Crick's article in Nature on their discovery of the structure of DNA, draw a diagram of DNA below, labeling all components of your diagram.

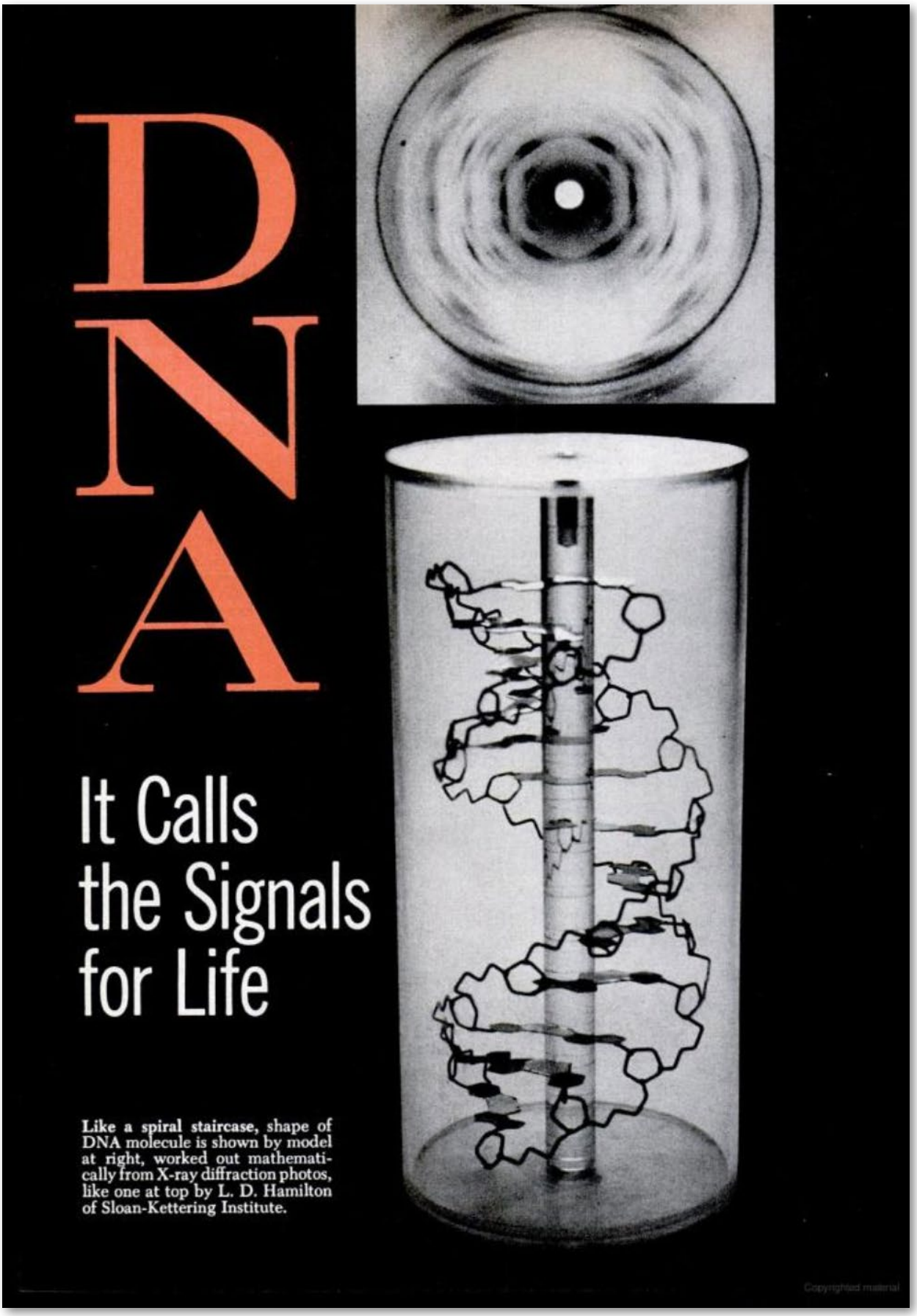
Explain the importance of the structure of DNA in understanding how our genetic material functions to make us who we are.

Activity

2 Reading Popular Articles

Building your Understanding of DNA Structure

Part II: After reading the *Popular Science* article describing the Nobel Prize-winning scientists' discovery of DNA, go back to your original diagram of DNA. Make changes or add to your diagram based on additional understanding gained from this article. You can also re-draw your diagram.


DNA
It Calls the Signals for Life
Like a spiral staircase, shape of DNA molecule is shown by model at right, worked out mathematically from X-ray diffraction photos, like one at top by L. D. Hamilton of Sloan-Kettering Institute.
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How three men got the Nobel Prize for solving a jigsaw puzzle: assembling the pieces of a molecule that made you what you are—and keeps you ticking

By Wallace Cloud

LAST December an American biologist and two English physicists received formal recognition, in the shape of a Nobel Prize, for a discovery made 10 years ago—a discovery that started a chain reaction in biology.

They determined the structure of a molecule that provides answers to questions scientists have been asking for over a century:

- How does a heart muscle "know" how to beat?
- How does a brain cell "know" how to play its role in thinking and feeling?
- How do the cells of the body "know" how to grow, to reproduce, to heal wounds, to fight off disease?
- How do infectious bacteria "know" what diseases to cause?
- How do single fertilized egg cells, from which most of nature's creatures begin, "know" how to become plants, animals, people?
- If one such cell is to multiply and form a human being, how does it "know" how to produce a potential Einstein or a Marilyn Monroe?

The stuff that genes are made of. Sounds like a lot to expect of a molecule—even one with a jaw-breaking name like deoxyribonucleic acid (known more familiarly as DNA). But it's scientific fact that DNA is what genes are made of. DNA molecules supply the basic instructions that direct the life processes of all living things (except a few viruses). The DNA molecule contains information in a chemical code—the code of life.

The effects of discovery of the structure of DNA have been called "a revolution far greater in its potential significance than the atomic or hydrogen bomb." Professor Arne Tiselius, President of the Nobel Foundation, has said that it "will lead to methods of tampering with life, of creating new diseases, of controlling minds, of influencing heredity—even, perhaps, in certain desired directions."

I asked the American member of the Nobel Prize trio, Dr. James D. Watson, about these speculations in his laboratory at Harvard. It was a few weeks before he flew to Stockholm to receive the award

CONTINUED

Three Nobelmen

Dr. James D. Watson, now at Harvard, worked on DNA in 1953 while in England.

Dr. Francis H. C. Crick of Cambridge was Watson's partner in the research.

Dr. Maurice H. F. Wilkins, King's College, London, made essential X-ray photos.

along with Dr. Francis H. C. Crick of Cambridge University and Dr. Maurice H. F. Wilkins of King's College, London.

The boyish 34-year-old Nobelman, who did the prize-winning research in England when he was only 25 (he entered college at 15, had been a Quiz Kid before that, in the days of radio), refused to endorse the wilder predictions about the future of DNA research. He said, "The average scientist busy with research looks ahead anywhere from an hour to two years, not more."

Conceding that discovery of the structure of DNA was as important as the working out of atomic structure that led to the atom bomb, he added, "It will have a very profound effect, slowly, on medicine. Doctors will stop doing silly things. Our knowledge of DNA won't cure disease, but it gives you a new approach—tells you how to look at a disease."

Dr. Watson went on to explain just what he and his co-workers discovered during those days of inspired brainwork in England, back in 1953, and how they did it.

The discovery was not the work of an institute-full of technicians, he said, but the product of four minds: He and Crick did the theoretical work, interpreting cryptic X-ray diffraction photos made by Wilkins, who had as collaborator an English woman scientist, Dr. Rosalind Franklin. She died in 1958. She "should have shared" the Nobel Prize, said Dr. Watson.

Picking up the thread. DNA was not a newly discovered substance. It had been isolated in 1869, and by 1944 geneticists were sure it was the substance of the genes—the sites of hereditary information in the chromosomes. Then they started asking, "How does it work?" That's the question Watson and his co-Nobelists answered.

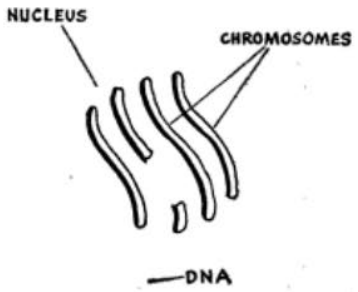
They knew DNA as one of the most complex of the "giant molecules" known to man. It was believed to have a long, chainlike structure consisting of repeating groups of atoms, with side groups sticking out at regular intervals.

The shape of the DNA molecule was important. In the cell, many of the larger molecules work together like machine parts, and their mechanical properties are as important as their chemical activity. However, even the electron microscope, through which it is possible to see some of the biggest giant molecules, shows DNA only as a thread, without detail.

