6 Writing Research Reports

Introduction

In this lesson, students compile and synthesize what they have learned in the preceding lessons by writing a research report. The research report includes ***Introduction***, ***Methods***, ***Results***, ***Discussion***, and ***References*** sections. Emphasis is placed on relating previous lesson activities to the original research question and hypothesis. Extensions and lesson alternatives include instructions for creating a scientific poster, writing a scientific abstract, or writing a science-related magazine article. In *Lesson Six*, students also learn how ***science and technical writers*** might use bioinformatics tools in their career.

Class Time

3–5 class periods of 50 minutes each and 1–2 nights homework time as needed.

Prior Knowledge Needed

- Knowledge and skills acquired in *Lessons One* through *Lesson Five*.
- Basic skills in essay writing are helpful.
- Basic skills in bibliographic formatting are helpful.

Learning Objectives

At the end of this lesson, students will know that:

- Research reports are designed to share scientific findings with other scientists in the spirit of scientific collaboration and to advance scientific knowledge.
- Research reports contain an ***Introduction***, ***Methods***, ***Results***, ***Discussion***, and ***References*** sections.

At the end of this lesson, students will be able to:

- Write a scientific research report that contains the standard sections: ***Introduction***, ***Methods***, ***Results***, ***Discussion***, and ***References***.
- Relate the methods they used and the results they found back to their original research question and hypothesis.

Key Concepts

- The components of the scientific method (developing a research question and hypothesis, gathering and analyzing data, interpreting results, and making conclusions) are conveyed in scientific research reports, which contain sections corresponding to each of these steps in the scientific process (***Introduction***, ***Methods***, ***Results***, and ***Discussion***).
- Scientists publish their research findings in the form of reports (also called papers or journal articles) to share their investigations with other scientists to promote collaboration and advance scientific knowledge.
- Research reports should be written in such a way that another researcher could repeat what you did.

Materials

Materials	Quantity
Copies of Student Handout—*Careers in the Spotlight* (handed out in *Lesson One*)	1 per student
Copies of Student Handout—*The Process of Genetic Research* (handed out in *Lesson One*)	1 per student
Class set of Student Handout—*Writing Research Reports* (optional; see *Part I*)	1 per student (class set)
Copies of Student Handout—*Research Report Template* (optional, see *Part II,* Step #21c)	1 per student or fewer as needed
Class set of Student Handout—*Making Scientific Posters in PowerPoint* (optional, see *Part II,* Step #21d and *Extension*)	1 per student (class set)
Copies of Student Handout—*Writing a Scientific Abstract about Cytochrome c Oxidase* (optional, see *Part II*, Step #21e)	1 per student or fewer as needed
Teacher Answer Key—*The Process of Genetic Research* (found in *Lesson One*)	1
Teacher Resource— *Student Research Report Rubric* [**Note:** Teachers may wish to provide students with copies of the Rubric (see *Part III*).]	1 – or – 1 per student (class set)
Teacher Resource—*Key Words to Include when Writing About Cytochrome c Oxidase* (optional, see *Part II*, Step #21e) [**Note:** Teachers may wish to provide students with copies of this list (see *Part II*, Step #21e and *Extension*).]	1 – or – 1 per student (class set)
Teacher Resource—*Student Magazine Article Rubric* (optional, see *Part II*, Step #21f) [**Note:** Teachers may wish to provide students with copies of the Rubric.]	1 – or – 1 per student (class set)

Computer Equipment, Files, Software, and Media
Computer and projector to display PowerPoint slides. ***Alternative:*** Print PowerPoint slides onto transparencies and display with overhead projector.
Lesson Six PowerPoint Slides—*Writing Research Reports*. Available for download at: http://www.nwabr.org/curriculum/advanced-bioinformatics-genetic-research.
A student version of lesson materials (minus *Teacher Answer Keys*) is available from NWABR's Student Resource Center at: http://www.nwabr.org/students/student-resource-center/instructional-materials/advanced-bioinformatics-genetic-research.
Computer lab with internet access and a word processing program such as Microsoft® Notepad or Word for writing the research reports.

