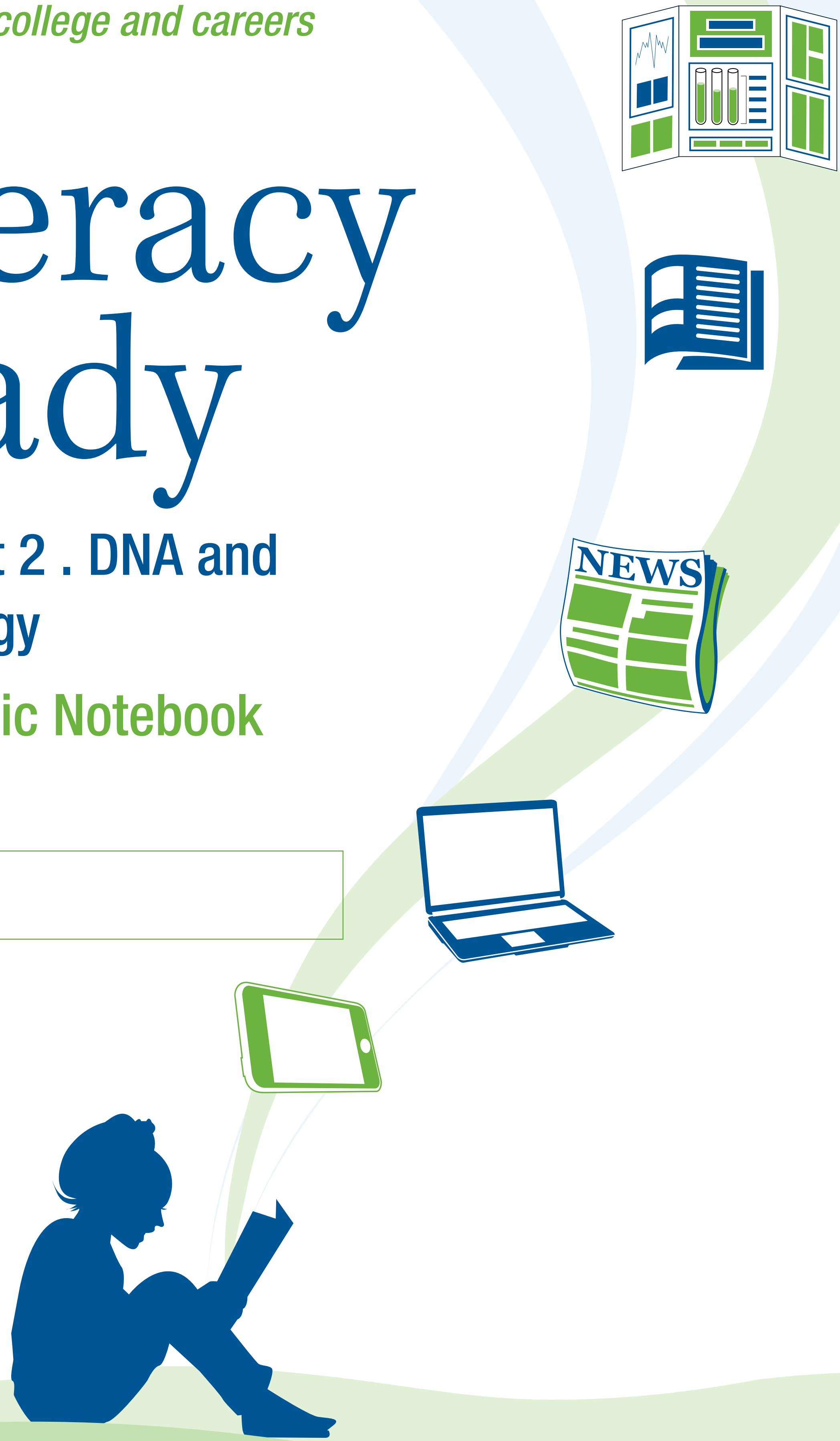
SREB Readiness Courses
Transitioning to college and careers