One way of "looking" at molecules is to take them apart by chemical treatments that make

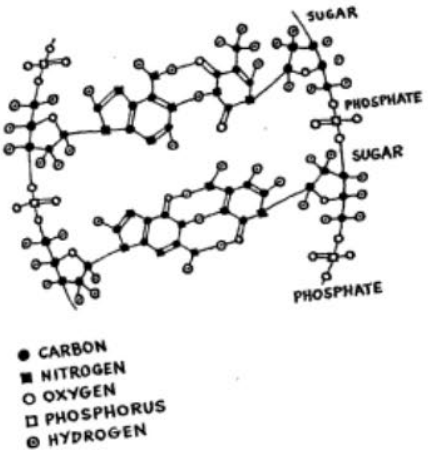
[Continued on page 186]

How DNA molecules



A miniature chemical factory, the living cell (diagramed above) is controlled by "executive molecules" of DNA—deoxyribonucleic acid. In all plant and animal cells, DNA is located in chromosomes, threadlike bodies in the nucleus. Bacteria have simpler structures, but are also directed by DNA.

Control depends on the ability of DNA molecules to store and transmit information. Long, twisted strands of DNA are archives of instructions for



all processes of the cell.

Information is recorded in a molecular code made possible by the structure of the DNA molecule, detailed above.

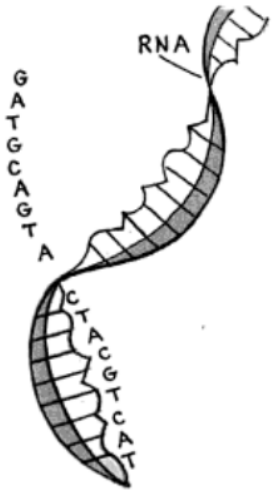
Twin backbones are repeating chains of submolecular units, called deoxyribose sug-

supply instructions to direct life processes of living things

ars, linked together by phosphate bonds. Bridging across are pairs of subunits named adenine, thymine, cytosine, and guanine—usually called A, T, C, and G.

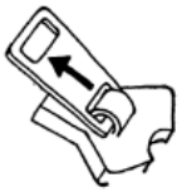
These units serve as a four-letter alphabet. As shown below, their sequence spells "words" that are meaningful to the cell.

Instructions are read by means of another kind of molecule, RNA (ribonucleic acid), a single twisted chain with side groups that correspond to the subunits of DNA. RNA molecules are built by the chemical machinery of the cell, using one strand of a DNA molecule as a template. Then the RNA molecule peels off, acts as a messenger to deliver instructions elsewhere in the cell.



Two-stranded structure of DNA makes possible use of the same information-transfer mechanism for copying DNA molecules, so that hereditary instructions can be passed from generation to generation.

Pairing of subunits follows a rule: A can pair only with T, C pairs only with G. (Note that this rule is followed throughout illustration.) Thus, the strands are not identical, but are complementary, and each can serve as a template for the reconstruction of the other.



When a DNA molecule is to be copied, the molecule "unzips," as shown symbolically above. Then the machinery of the cell uses the same zipper-like action to reconstruct each missing half, as shown below, from subunits freely available in the nucleus of the cell. Now there are two DNA molecules identical with the original one.

Every DNA molecule in the chromosomes of a cell is copied prior to cell division, the basis of all reproduction. When the cell divides, the chromosomes split in half and a full complement of half-chromosomes goes into each new cell.

Since all the information-bearing DNA molecules have doubled, each cell now contains exactly the same stored instructions as the original parent cell, and can carry out the same life processes.

That's how you got those big brown eyes. (The family secret for manufacturing the pigment in your eyes was handed down by means of your ancestral DNA.)

69

DNA: It Calls the Signals for Life

[Continued from page 68]

small molecules out of big ones. In the case of DNA, the pieces—six kinds of submolecular units—had been identified. Now it was necessary to figure out how the jigsaw puzzle fitted together.

Another way is to use X rays, but in a special manner. A technique called X-ray diffraction lets physicists take a peculiar kind of look inside certain kinds of molecules—those that form crystals.

DNA extracted from cells and purified is a jelly-like material. Not much resemblance to a crystal, you might think. But when it's pulled like taffy and dried under the right tension, it forms fibers that do have a complicated crystalline structure.

One of the Nobel Prize winners, Dr. Wilkins, is a physicist who worked in this country on the Manhattan Project. After World War II, back in England, he got interested in biological problems and became a biophysicist. During the early 1950s he perfected a method of making X-ray diffraction photos of DNA fibers.

Such photos are taken by shooting a very narrow beam of X rays through the sample. Some of the X rays are bent by interaction with atoms. The emerging X-ray waves interfere with each other to form a pattern that registers on the film.

X-ray diffraction photos do not show the outlines of the molecules they represent. They are in "reciprocal space"—small distances on a photograph stand for large spaces in the molecule, and vice versa. The pictures must be interpreted by mathematical analysis; and the more complex the molecule, the more difficult that is.

Drs. Crick and Watson began to work on methods of interpreting the X-ray diffraction photos of DNA. They met at Cambridge, where Watson had gone to do research a couple of years after getting a Ph. D. from Indiana University.

Working backwards. Crick had worked out a theory for predicting what X-ray pictures of various molecular models would look like. That is, the pictures were so hard to interpret they had to work backwards: devise a model, then determine mathematically what its X-ray diffraction equivalent should be. Then the prediction was compared with actual distances and angles on the X-ray photos.

The two experimenters shared with Wilkins the idea that a twisted, helical molecular structure might fit the X-ray data (it had been discovered that such twists exist in other molecules produced by the cell). They built a model of rods, clamps, and sheet-metal cutouts (representing the various known pieces of the jigsaw puzzle), and evaluated it mathematically.

This first model didn't prove out, and they temporarily dropped the problem, going on to other research. Some months later, in February, 1953, they learned of a structure proposed for DNA by Linus Pauling, Caltech's Nobel-Prize-winning chemist. From their previous work, they knew that Pauling had to be wrong. This stimulated them to try another model, incorporating new information about the exact shapes of some of the subunits of DNA.

A month later they had a model that fitted the X-ray data closely. From it, they worked out the profound "Watson-Crick hypothesis," which explains how the DNA molecule does its work in the cell. That hypothesis has been tested through ingenious experiments in numerous laboratories, and is accepted as gospel in the new world of molecular biology.

The key to life. The DNA molecule stands revealed as a double helix shaped roughly like a twisted ladder.

The two legs of the ladder are identical, but the rungs are not, and this is the key to the molecule's ability to store information. The order of the four different subunits that make up the rungs is the code of life.

The way the subunits link across the rungs is the key to DNA's ability to transmit information. Each rung actually consists of two units, but the pairing of the units follows definite rules; the molecule can "unzip," and each half serves as a template for rebuilding the missing half, producing two new molecules identical to the original one.

The Watson-Crick hypothesis has made possible a new view of the "molecular basis of life": In the cell—really a miniature chemical factory—DNA molecules contain the instructions that tell the molecular machinery of the factory what new molecules to build. The product molecules in turn determine the function of the cell—whether it's a blood cell, a nerve cell, a sperm cell, or (if not part of a many-celled organism) perhaps a harmful bacterium.

DNA: It Calls the Signals for Life

In this way, the information stored in DNA molecules specifies an entire community of cells, such as those that add up to a human being—the color of his hair and eyes, his basic aptitudes, his built-in sensitivity or resistance to disease.

Programing a man. An individual DNA molecule is about 10,000 subunits long (that is, there are that many rungs on the ladder), and the list of instructions necessary to specify a human being is about 10 billion DNA units long. If the DNA molecules containing that message were placed end to end, they would make a strand 10 feet long, but only one twelve-millionth of an inch thick. Actually the strands are bundled in the microscopic bodies called chromosomes, in the nucleus of each cell, which hold the machinery of heredity.

The specifications must be passed on from generation to generation. This takes place during the cell division, when the chromosomes divide. Preparatory to cell division, the DNA molecules in the chromosomes have unzipped and have been copied by the machinery of the cell.

Work in the cell, controlled by DNA, is important not only to healthy life, but also to disease. Viruses, for example, take over cells and turn them into virus factories by interfering with the normal flow of instructions and substituting new instructions. Hereditary diseases are the result of "errors" that have crept into the coded instructions during copying of DNA molecules. Such changes also transform normal cells into cancer cells, which have "forgotten" their usual roles and "learned" new functions.

Those facts explain why DNA has created such excitement among biologists. If a way can be found to send man-made chemical messages into cells and alter the instructions stored there by DNA molecules, almost anything is possible.

But that isn't likely to come about this year or next. First the code must be deciphered. That's where most of the research on DNA is concentrated today.

Another unsolved problem, perhaps even more mysterious, is how cells "decide" to use particular instructions stored in their DNA archives. Discoveries on this frontier will explain how cells respond to outside stimuli—and how a single fertilized cell can multiply selectively to produce the many different kinds of specialized cells that make up a human being. ■■

Add to your explanation of the importance of the structure of DNA in understanding how our genetic material functions to make us who we are.