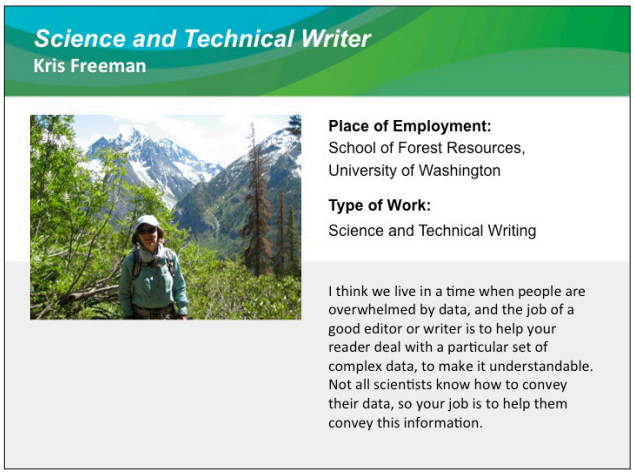
Teacher Preparation

- Load the classroom computer with the *Lesson Six* PowerPoint slides.
- Decide which form or type of assessment you will be using: traditional research report or one of the options for differentiation (poster, abstract, or magazine article; see Step #21 for more details).
- Make copies of the *Student Handouts*, as needed. Some are designed as *Worksheets* (Student Handout—*Research Report Template* and Student Handout—*Writing a Scientific Abstract about Cytochrome c Oxidase*), while others are designed to be re-used as *Class Sets* (Student Handout—*Writing Research Reports* and Student Handout—*Making Scientific Posters in PowerPoint*).

Procedure

Warm Up

1. As students enter the classroom, display the PowerPoint slides for *Lesson Six*, beginning with ***Slide #1***. This slide highlights science and technical writer Kris Freeman.



Writing Reports: ***Slide #1***

2. Have students retrieve Student Handout—*Careers in the Spotlight*, which they were given during *Lesson One*.
3. Students should think about, and write down, what kind of work a science and technical writer might do (*Science and Technical Writer Question #1*). This will be revisited at the end of the lesson, including how a science and technical writer might use bioinformatics in his or her job.
4. Tell students to keep their *Careers in the Spotlight* Handout available for future lessons.

PART I: Explanation of the Research Report

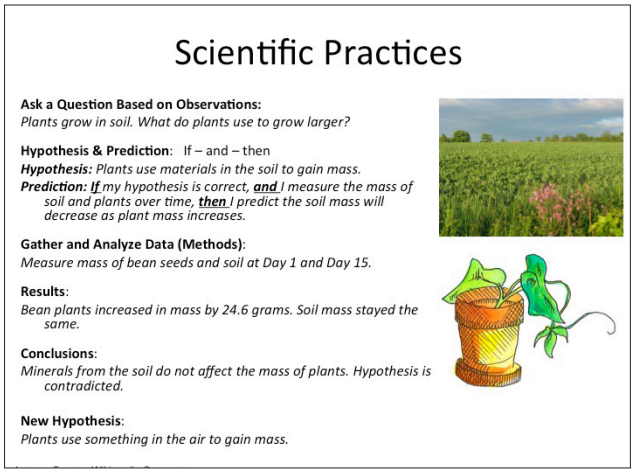
5. Explain to students the ***aims of this lesson***. Some teachers may find it useful to write the aims on the board.
   a. **Lesson Aim:** Understand the standard components of a research report.
   b. **Lesson Aim:** Communicate the findings of your research.

   Teachers may also wish to discuss the *Learning Objectives* of the lesson, which are listed at the beginning of this lesson plan.
6. Share the following with students:
   - They will be writing a research paper to communicate their findings from *Lessons Two*, *Three*, *Four*, and *Five*, using Student Handout—*The Process of Genetic Research*.
   - The purpose of a scientific research report is to share your results with other scientists.

- All of the reports and publications in databases like PubMed at the NCBI were published by other scientists in the spirit of sharing data, promoting scientific collaboration, and advancing scientific knowledge.
- Ideally, your report will tell other scientists what you did, how you did it, why you did it, and what you found.
- Your report should explain what you did in enough detail that other scientists could repeat your experiments and confirm your findings.