Literacy Ready

Science Unit 2 . DNA and Biotechnology

The Academic Notebook

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

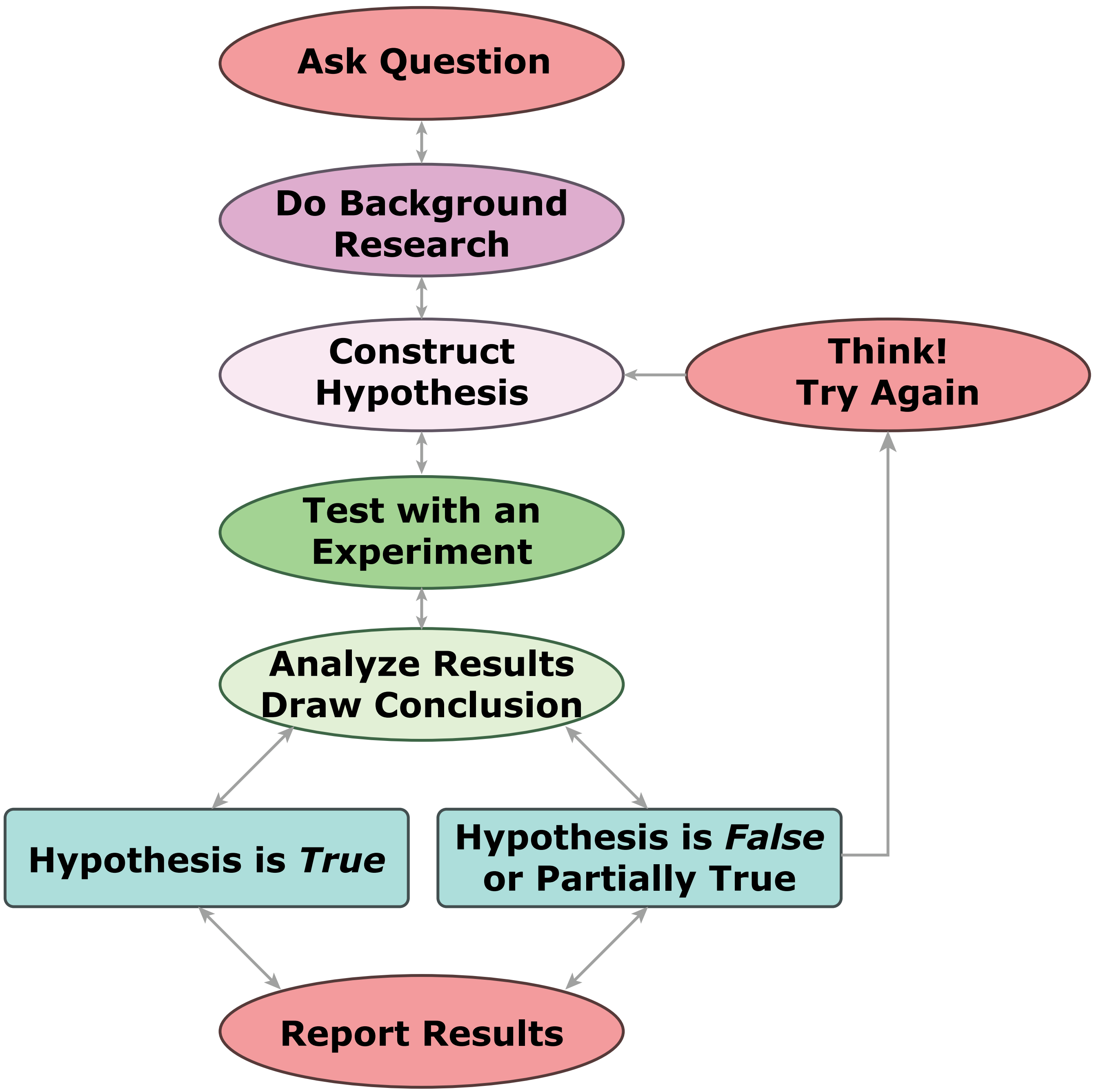
In this lesson, you will . . .