Activity

3 Reading Textbook Explanations

Building your Understanding of DNA Structure

Part III: After reading and annotating Section 3.5 of your biology text, paying special attention to the diagrams and figures, go back to your original diagram of DNA. Make changes or add to your diagram based on additional understanding gained from this article. You can also re-draw your diagram.

Add to your explanation of the importance of the structure of DNA in understanding how our genetic material functions to make us who we are.

Add to your explanation of the importance of the structure of DNA in understanding how our genetic material functions to make us who we are.

Lesson 4

Close Reading and Annotating for Concepts

In this lesson, you will . . .

- Develop skills to analyze information from a variety of sources.
- Integrate ideas to develop a larger understanding of contributions made by researchers on the discovery of DNA.
- Extend your knowledge by transforming the information into a concept map.
- Learn to summarize and synthesize your findings to discuss how our understanding of DNA developed.

Activity

3 Concept Maps

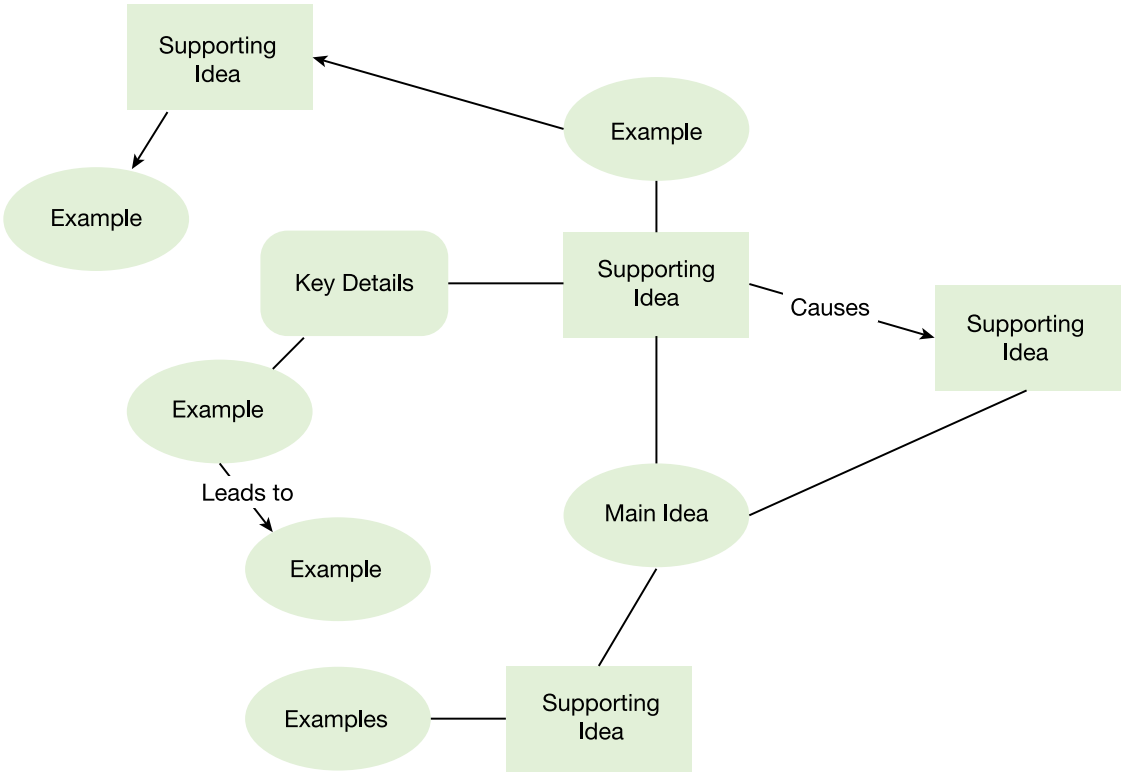
Concept maps are visual representations of information, so using this strategy is very useful for students who tend to learn visually. A concept map is organized in such a way that it is easy to see the major concept that is being mapped, related concepts, and how everything is related.

Concept mapping works well when it is important to see the relationship between complex concepts, and it works particularly well in courses where many ideas are related or interconnected. For example, mapping might work well to see the relationship between hormones of the endocrine system or the stages of meisis. Mapping is especially useful for students who like to personalize strategies because there is no right or wrong way to map. The important thing is that the way ideas are linked together be clearly shown in your concept map.

How Do You Use Maps to Study? When you study your map, you can begin by rehearsing one concept at a time. Then cover up everything except the main concept, and begin to talk the information through. Say the related material and then check your accuracy. Focus on how the concepts are related to each other because that is the major strength of mapping. Rather than viewing ideas one at a time, as you would with CARDS, mapping enables you to understand how these ideas fit together.

(Adapted from Nist-Olejnik, S. L. & Holschuh, J. P. (2013). *College Success Strategies 4th ed.*)

General Structure of a Concept Map

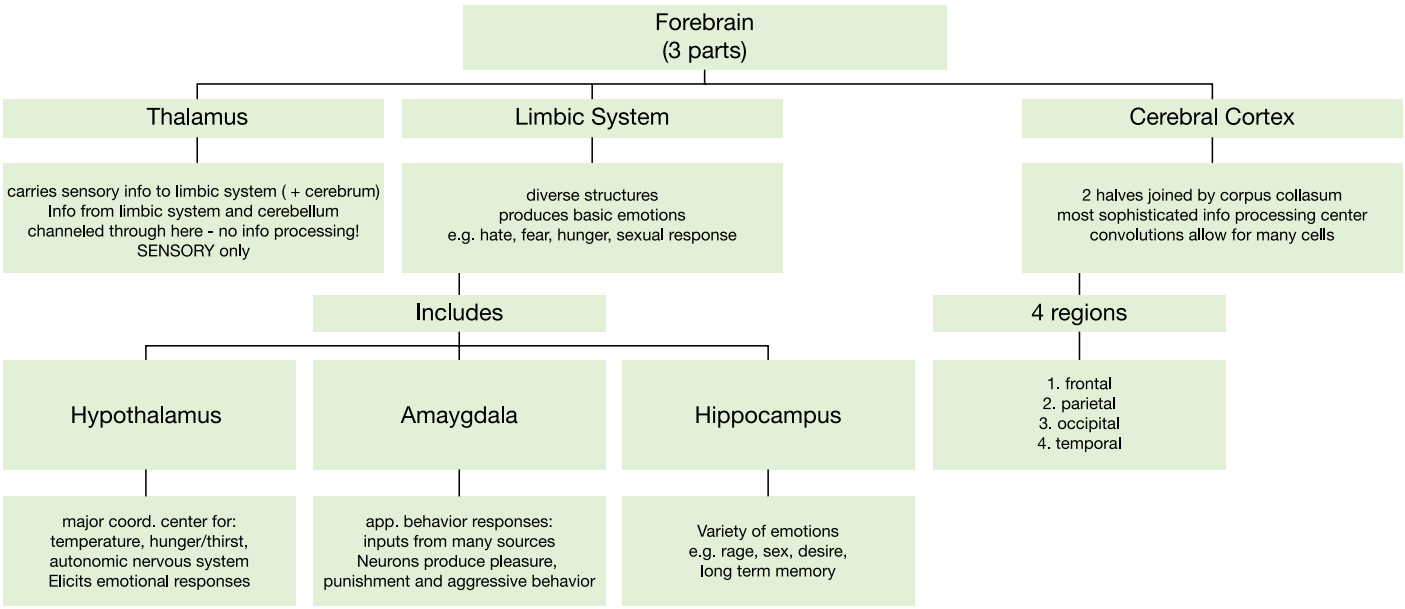


You can see in this example that the map includes both main and supporting ideas as well as details and examples.

Components of a concept map:

1. Enclosed space (circle, box, etc.) to represent the concepts
2. Lines to represent the relationship between the concepts
3. Labels on the line to describe the relationship, such as:
   - causes,
   - composed of,
   - depends on,
   - affects (increases, decreases, inhibits, generates, etc.),
   - includes,
   - leads to.
4. Arrows indicate the direction(s) of the relationship.

It also can show how one concept leads to another or how concepts are interrelated. In the example below, a student has depicted the parts of the forebrain.



Concept Map

Concept Map Grading Rubric

	Excellent	Good	Below Average	Poor
Organization	Well organized. Logical format. Contains main concepts. Contains an appropriate number of concepts.	Thoughtfully organized. Easy to follow most of the time. Contains most of the main concepts. Contains an adequate number of concepts.	Somewhat organized. Somewhat incoherent. Contains only a few of the main concepts.	Choppy and confusing. Contains a limited number of concepts.
Content	Linking words demonstrate superior conceptual understanding. Links are precisely labeled.	Linking words easy to follow but at times ideas unclear. Links are not precisely labeled.	Linking words are clear but present a flawed rationale. Links are not labeled.	Difficult to follow. No links.
Cooperation	Worked extremely well with each. Respected and complemented each others ideas.	Worked very well with each other. Worked to get everyone involved.	Attempted to work well with others. At times “off task” and not everyone was actively involved.	Little or no teamwork.