7. Show ***Slide #2***, and remind students of the Scientific Process first reviewed in *Lesson One*.
   - Ask a ***question*** based on ***observations*** of the natural world.
   - Formulate a hypothesis about your question and observations. Often the ***If-and-then*** format is used. ***If*** your hypothesis is correct ***and*** you perform experiment A, ***then*** you should get result **B** (prediction).
   - ***Gather and analyze your data*** to see if it supports your hypothesis. These are also called your ***methods***.
   - Report your ***results***.
   - Make ***conclusions*** about your hypothesis and your results.
   - Make a ***new hypothesis*** if needed.

Writing Reports: ***Slide #2***



Data-driven research: Using bioinformatics tools to analyze large datasets in order to generate predictions and testable hypotheses.

8. Remind students that bioinformatics is making it possible to analyze larger data sets than ever before. Using bioinformatics tools to analyze large datasets to generate predictions and testable hypotheses is sometimes called **data-driven research**.

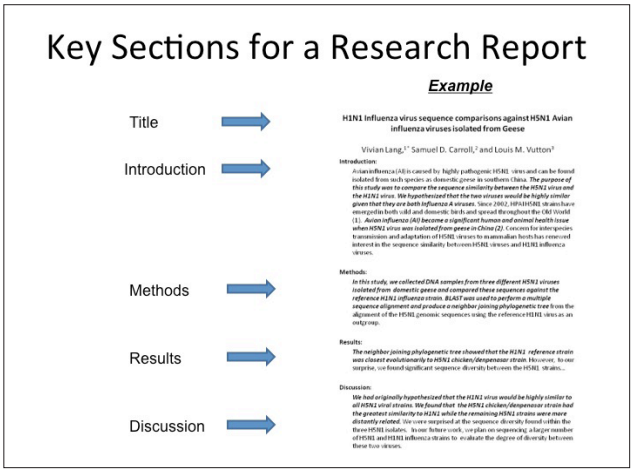
9. Explain to students that the components of the research report parallel the steps of the scientific method.

10. Pass out the class set of Student Handout—*Writing Research Reports*, one per student, and ask them to follow along with you as you discuss each section of the research report. Students will use this handout as a reference when writing their reports.

[**Note:** For classes that have already written research reports, tell students to follow the format consistent with your previous exercises.]

11. Show ***Slide #3***, which outlines the key sections of a research report. In the following slides, students will be able to visualize examples of the sections of a research report in the context of the influenza virus A.

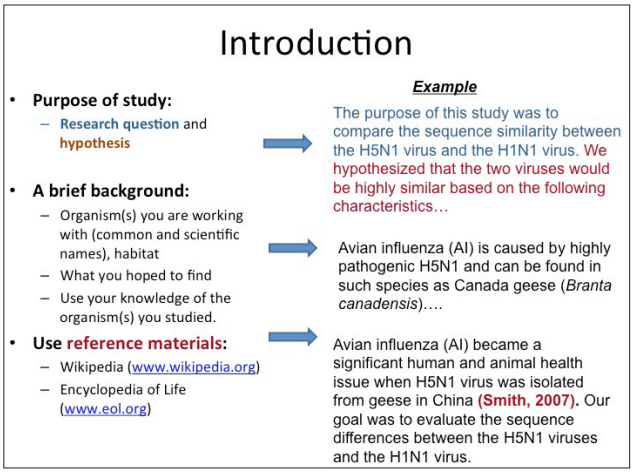
Writing Reports: ***Slide #3***



12. Show ***Slide #4***, which describes what is included in the first part of a research report, the ***Introduction***. This section includes:

- Your ***research question*** and your ***hypothesis***, which is the purpose of your study.
- A brief ***background*** on what you are studying, such as the organism(s) you are working with, and their common and scientific names.
- What you hoped to find. You can use the ***If-and-then*** format described above in ***Slide #2*** and below in ***Slide #4***.

Writing Reports: ***Slide #4***



13. Tell students that they can draw on their own knowledge of the organism(s) studied, but should also use reference materials. Online sources include Wikipedia (http://www.wikipedia.org) and the Encyclopedia of Life (http://www.eol.org).

For example: Our goal was to evaluate the sequence divergence between the H5N1 viruses and the H1N1 virus.