- 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

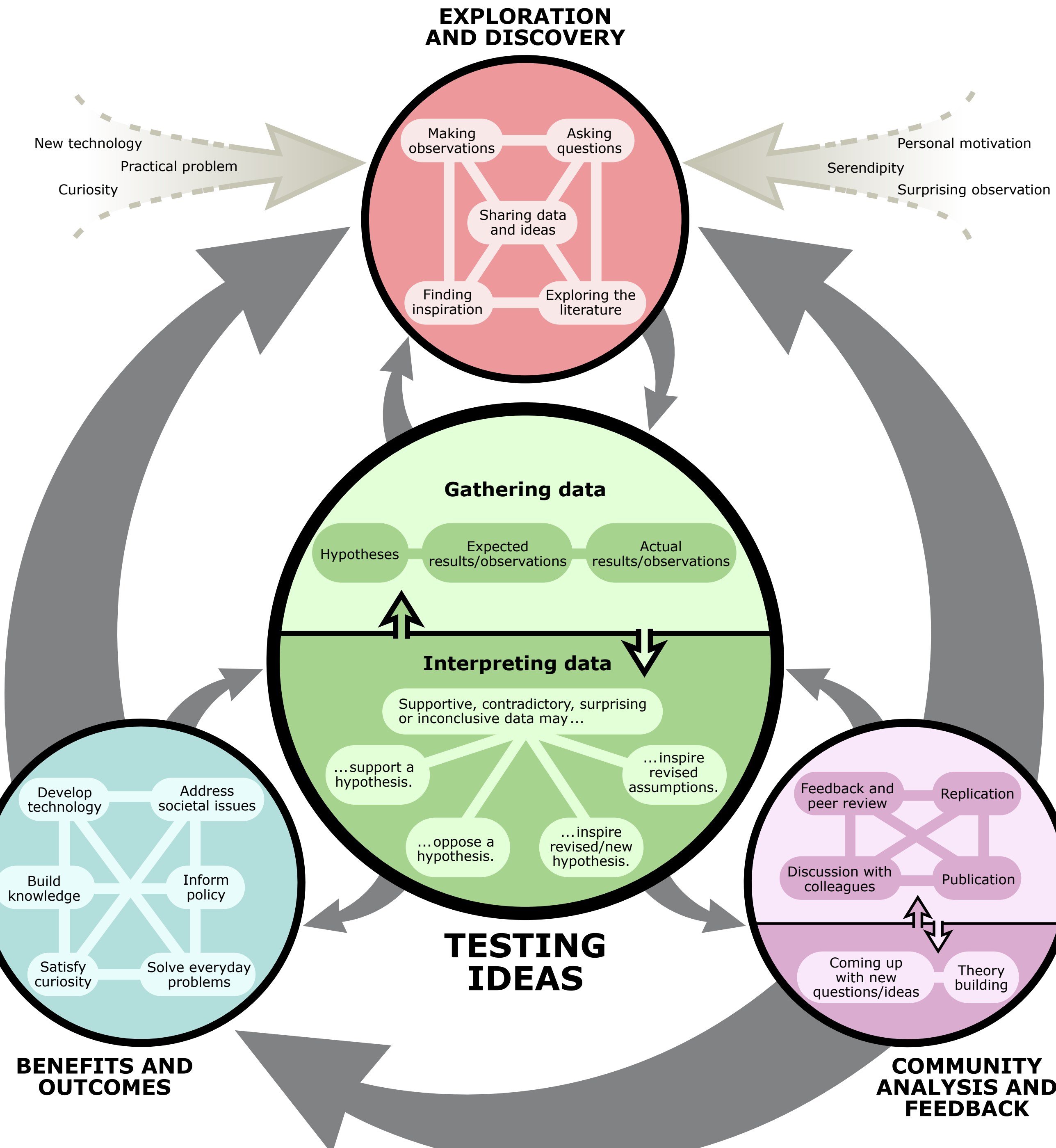
2 Understanding How Science Works

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.

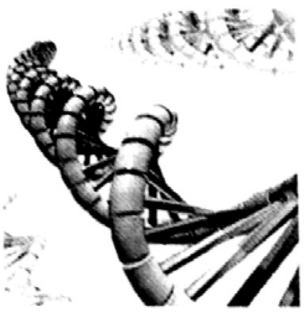
When you annotate your science text, you need to match your annotations to the course expectations. For example, if you are expected to think at higher levels, be sure your annotations include more than just the bold-faced terms. If you are expected to be able to explain science processes, be sure your 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?