Activity
5

Week 2
Weekly Reflection

Reflect on your experience:

1. Think about the science. What did you learn about the discovery, structure and function of DNA?

2. Think about your learning. How will this experience change the way you approach reading in the sciences?

Lesson 5
Taking Notes

In this lesson, you will . . .

- Understand the five steps involved in biotechnology.
- Learn note-taking strategies for science documentaries.

Activity

1 Summarizing the Fields of Biotechnology

Genetic Engineering

Medicine and Agriculture

Production of Vaccines, Antibiotics and Hormones

Transgenic Animals

Transgenic Plants

Activity

3 Note-taking from Lecture

(Adapted from Nist-Olejnik & Holschuh 2013 College Success Strategies, 4th ed.)

Because many scientists view the textbook as a supplement and class lecture to be the most important, up-to-date material, it is crucial that you go to class every day and take excellent notes. Your notes are the only record of what was said in class.

If the lecture includes diagrams, figures, or illustrations, it is important to put the visuals in your notes. It is also important to write down any formulas, equations, charts, or graphs accurately and completely. Although we have discussed paraphrasing ideas and putting them into your own words as much as possible, in science there are some technical ideas that have specific meanings and should be written exactly as the professor specifies. In addition, use scientific notation and abbreviations as much as possible as you take notes so that you are comfortable with their meaning come exam time.

Strategies for note taking during a lecture

One form of culture shock that high school students always encounter when they go to college is how to cope with the lecture in science class. The college lecture can be an intense 50 minute to one and a half hour narrative presented by a professional scientist who is attempting to explain scientific processes and phenomena. Unlike small high school classrooms, college classrooms at large universities may contain 300 students. As a result, there is little interaction with the instructor beyond the lecture. You have to do a good deal of self-imposed studying. The best way to deal with this daunting task is to be prepared and organized. Here are a few strategies that may help with note taking during a lecture.

- *Read ahead of time:* Most college instructors provide outlines in their syllabi of what materials will be read and when. Read these closely before attending class. A close reading of the assigned materials beforehand will alleviate the need to take tons of notes because lectures often repeat material covered in the textbooks.
- *Take reading notes:* Again, in preparation for the lecture, find a system that works for you and take reading notes. You may read a small section of the text, then review it, and then take notes.
- *Listen closely:* This may seem simple but during a long lecture it is easy to drift away and not listen. Stay focused during class and try to identify aspects of the lecture that are not covered in the assigned readings. These new components are perfect note taking opportunities. Keep your mind actively engaged.
- *Be organized in your note taking:* Date each lecture. Leave a space at the top of the page so that you can come back later and outline the major topics covered in the lecture. This mini-outline creates a kind of running table of contents for you that you can review on a day-to-day basis. Use a note-taking tool, like a graphic organizer, that helps you identify the key science processes, terms, and ideas.
- *Deal with diagrams:* An important component in most science lectures is diagrams, tables, and illustrations. When this information is discussed, it is sometimes difficult to take notes on both the diagrams and what the instructor is saying. One way to deal with this problem is to write down the title of the diagram (e.g., the Fluid Mosaic Model) but focus your note taking on the instructor's explanation. Then, refer to your textbook after class to connect the visual with your notes.

Cornell Notes page

Cornell Notes page

Cornell Notes page

Activity

4 Homework

Introduction to Biotechnology

Based on the video you watched and the text you read, respond to the following questions:

Why might a scientist want to modify organisms?

What are the current concerns and advancements in biotechnology?

What interests you about biotechnology?

Lesson 6
Preparing for Science Exams

In this lesson, you will . . .

- Utilize strategies to generate your own exam reviews.
- Learn to ask and answer higher-level questions.
- Learn to organize concepts as a way to comprehend science processes.
- Take a multiple-choice and short essay exam.

Activity

2 Creating a Jot List

When you are preparing for an exam, you need to organize all of the concepts you need to know. One way to do this is to make a jot list of the concepts. First, think about all of the material that will be covered on the exam. Remember to think beyond the textbook alone.

Make a list of the materials you used in this unit:

Make a list of the important concepts you need to know for the exam:

Concept Maps

(Adapted from Nist & Holschuh, *2012 College Success Strategies,* 4th edition)

How Do You Use Maps to Study?

When you study your map, you can begin by rehearsing one concept at a time. Then cover up everything except the main concept, and begin to talk the information through. Say the related material and then check your accuracy. Focus on how the concepts are related to each other because that is the major strength of mapping.

Question and Answer Strategy Predict 10 higher-level questions about the material. You will use these questions with classmates as part of your exam review. Write a response for each answer (note: your answers do not need to be in full sentences—you need enough information to know if your classmate's response is correct when you are quizzing them during the exam review).

Activity

4 Predicting Test Questions

	Question	Answer
1		
2		
3		
3		
4		
6		
7		
8		
9		
10		

Activity

7 Exam Reflection

The purpose of this evaluation is to help you learn from your experience preparing for and the exam. Think about how you felt about your level of preparation before the exam, where you focused your effort, and how you felt taking the exam.

1. What went right? Analyze the exam to discuss what you did well and what helped your thinking about these concepts.

2. What went wrong? Analyze the exam to discuss areas you might want to work on. In this analysis: Think about the errors you made and diagnose the nature of your difficulties as they relate to the DNA and biotechnology concepts learned, problem solving expected, or your beliefs about science and/or science learning. Note: don't just describe a difficulty; you need to analyze your thinking. (For example, a poor diagnosis would be, "I was confused" or "I picked the wrong answer." A good diagnosis would provide a reason for the errors, " I thought that a person's tRNA was the same as mRNA.")

3. What will I do differently next time? Conduct an overall assessment of your performance. This is where you will look for patterns to your errors, think about particular aspects of the exam that may have been difficult for you, types of questions you missed, general concepts that were difficult, etc. In your assessment write about how understanding these issues will impact your science test-taking in the future.

Lesson 7
Analyzing Science Arguments

In this lesson, you will . . .

- Learn to analyze scientific arguments.
- Construct diagrams to visualize the arguments.
- Learn that science argumentation is based on evidence to support claims and science principles used as warrants.

Activity

2 Analyzing Science Arguments

In textbooks science is often presented as a series of experiments and observations. Reading these books can make it seem like all scientists agree on every idea. Actually, the majority of scientific concepts are continually contested and modified in the scientific community. Scientists can agree on one thing: arguing science creates better understandings. Once you learn to spot scientific arguments, you will find them in most science writing—including your textbooks.

In this lesson you will examine some of the argument made an article on GMOs from the journal *Nature Education*.

A good argument includes all of the following:

Data: these are the facts involved in your argument that support your claims.

Claim: this is the conclusion that is drawn from the data.

Warrants: these are the reasons that justify the connection between the data and the claim.

Backing: these are the basic assumptions that are commonly agreed upon that provide justification for the warrants.

The overall goal is to present the argument in a sentence: "The author argues . . . because (*data*) . . . since (*warrant*) . . . on account of (*backing*) . . . although some believe/are concerned about (*qualifiers*) . . . however, the data suggests (*rebuttal*) . . . therefore (*conclusion*)."

(Adapted from Driver, R., Newton, P., Osborne, J. (1998). Establishing the norms of scientific argumentation in classrooms.)

In more complex arguments, the following ideas are added:

Qualifiers: These are the special conditions under which the claim can be true. They are the limitations on the claim.