14. Show ***Slide #5***, which describes what is included in the ***Methods*** section of the report. Emphasize to students that your ***Methods*** section includes a description of what you did (without any analysis, as that is covered in the ***Results*** and ***Discussion***). This section includes:

    • What ***data*** you collected and/or what gene(s) you studied and why. Often, some of the data are obtained from public databases such as the NCBI. For those data, accession and/or PDB numbers must also be included to allow other researchers to reproduce your results.

    For example: *Three different DNA sequences were collected from 3 H5N1 viral samples…*

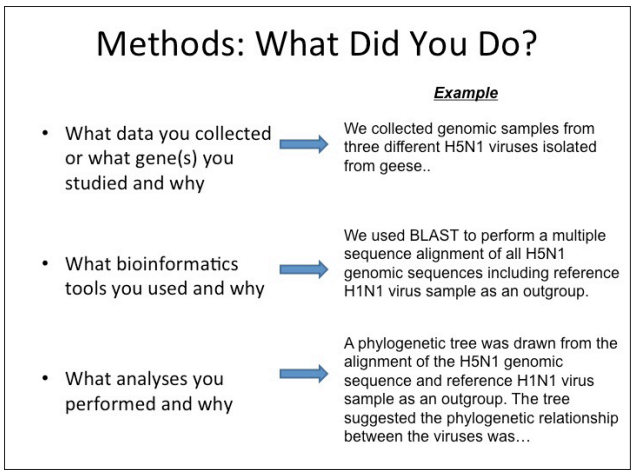
    • What ***bioinformatics tools*** you used and why.

    For example: *BLAST was used to identify unknown DNA sequences…*

    • What ***analyses*** you performed and why.

    For example: *H1N1 and H5N1 viral DNA sequences were compared using BLAST to generate a phylogenetic tree that will help reveal the sequence diversity between the two viruses.*

Writing Reports: ***Slide #5***



15. Show ***Slide #6***, which describes what is included in the ***Results*** section of the report. Emphasize to students that your ***Results*** section reports on what you found. This section includes:

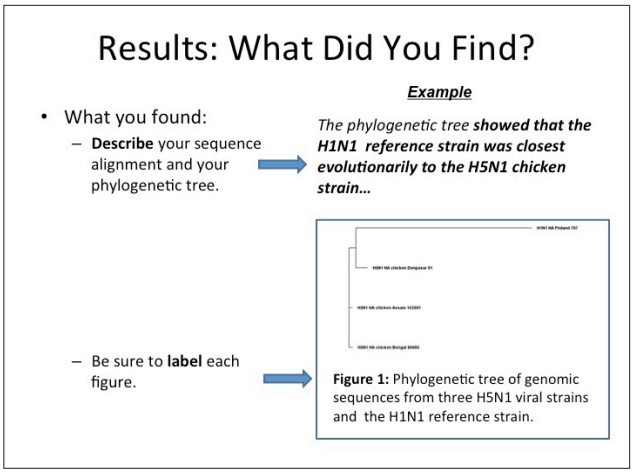
    • ***What you found***.

    The phylogenetic tree showed that the H1N1 reference strain was closest evolutionarily to an H5N1 chicken strain.

    • ***Figures*** you made, such as your DNA alignment and/or your phylogenetic tree. Be sure to label each figure, and describe what it means in the text of this section. These could be hand-drawn illustrations, photographs or digital photos, digital images, or images captured from a computer screen.

    For example: *Figure 1 is a phylogenetic tree of genomic sequences from three H5N1 viral strains and the H1N1 reference strain.*