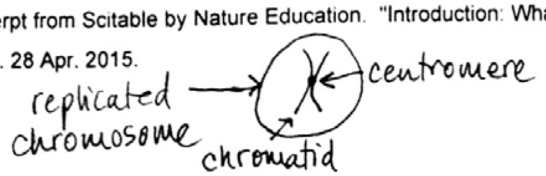
Deoxyribonucleic acid, more commonly known as DNA, is a complex molecule that contains all of the information necessary to build and maintain an organism. All living things have DNA within their cells. In fact, nearly every cell in a multicellular organism possesses the full set of DNA required for that 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

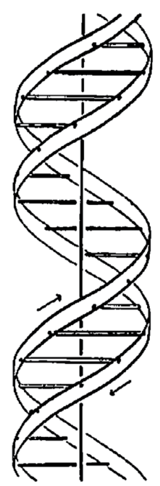
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

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.

[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).

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

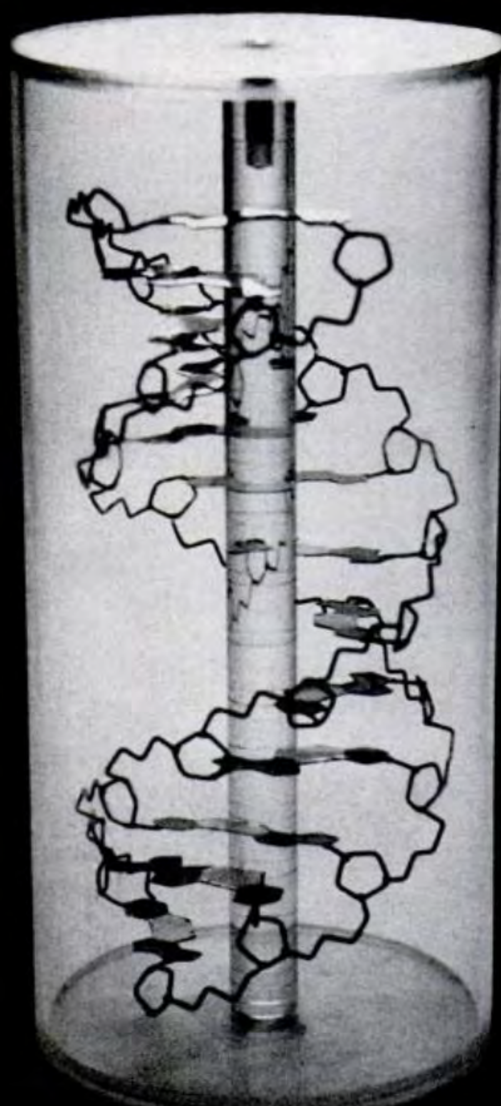
2 Reading Popular Articles

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.

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.

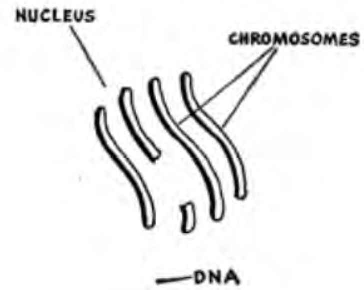
They knew DNA as one of the most complex of the "giant molecules" known to man. It was believed to have a long, chainlike structure consisting of repeating groups of atoms, with side groups sticking out at regular intervals.

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

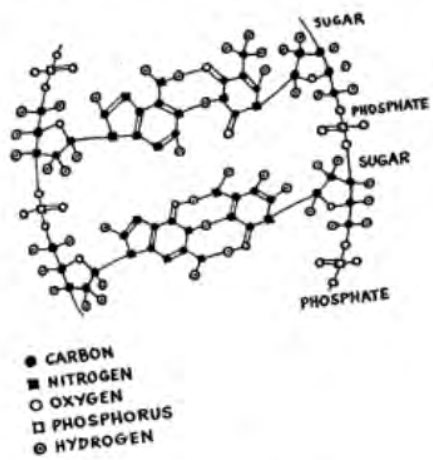
[*Continued on page 186*]

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.

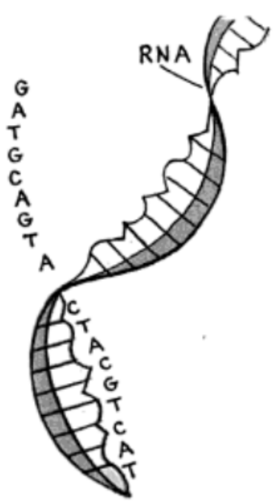
Twin backbones are repeating chains of submolecular units, called deoxyribose sug-

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 mole-



cules 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.