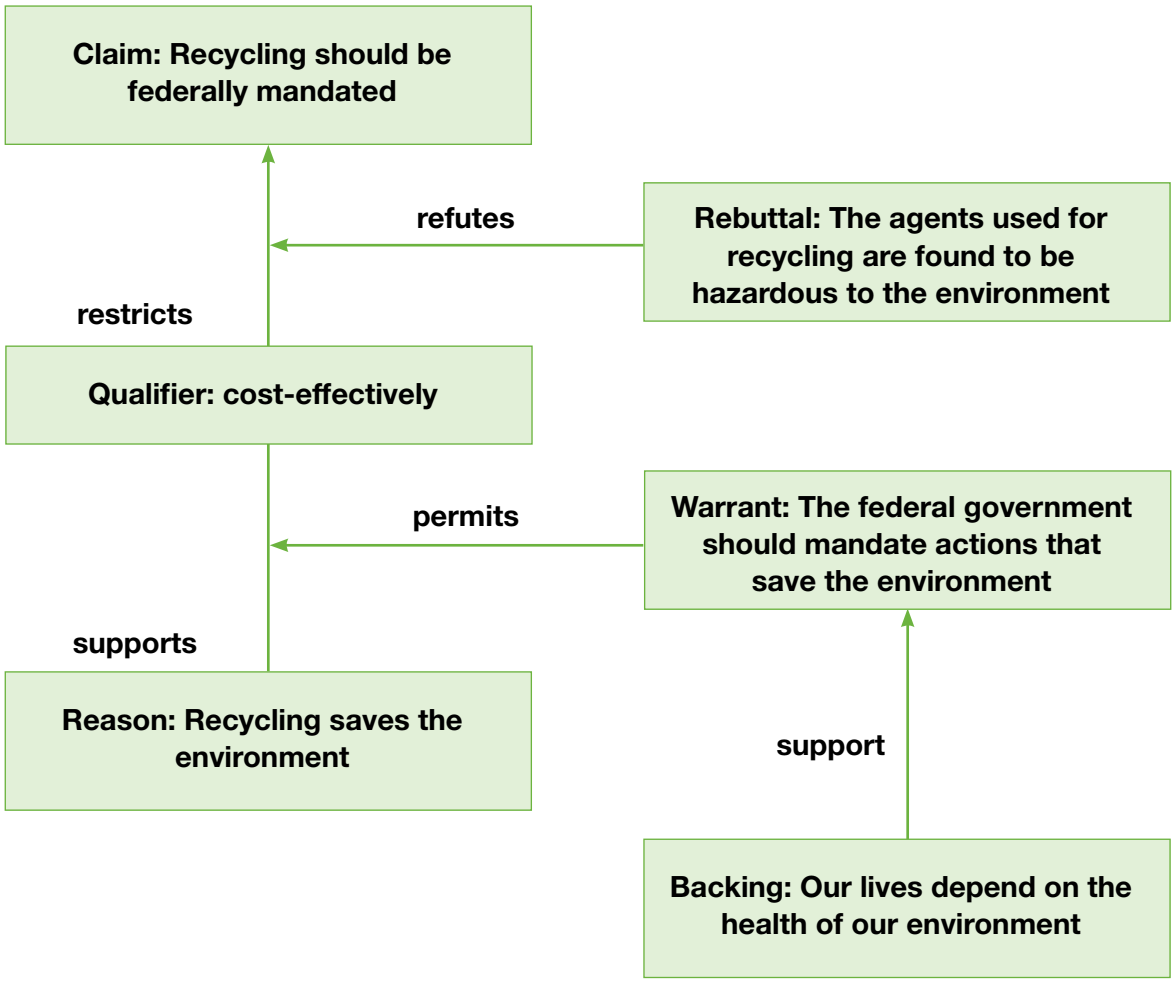
Rebuttals: These are the conditions when the claim will not be true.

Pro/Con Chart – Biotechnology and Crops

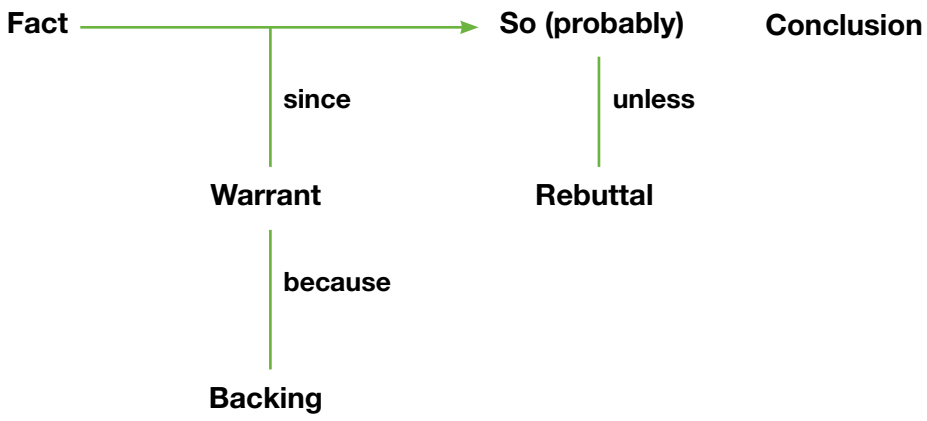
Use chart below to determine the arguments from the *Nature Education* article.

Pros	Cons

Use the following examples to help your group diagram the arguments in the text.



From Britt, M. A., & Larson, A. A. (2003) Constructing representations of arguments. *Journal of Memory and Language, 48,* 794-810.



Toulamin's (1958) Argument Frame

Write your argument as a sentence using the following example as your guide:

The overall goal is to present the argument in a sentence: "The author argues . . . because (*data*) . . . since (*warrant*) . . . on account of (*backing*) . . . although some believe/are concerned about (*qualifiers*) . . . however, the data suggests (*rebuttal* . . . therefore (*conclusion*)."

(Adapted from Driver, R., Newton, P., Osborne, J. (1998). Establishing the norms of scientific argumentation in classrooms.)

Activity

4 Writing a Purpose Statement

From https://writing.wisc.edu/Handbook/Thesis_or_Purpose.html

Thesis and Purpose Statements

Use the guidelines below to learn the differences between thesis and purpose statements.

- In the first stages of writing, thesis or purpose statements are usually rough or ill-formed and are useful primarily as planning tools.
- A thesis statement or purpose statement will emerge as you think and write about a topic. The statement can be restricted or clarified and eventually worked into an introduction.
- As you revise your paper, try to phrase your thesis or purpose statement in a precise way so that it matches the content and organization of your paper.

Thesis statements

- A thesis statement is a sentence that makes an assertion about a topic and predicts how the topic will be developed. It does not simply announce a topic: it says something about the topic.

  Good: X has made a significant impact on the teenage population due to its . . .

  Bad: In this paper, I will discuss X.
- A thesis statement makes a promise to the reader about the scope, purpose, and direction of the paper. It summarizes the conclusions that the writer has reached about the topic.
- A thesis statement is generally located near the end of the introduction. Sometimes in a long paper, the thesis will be expressed in several sentences or an entire paragraph.
- A thesis statement is focused and specific enough to be proven within the boundaries of the paper. Key words (nouns and verbs) should be specific, accurate, and indicative of the range of research, thrust of the argument or analysis, and the organization of supporting information.

Purpose statements

- A purpose statement announces the purpose, scope, and direction of the paper. It tells the reader what to expect in a paper and what the specific focus will be.

  Common beginnings include: *"This paper examines …," "The aim of this paper is to …," and "The purpose of this essay is to…"*
- A purpose statement makes a promise to the reader about the development of the argument but does not preview the particular conclusions that the writer has drawn.
- A purpose statement usually appears toward the end of the introduction. The purpose statement may be expressed in several sentences or even an entire paragraph.
- A purpose statement is specific enough to satisfy the requirements of the assignment. Purpose statements are common in research papers in some academic disciplines, while in other disciplines they are considered too blunt or direct. If you are unsure about using a purpose statement, ask your instructor.

  This paper will examine the ecological destruction of the Sahel preceding the drought and the causes of this disintegration of the land. The focus will be on the economic, political, and social relationships which brought about the environmental problems in the Sahel.

DNA Final Project Topic Idea and Purpose Statement

Critical Focus Question: This will help you focus your research and the development of your project: "What are the current trends and future applications of biotechnology?"

After researching peer-reviewed journal articles on a topic related to biotechnology and health or biotechnology and agriculture, write a research report in the form of a scientific poster that discusses the science behind the technology and evaluates current and future applications. Be sure to support your position with evidence from your research. Cite at least ***six to eight*** *sources, pointing out key elements from each source.*

You will create a poster presentation on your topic. To complete this assignment you will read research articles, synthesize the information and write an evaluative argument on your topic.

You will present the poster of your project to the class in a research symposium and create a handout for your classmates.

Select your research topic. Write up a purpose statement outlining the following:

- **What is your topic?** You can choose one of the suggested topics or come up with one of your own.

  Example:

  Topic: Engineered crops

- **What is your question?** This is where you take your topic idea and transform it into a question to ask the literature.

  Example:

  Question: How does genetic engineering of crops impact efforts to fight disease in third world countries?

  This question is tentative at this point, but it will help you enter the research with some kind of focus. Next you need to figure out how to answer this question.

- **What will you need in order to answer this question?**

  Example: First I will need to find out exactly what is being done in the area of engineered crops and disease. I know that there are some studies on "edible vaccinations." I need to find research on how that is being done and what else the field is working on.

- **List the issues that will be addressed** (Note: this is just a starting off point. Your list will expand as you do your research).

  Example:

  - Types of diseases being treated.
  - Types of vaccines available now and types in production.
  - The technology behind creating the edible vaccines.
  - Types of foods being used for vaccines.
  - Benefits.
  - Drawbacks.
  - Future benefits and drawbacks.

Prompt: In your own words, write a brief explanation of how will you go about selecting research articles? What are all of the components of this final project?

Lesson 8
Critiquing Science Research

In this lesson, you will . . .

- Gather and critically evaluate information.
- Identify important concepts from science articles and use the information to support your ideas.
- Explain the science topic you are researching by citing specific evidence from your sources.
- Engage in scientific inquiry by forming hypotheses, researching evidence and providing support across text by synthesizing research from multiple sources to support your claims.

Activity

1 Preparing for the Final Project

Project Planning Timeline

Make a plan for completing the project by the due date. Be sure to include deadlines for finding and reading your sources, creating a rough draft and practicing your presentation for the class.

Project Title

What will be done? | By when?

What resources will I need? | What goals do I have?

Notes

Library sources

What will be done? | By when?

What resources will I need? | What goals do I have?

Notes

Library sources

What will be done? | By when?

What resources will I need? | What goals do I have?

Notes

Library sources

What will be done? | By when?

What resources will I need?

What goals do I have?

Notes

Library sources

What will be done? | By when?

What resources will I need?

What goals do I have?

Notes

Library sources

Activity

4 How to Read a Scientific Article

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Jan Hewitt, Ph.D. jhewitt@rice.edu
Cain Project in Engineering and Professional Communication

Reading a scientific article is a complex task. The *worst* way to approach this task is to treat it like the reading of a textbook—reading from title to literature cited, digesting every word along the way without any reflection or criticism. Rather, you should begin by skimming the article to identify its structure and features. As you read, look for the author's main points. Generate questions before, during, and after reading. Draw inferences based on your own experiences and knowledge. And to really improve understanding and recall, take notes as you read. This handout discusses each of these strategies in more detail.

1. Skim the article and identify its structure.

Most journals use a conventional IMRD structure: An abstract followed by **I**ntroduction, **M**ethods, **R**esults, and **D**iscussion. Each of these sections normally contains easily recognized conventional features, and if you read with an anticipation of these features, you will read an article more quickly and comprehend more.

Features of Abstracts

Abstracts usually contain four kinds of information:

- purpose or rationale of study (why they did it)
- methodology (how they did it)
- results (what they found)
- conclusion (what it means)

Most scientists read the abstract first. Others—especially experts in the field—skip right from the title to the visuals because the visuals, in many cases, tell the reader what kinds of experiments were done and what results were obtained. You should probably begin reading a paper by reading the abstract carefully and noting the four kinds of information outlined above. Then move first to the visuals and then to the rest of the paper.

Features of Introductions

Introductions serve two purposes: creating readers' interest in the subject and providing them with enough information to understand the article. Generally, introductions accomplish this by leading readers from broad information (what is *known* about the topic) to more specific information (what is *not known*) to a focal point (what *question* the author asked and answered). Thus, authors describe previous work that led to current understanding of the topic (the broad) and then situate their work (the specific) within the field.

Features of Methods

The Methods section tells the reader what experiments were done to answer the question stated in the Introduction. Methods are often difficult to read, especially for graduate students, because of technical language and a level of detail sufficient for another trained scientist to repeat the experiments. However, you can more fully understand the design of the experiments and evaluate their validity by reading the Methods section carefully.

Features of Results and Discussion

The Results section contains results—statements of what was found, and reference to the data shown in visuals (figures and tables). Normally, authors do not include information that would need to be referenced, such as comparison to others' results. Instead, that material is placed in the Discussion—placing the work in context of the broader field. The Discussion also functions to provide a clear answer to the question posed in the Introduction and to explain how the results support that conclusion.

Atypical Structure

Some articles you read will deviate from the conventional content of IMRD sections. For instance, Letters to *Nature* appear to begin with an abstract, followed by the body of the article. Upon reading, however, you will see that the "abstract" is a summary of the work filled with extensive introduction (for the purpose of catching the attention of a wide audience), and the next paragraph begins a description of the experiments.

Therefore, when you begin to read an article for the first time, skim the article to analyze the document as a whole. Are the sections labeled with headings that identify the structure? If not, note what the structure is. Decide which sections contain the material most essential to your understanding of the article. Then decide the order in which you will read the sections.

2. Distinguish main points.

Because articles contain so much information, it may be difficult to distinguish the main points of an article from the *subordinate points*. Fortunately, there are many indicators of the author's main points:

Document level

Title	visuals (especially figure and table titles)
Abstract	first sentence or the last 1-2 sentences of the Introduction
Keywords	

Paragraph level: words or phrases to look for

surprising	*in contrast with previous work*
unexpected	*has seldom been addressed*
we hypothesize that	*we develop*
we propose	*the data suggest*
we introduce	

3. Generate questions and be aware of your understanding.

Reading is an active task. Before and during your reading, ask yourself these questions:

- Who are these authors? What journal is this? Might I question the credibility of the work?
- Have I taken the time to understand all the terminology?
- Have I gone back to read an article or review that would help me understand this work better?
- Am I spending too much time reading the less important parts of this article?
- Is there someone I can talk to about confusing parts of this article?

After reading, ask yourself these questions:

- What specific problem does this research address? Why is it important?

- Is the method used a good one? The best one?
- What are the specific findings? Am I able to summarize them in one or two sentences?
- Are the findings supported by persuasive evidence?
- Is there an alternative interpretation of the data that the author did not address?
- How are the findings unique/new/unusual or supportive of other work in the field?
- How do these results relate to the work I'm interested in? To other work I've read about?
- What are some of the specific applications of the ideas presented here? What are some further experiments that would answer remaining questions?

4. Draw inferences.

Not everything that you learn from an article is stated explicitly. As you read, rely on your prior knowledge and world experience, as well as the background provided in the article, to draw inferences from the material. Research has shown that readers who actively draw inferences are better able to understand and recall information.

As an example, in the box below is an excerpt from the Introduction of an article in the journal *Biochemistry* (Ballestar et al., 2000). The comments in italics are questions and inferences that might be drawn by a student reader.

> Rett Syndrome is a childhood neurodevelopmental disorder and one of the most common causes of mental retardation in females *Comment: Hmmm…must be related to a gene on the X-chromosome*, with an incidence of 1 in 10000-15000. *Comment: How common is that? Not too likely to happen to me, but there must be several such children born in Houston every year.* Rett syndrome patients are characterized by a period of normal growth and development (6-18 months) followed by regression with loss of speech and purposeful hand use. *Comment: What happens? Something must be triggered or activated at late infancy.* Patients also develop seizures, autism, and ataxia. After initial regression, the condition stabilizes and patients survive into adulthood. Studies of familial cases provided evidence that Rett is caused by X-linked dominant mutations in a gene subject to X-chromosome inactivation. Recently, a number of mutations in the gene encoding the methyl-CpG binding transcriptional repressor MeCP2 have been associated with Rett Syndrome. *Comment: MeCP2 mutations probably cause Rett Syndrome. This must be an important master-regulator to affect so many processes in the brain. I wonder what they know about it…*

5. Take notes as you read.

Effective readers take notes—it improves recall and comprehension. You may think you'll remember everything you read in researching class assignments, professional papers, proposals, or your thesis, but details will slip away. Develop a template for recording notes on articles you read, or adapt the template below for use. As you accumulate a large collection of articles, this template will help you distinguish articles and quickly locate the correct reference for your own writing. The time spent filling out the form will save you hours of rereading when you write a Background, Related Work or a Literature Review section.

Template for Taking Notes on Research Articles: Easy access for later use

Whenever you read an article, pertinent book chapter, or research on the Web, use the following format (or something similar) to make an electronic record of your notes for later easy access. Put quotation marks around any exact wording you write down so that you can avoid accidental plagiarism when you later cite the article.

Complete citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

General subject:

Specific subject:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

References

Ballestar, E., Yusufzai, T.M., and Wolffe, A.P. (2000) Effects of Rett Syndrome Mutations of the Methyl-CpG Binding Domain of the Transcriptional Repressor MeCP2 on Selectivity for Association with Methylated DNA. *Biochemistry* 31, 7100-7106.

Burnett, R. (2001) *Technical Communication*. 5th ed. San Antonio: Harcourt CollegePublishers.

Zeiger, M. (2000) *Essentials of Writing Biomedical Research Papers*. 2nd Ed. St. Louis: McGraw-Hill.

Supported by the Cain Project for Engineering and Professional CommunicationRice University, 2004.

Citing Sources: Using APA Style

Within the text cite the author and the year of publication.

According to Jones (2013) biotechnology can benefit poor nations by increasing access to nutritious food.

Jones (2013) stated that biotechnology can benefit poor nations by increasing access to nutritious food.

Jones (2013) suggested that "biotechnology is our greatest tool for addressing the needs of the undernourished poor" (p. 207).

http://owl.english.purdue.edu/owl/resource/560/07/

APA Basic Form:

Articles

Author, A. A., Author, B. B., & Author, C. C. (Year). Title of article. *Title of Periodical*, *volume number* (issue number), pages. doi:http://dx.doi.org/xx.xxx/yyyyy

Books

Author, A. A. (Year of publication). *Title of work: Capital letter also for subtitle.*
Location: Publisher. (this type also uses a hanging indention)

Online periodical

Author, A. A., & Author, B. B. (Date of publication). Title of article. *Title of Online Periodical, volume number* (issue number if available). Retrieved from http://www.someaddress.com/full/url/

For other APA style citations, please visit the Purdue OWL website — https://owl.english.purdue.edu/owl/resource/560/02/.