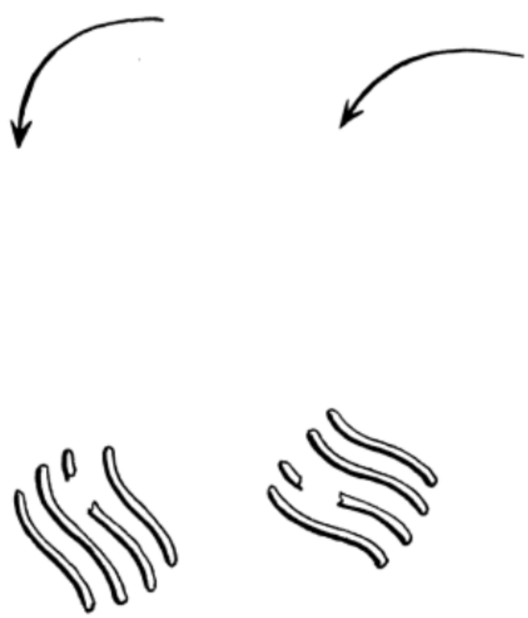
Pairing of subunits follows a rule: A can pair only with T, C pairs only with G. (Note that this rule is followed throughout illustration.) Thus, the strands are not identical, but are complementary, and each can serve as a template for the reconstruction of the other.

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.)



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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. ■■

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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

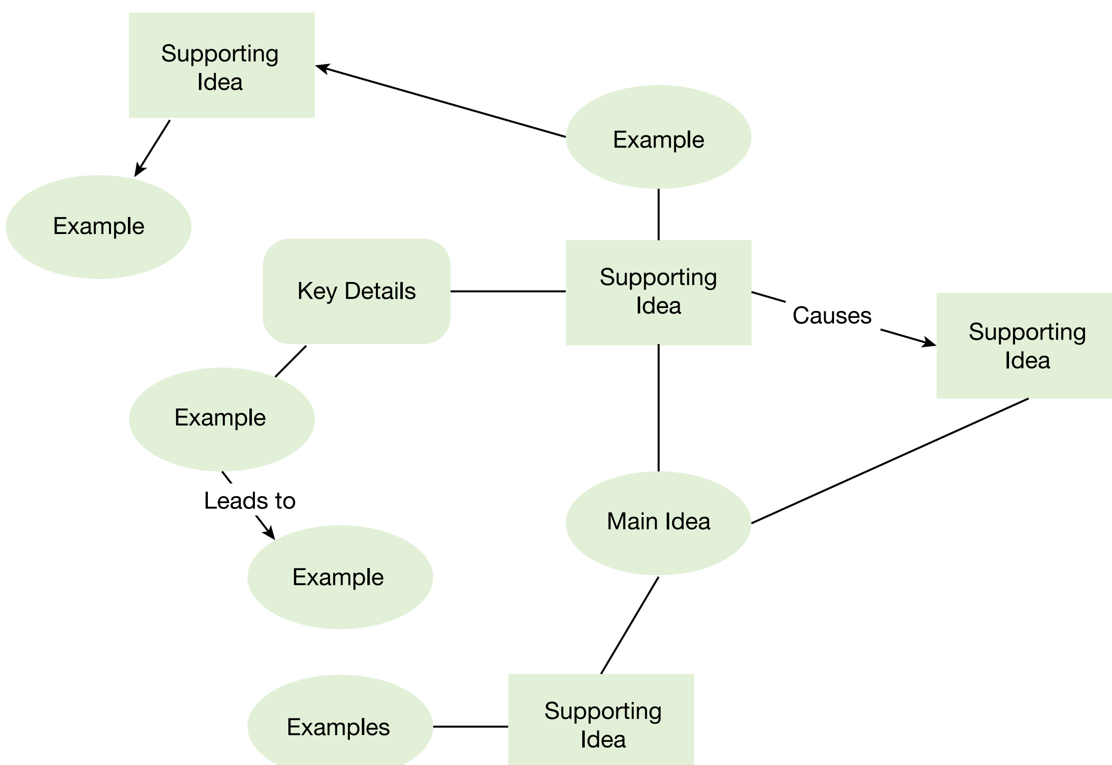
Concept maps are visual representations of information, so using this strategy is very useful for students who tend to learn visually. A concept map is organized in such a way that it is easy to see the major concept that is being mapped, related concepts, and how everything is related.