SOURCE 1:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

SOURCE 2:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

SOURCE 3:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

SOURCE 4:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

SOURCE 5:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

SOURCE 6:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

SOURCE 7:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

SOURCE 8:

Complete APA citation. Author(s), Date of publication, Title (book or article), Journal, Volume #, Issue #, pages:

If Web access: url; date accessed

Key Words:

Hypothesis:

Methodology:

Result(s):

Summary of key points:

Context (how this article relates to other work in the field; how it ties in with key issues and findings by others, including yourself):

Significance (to the field; in relation to your own work):

Important Figures and/or Tables (brief description; page number):

Cited References to follow up on (cite those obviously related to your topic AND any papers frequently cited by others because those works may well prove to be essential as you develop your own work):

Other Comments:

Activity
5

Weekly Reflection

1. Think about the science. What did you learn about critiquing science research?

2. Think about your learning. How will this experience change the way you approach reading in the sciences?

Lesson 9
Research Poster Symposium

In this lesson, you will . . .

- Identify important concepts from science articles and use the information to support your ideas.
- Explain the science topic you are researching by citing specific evidence from your sources.
- Engage in scientific inquiry creating an evaluative argument about your topic.
- Synthesize research articles to explain science in a research symposium.

Activity

3 Drafting the Poster

Work on an outline of your poster using the following guidelines:

1. Title of a presentation; name; school name; teacher's name.
2. Background and introduction to the topic: This section introduces the topic, describes the questions you are asking, and provides the claim. In this section you will explain the science behind the particular method and connect it to what you have learned in class. Describe the biotechnology—what is it? How is the process accomplished? (The detailed description of your biotechnology application will lead to your **claim**.)
3. Current advances and results: This is the major focus of your poster. This section presents the current issues, themes, and research goals. Where is this technology being used? You will describe the important results and explain how those results shape our current understanding of the topic. You should mention the types of experiments done and discuss their findings but do not report the experimental procedure step-by-step. You might include a figure to help discuss the data. What are the outcomes of this technology? Think about the following:

   Which studies support your hypothesis/claim/question?

   Do some studies support alternative hypotheses?

   Is there controversy in the scientific community over this topic, or is there general agreement?

   What graphs, figures or tables might be relevant to include?

   (This is where you discuss the **data**, **warrants** and **backing**.)
4. Discussion: This section discusses the current advances and results by putting them in context. Highlight any agreements or disagreements in the field and comment on possible reasons for those disagreements.

   (This is where you discuss the **qualifiers** and **rebuttals**.)
5. Conclusions/future directions: This section summarizes your major points and points out the significance. It also discusses where the science is headed in the future and questions that remain based upon the current findings.
6. References in APA style.

Activity

4 Editing and Revising

Revising and Editing Worksheet

Adapted from: J. Cline, (2009) The Writing Program, j-cline@northwestern.edu

Writing and Speaking About Science

Student's Name _____

Topic _____

Key Message(s): _____

Revising = Checking Broad Structure	R

Does the introduction

- Introduce topic and significance? ☐
- Describe the research questions? ☐
- Explain the technology? ☐
- Provide a thesis outlining the argument? ☐

Does the Current Advancements and Results Section

- Present current issues? ☐
- Discuss where the technology is being used? ☐
- Describe important results? ☐
- Provide clear and supported data? ☐
- Illuminate the arguments? ☐
- Are the data persuasive and support the key message? ☐
- Do graphics follow guidelines, including
  - Illustrations self-explanatory? ☐
  - Informative titles ABOVE tables? ☐
  - Informative captions BELOW figures? ☐
  - Integrated explicitly and appropriately in the poster? ☐

Does the conclusion and/or discussion

- Highlight agreements and disagreements in the field? ☐
- Address advantages and limits of methods used? ☐
- Explain implications for current practice or theory? ☐
- Outline research questions that remain? ☐

Does the Conclusions and Future Directions section

- Summarize major points? ☐
- Discuss future directions? ☐

Is anything missing that a reader in the target audience needs to know?

Is the key message(s) clear?

Other elements as needed:

Revising = Checking Finer Structure	R
Does the poster present a logical flow of ideas?	☐
Are all quotes used necessary? Do the quotes advance the argument?	☐
Are there empty, inflated, or redundant words? (Circle in the draft)	☐
Are there choppy sentences that could be combined?	☐
Is there a good variety of words to begin sentences? (Circle redundant starters in the draft)	☐
Are there clichés that need to be removed? (Underline in the draft)	☐
Are sentences of varied length used to draw readers in?	☐
Are there grammar and spelling errors that need to be fixes? (Circle the errors in the draft)	☐
Would subheads improve your understanding?	☐
Is APA style used consistently and correctly? (Underline errors in the draft)	☐

Other elements as needed:

One thing done well in this poster is:

Comments to help the author improve this poster:

Activity
5 Preparing for the Symposium

UCI UNDERGRADUATE RESEARCH SYMPOSIUM PRESENTATION GUIDELINES

Adapted from urop@uci.edu

ORAL PRESENTATIONS

An oral presentation is more than just reading a paper or set of slides to an audience. How you deliver your presentation is at least as important in communicating your message effectively as what you say. Use these Guidelines to learn simple tools that help you prepare and present an effective presentation, and design PowerPoint slides that support and enhance your talk.

PREPARING AN EFFECTIVE PRESENTATION

An effective presentation is more than just standing up and giving information. A presenter must consider how best to communicate their information to the audience. Use these tips to create a presentation that is both informative and interesting.

Organize your thoughts. Start with an outline and develop good transitions between sections. Emphasize the real-world significance of your research.

Have a strong opening. Why should the audience listen to you? One good way to get their attention is to start with a question, whether or not you expect an answer.

Define terms early. If you are using terms that may be new to the audience, introduce them early in your presentation. Once an audience gets lost in unfamiliar terminology, it is extremely difficult to get them back on track.

Finish with a bang. Find one or two sentences that sum up the importance of your research. How is the world better off as a result of what you have done?

Time yourself. Do not wait until the last minute to time your presentation.

Create effective notes for yourself. Have notes that you can read. Do not write out your entire talk; use an outline or other brief reminders of what you want to say. Make sure the text is large enough that you can read it from a distance.

Practice, practice, practice. The more you practice your presentation, the more comfortable you will be in front of an audience. Practice in front of a friend or two and ask for their feedback. Record yourself and listen to it critically. Make it better and do it again.

PRESENTING EFFECTIVELY

When you start your presentation, the audience will be interested in what you say. Use these tips to help keep them interested throughout your presentation.

Be excited. You are talking about something you find exciting. If you remember to be excited, your audience will feel it and automatically become more interested.

Speak with confidence. When you are speaking, you are the authority on your topic, but do not pretend that you know everything. If you do not know the answer to a question, admit it. Consider deferring the question to your mentor or offer to look into the matter further.

Make eye contact with the audience. Your purpose is to communicate with your audience, and people listen more if they feel you are talking directly to them. As you speak, let your eyes settle on one person for several seconds before moving on to somebody else. You do not have to make eye contact with everybody, but make sure you connect with all areas of the audience equally.

Avoid reading from the screen. First, if you are reading from the screen, you are not making eye contact with your audience. Second, if you put it on your slide, it is because you wanted them to read it, not you.

Blank the screen when a slide is unnecessary. A slide that is not related to what you are speaking about can distract the audience. Pressing the letter B or the period key displays a black screen, which lets the audience concentrate solely on your words. Press the same key to restore the display.

Use a pointer only when necessary. If you are using a laser pointer, remember to keep it off unless you need to highlight something on the screen.

Explain your equations and graphs. When you display equations, explain them fully. Point out all constants and dependant and independent variables. With graphs, tell how they support your point. Explain the x- and y-axes and show how the graph progresses from left to right.

Pause. Pauses add audible structure to your presentation. They emphasize important information, make transitions obvious, and give the audience time to catch up between points and to read new slides. Pauses always feel much longer to speakers than to listeners. Practice counting silently to three (slowly) between points.

Avoid filler words. Um, like, you know, and many others. To an audience, these are indications that you do not know what to say; you sound uncomfortable, so they start to feel uncomfortable as well. Speak slowly enough that you can collect your thoughts before moving ahead. If you really do not know what to say, pause silently until you do.

Relax. It is hard to relax when you are nervous, but your audience will be much more comfortable if you are too.

Breathe. It is fine to be nervous. In fact, you should be—all good presenters are nervous every time they are in front of an audience.
The most effective way to keep your nerves in check—aside from a lot of practice beforehand—is to remember to breathe deeply throughout your presentation.

Acknowledge the people who supported your research. Be sure to thank the people who made your research possible, including your mentor, research team, collaborators, and other sources of funding and support.

Keep these Tips in Mind

Establish early a clear and unifying point. Clearly explain the applicability of your research. Be sensitive to those outside your discipline.

Before the Symposium, present to friends and family and invite their feedback. Ask them questions to see if you communicated your points successfully.