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

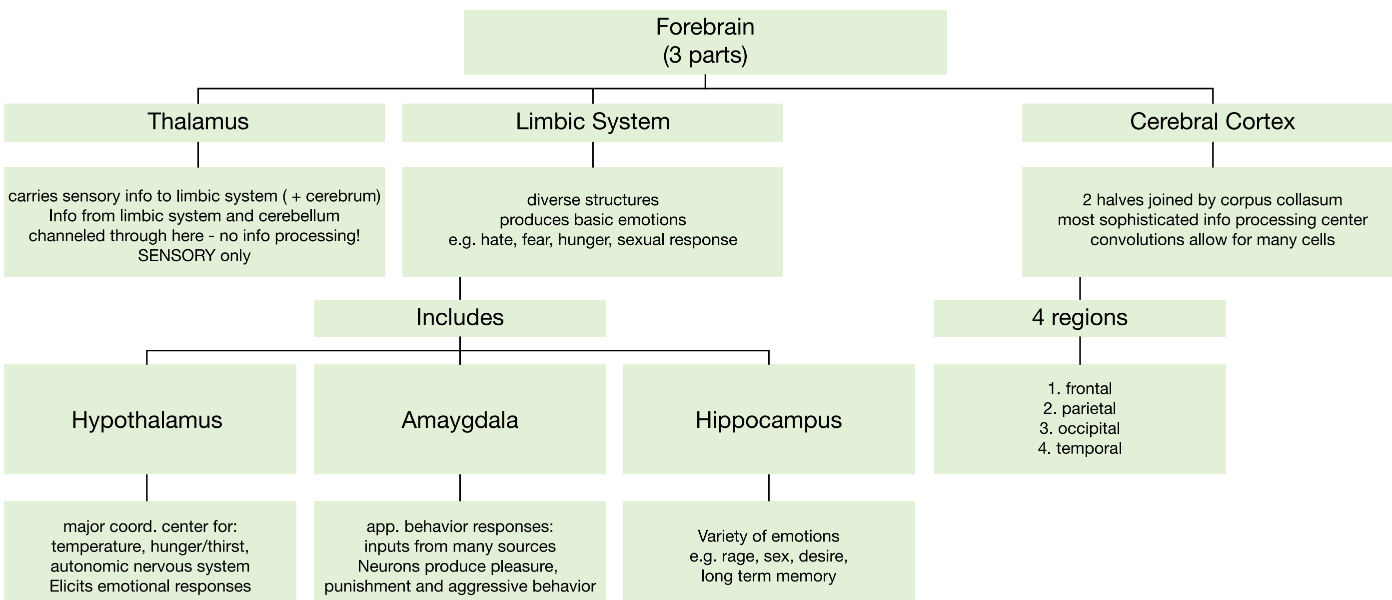


You can see in this example that the map includes both main and supporting ideas as well as details and examples.

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.

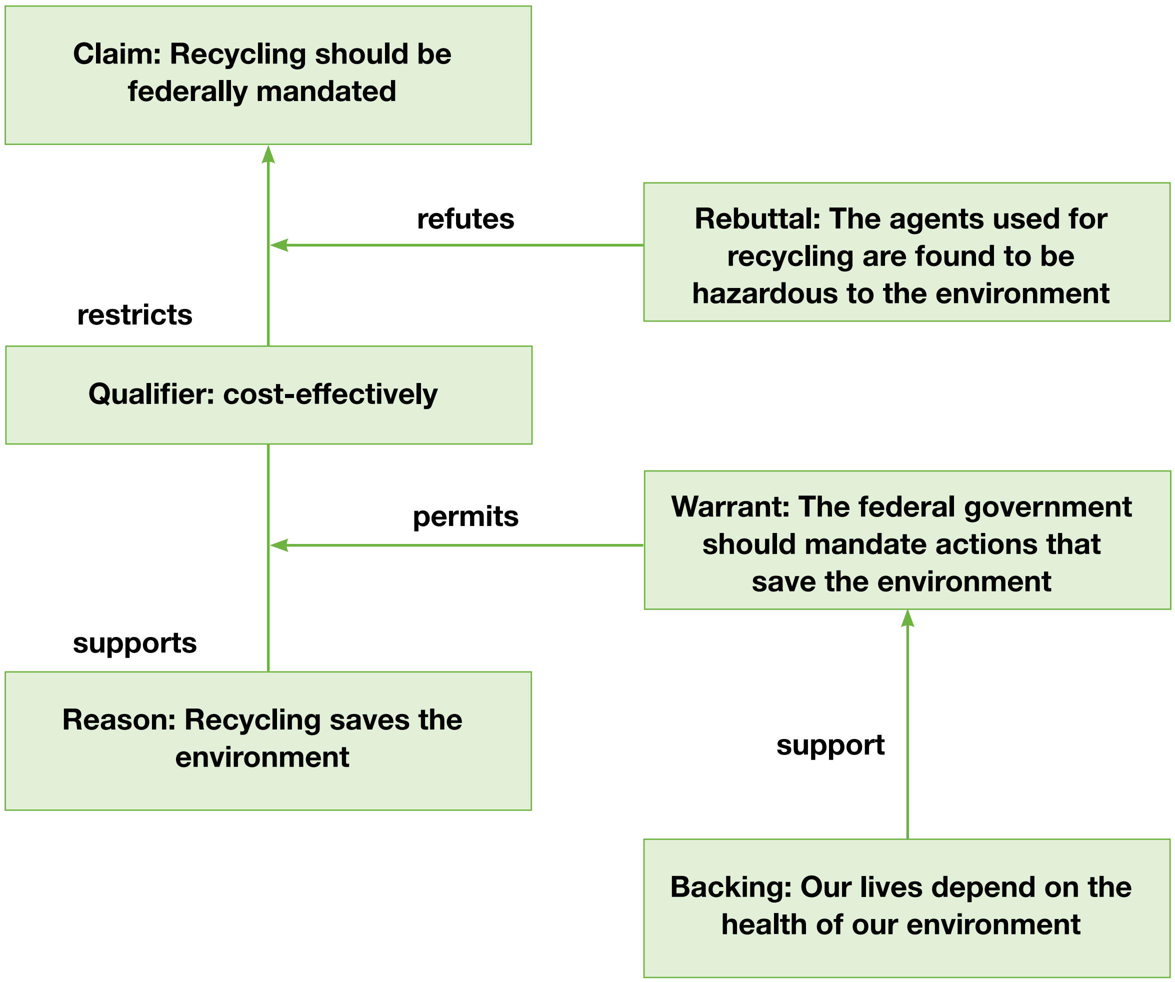
Rebuttals: These are the conditions when the claim will not be true.

Pro/Con Chart – Biotechnology and Crops

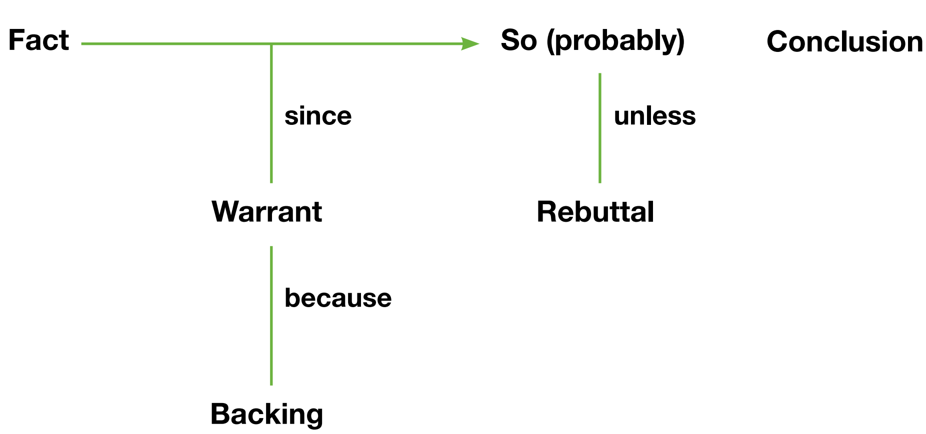
Use chart below to determine the arguments from the *Nature Education* article.

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:

		Comments:
How effectively did the presenter introduce the audience to the topic?	5 4 3 2 1 Excellent Good Poor	
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	
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?

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?

Reading Notes