Include or discuss the following, if applicable: Introduction, Methods, Results, Discussion, Conclusion, References, and Acknowledgements.

Make sure that your presentation material is readable, grammatically correct, and has been edited and proofread thoroughly.

Cite sources to support your ideas and provide credibility to your findings. Provide credit for text, graphs, etc.

Always acknowledge your sponsors and mentors. Anticipate possible questions and prepare answers.

Be proud of your work, but acknowledge errors. Explain unexpected results and future research that is needed. Always be truthful in presenting your information, and respect your audience. Bring a pen and pad of paper for notes and to record names and addresses of contacts.

Poster Presentations

A poster lets you summarize your research in an engaging visual format. Effective posters communicate the significance of the research, an overview of how the research was conducted, the results, and the implications of those results. These Guidelines help you design a poster to communicate your message clearly.

Prepare and practice a short summary speech—no than 3 minutes—about your project.

DESIGNING YOUR POSTER

Space on a poster is limited, so pick what to present wisely. Your display should be self-explanatory and have a logical flow—viewers should be able to follow the order even if you are not present. Start with a rough draft of your design on paper, using graph paper or Post-it notes to simulate sections. The sample layouts at the end of these Guidelines may give you some layout ideas.

Place your title at the top of the poster and make sure that the text is large and clear. Include your name and major, and the name and department of your faculty mentor, in addition to other co-authors.

Incorporate appropriate graphics in your poster. Label or describe any charts, tables, figures, graphs, or photos that you use. Make sure all edges line up evenly.

Before you attach the pieces to your board, edit and review them and check your spelling. Be sure to attach all materials to your poster board firmly (spray adhesive, found in art supply stores, works best). All posters MUST be complete and ready for presentation upon arrival. Incomplete posters will not be displayed.

DOES YOUR POSTER COMMUNICATE ITS MESSAGE?

Many posters look great but fail to communicate their information clearly. Ask yourself these questions when you are designing your poster.

Is your message clear? Focus on the results and their importance. Avoid overly detailed descriptions of your methods.

Is everything on your poster critical to communicating your message? Remove everything that is not vitally important. Simplify your text by using short bullet points and phrases instead of complete sentences.

Is your organization easy to follow? Most people read from top to bottom, then left to right. Consider numbering your headings to further clarify the flow of information.

Do your headings deliver real information? Good headings by themselves can summarize the main points of your poster if readers are in a hurry.

Is your text easy to read? The poster title should be at least 144 point text, and information about the student(s) and mentor(s) should be 72 points. Headings should be at least 36 point text and easily readable from at least 6 feet. All other text should be at least 18 point and legible from 4 feet.**Is your poster cluttered by too many fonts?** Do not use more than two typefaces. Instead use bold, italic and size to set type differently. Times New Roman, Arial, Garamond, and Verdana are suggested typefaces.

Are your colors distracting? Stick to a simple color scheme (try a couple that complement or contrast with each other, such as black or navy on white). Avoid red/green combinations, as this is the most common form of color blindness.

Are your graphics clear and easy to understand? Avoid elements—such as unnecessary background colors and overly specific labels—that do not add useful information. Explanations should be within or next to figures, not referred to from elsewhere.

Does your poster have a good balance between text, graphics, and white space? Use white space consistently to emphasize separate sections and to keep the poster from becoming too cluttered and difficult to read.

Do readers have to move back and forth to read your poster? Arranging your information in columns makes the poster easy to read in crowded situations, such as the Symposium Poster Session.

Can you talk about your poster without reading directly from it? Be ready to discuss details that questioners cannot read for themselves. People are interested in additional information and your interpretations.

Assessments:

Outcome 4: Students will be able to synthesize research articles to explain science in a research symposium.

- Poster

LDC Argumentation Classroom Assessment

Scoring Elements	1 Not Yet	1.5	2 Approaches Expectations	2.5	3 Meets Expectations	3.5	4 Advanced
Focus	Attempts to address prompt, but lacks focus or is off-task.		Addresses prompt appropriately and establishes a position, but focus is uneven.		Addresses prompt appropriately and maintains a clear, steady focus. Provides a generally convincing position.		Addresses all aspects of prompt appropriately with a consistently strong focus and convincing position.
Controlling Idea	Attempts to establish a claim, but lacks a clear purpose. Makes no mention of counter claims.		Establishes a claim Makes note of counter claims.		Establishes a credible claim. Develops claim and counter claims fairly.		Establishes and maintains a substantive and credible claim or proposal. Develops claims and counter claims fairly and thoroughly.
Reading/ Research	Attempts to reference reading materials to develop response, but lacks connections or relevance to the purpose of the prompt.		Presents information from reading materials relevant to the purpose of the prompt with minor lapses in accuracy or completeness.		Accurately presents details from reading materials relevant to the purpose of the prompt to develop argument or claim.		Accurately and effectively presents important details from reading materials to develop argument or claim.
Development	Attempts to provide details in response to the prompt, but lacks sufficient development or relevance to the purpose of the prompt. Makes no connections or a connection that is irrelevant to argument or claim.		Presents appropriate details to support and develop the focus, controlling idea, or claim, with minor lapses in the reasoning, examples, or explanations. Makes a connection with a weak or unclear relationship to argument or claim.		Presents appropriate and sufficient details to support and develop the focus, controlling idea, or claim. Makes a relevant connection to clarify argument or claim.		Presents thorough and detailed information to effectively support and develop the focus, controlling idea, or claim. Makes a clarifying connection(s) that illuminate argument and adds depth to reasoning.
Organization	Attempts to organize ideas, but lacks control of structure.		Uses an appropriate organizational structure for development of reasoning and logic, with minor lapses in structure and/or coherence.		Maintains an appropriate organizational structure to address specific requirements of the prompt. Structure reveals the reasoning and logic of the argument.		Maintains an organizational structure that intentionally and effectively enhances the presentation of information as required by the specific prompt. Structure enhances development of the reasoning and logic of the argument.
Conventions	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics. Sources are used without citation.		Demonstrates an uneven command of standard English conventions and cohesion. Uses language and tone with some inaccurate, inappropriate, or uneven features. Inconsistently cites sources.		Demonstrates a command of standard English conventions and cohesion, with few errors. Response includes language and tone appropriate to the audience, purpose, and specific requirements of the prompt. Cites sources using appropriate format with only minor errors.		Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors. Response includes language and tone consistently appropriate to the audience, purpose, and specific requirements of the prompt. Consistently cites sources using appropriate format.
Content Understanding	Attempts to include disciplinary content in argument, but understanding of content is weak; content is irrelevant, inappropriate, or inaccurate.		Briefly notes disciplinary content relevant to the prompt; shows basic or uneven understanding of content; minor errors in explanation.		Accurately presents disciplinary content relevant to the prompt with sufficient explanations that demonstrate understanding.		Integrates relevant and accurate disciplinary content with thorough explanations that demonstrate in-depth understanding.

Activity

6 Research Poster Symposium

Poster presentation

Presenter:

Reviewer:

Topic: Date:

Notes:

How effectively did the presenter introduce the audience to the topic?	5 4 3 2 1 Excellent Good Poor	Comments:
How clearly and fully was the science evidence presented? Did the speaker use effective and clear examples?	5 4 3 2 1 Excellent Good Poor	
Were the conclusions effective, logical, and complete?	5 4 3 2 1 Excellent Good Poor	
What was the strongest part of the presentation?		
What changes would you suggest for improvement?		

Poster presentation

Presenter:

Reviewer:

Topic: Date:

Notes:

How effectively did the presenter introduce the audience to the topic?	5 4 3 2 1 Excellent Good Poor	Comments:
How clearly and fully was the science evidence presented? Did the speaker use effective and clear examples?	5 4 3 2 1 Excellent Good Poor	
Were the conclusions effective, logical, and complete?	5 4 3 2 1 Excellent Good Poor	

What was the strongest part of the presentation?

What changes would you suggest for improvement?

Poster presentation

Presenter:

Reviewer:

Topic: Date:

Notes:

How effectively did the presenter introduce the audience to the topic?	5 4 3 2 1 Excellent Good Poor	Comments:
How clearly and fully was the science evidence presented? Did the speaker use effective and clear examples?	5 4 3 2 1 Excellent Good Poor	
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What was the strongest part of the presentation?

What changes would you suggest for improvement?

Poster presentation

Presenter:

Reviewer:

Topic: Date:

Notes:

How effectively did the presenter introduce the audience to the topic?	5 4 3 2 1 Excellent Good Poor	Comments:
How clearly and fully was the science evidence presented? Did the speaker use effective and clear examples?	5 4 3 2 1 Excellent Good Poor	
Were the conclusions effective, logical, and complete?	5 4 3 2 1 Excellent Good Poor	

What was the strongest part of the presentation?

What changes would you suggest for improvement?

Week 6 Reflection

1. Think about the science. What did you learn presenting science research?

2. Think about your learning. How will this experience change the way you approach reading in the sciences?