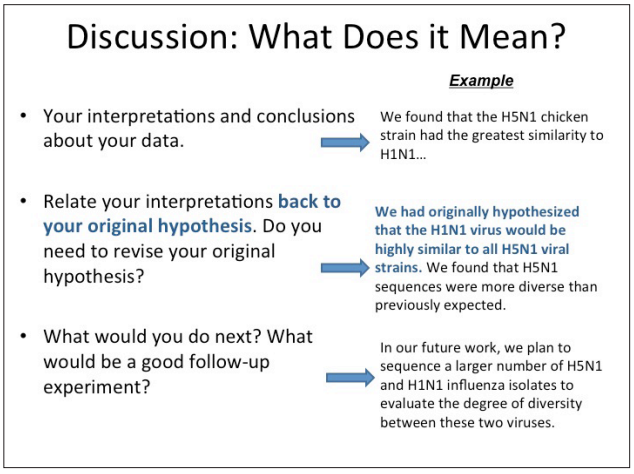
Writing Reports: ***Slide #6***



16. Show ***Slide #7***, which describes what is included in the ***Discussion*** section of the report. In your ***Discussion*** section, the author(s) describe what the results mean. This section includes:
    - Your ***interpretations*** and ***conclusions*** about your data.
    - An explanation of how ***your interpretations relate*** back to your original hypothesis; for example, whether your results support or refute your hypothesis, or were inconclusive.
    - What would you do next? What would be a good ***follow-up experiment***? Do you need to revise your original hypothesis?

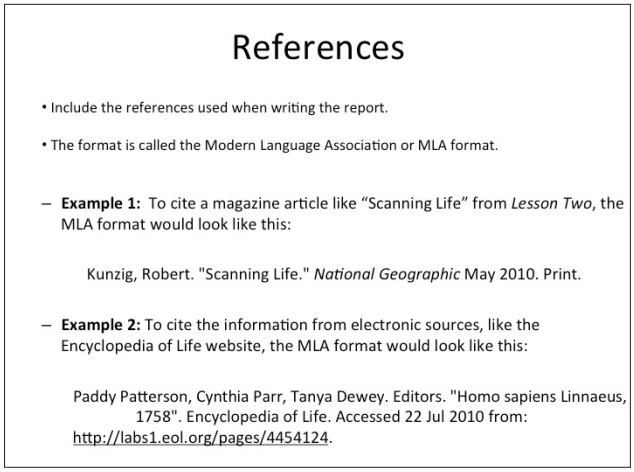
    We had originally hypothesized that the H1N1 virus would be highly similar to all H5N1 viral strains. We found that H5N1 sequences were more diverse than previously expected. In our future work, we plan to sequence a larger number of H5N1 and H1N1 influenza isolates to evaluate the degree of diversity between these two viruses.

Writing Reports: ***Slide #7***



17. Show ***Slide #8***, which describes what is included in the ***References*** section of the report. This section includes the references used when writing a research report. A common format is called the Modern Language Association or MLA format. Point out the key components, including author(s), title, source, and date. Refer students to the Purdue Online Writing Lab for more information; the website address is listed on Student Handout—*Writing Research Reports*.

Writing Reports: ***Slide #8***



PART II: Writing the Research Report

18. Students will likely need scaffolding to complete this report, especially if it is their first attempt at writing a research report. Students can start by making an outline. Have them write down each section on a separate piece of paper and list underneath the key points they would like to include in each section. Refer students to their notes on Student Handout—*The Process of Genetic Research* for items to include in their report. This handout can also serve as the first step in an outline for their research report.

19. Once students have completed their outlines, you may want to assign incremental due dates: ***Title***, ***Introduction***, and ***Methods*** at the end of the first day, ***Results*** at the end of the second day, etc.

20. Depending upon class time, you could:
    - Have students write their reports in class. Estimated class time: Three to five 50-minute periods (one or two for outlining the report and two or three for writing the report).
    - Assign the outline and report as homework. It might be most useful for students to turn in their outline and get feedback on that before continuing with the final report.
    - Have students begin their report in class, and then finish the report as homework (i.e., one 50-minute class session and two to three nights of homework).

21. **Further options for differentiation:** Students in your class may have different abilities and comfort levels with writing a research report. You can provide them with multiple options for this project:

    a. Students can write the report individually, as directed above.

    b. Students can collaborate with a partner to produce a report together.

    c. Students can use the template provided (Student Handout—*Research Report Template*) to write the research report. This handout includes topic sentences for each section.

    d. Students can create a ***poster*** to report their findings using the class set of Student Handout—*Making Scientific Posters in PowerPoint*. A PowerPoint poster template is provided on the Bio-ITEST website (http://www.nwabr.org/curriculum/advanced-bioinformatics-genetic-research).

    e. Students may write a ***scientific abstract*** in lieu of a research paper. Abstracts are a key element of scientific communication and are used in all fields of science. Student Handout—*Writing a Scientific Abstract* can be used for this exercise. Given the strict word limit of most abstracts, teachers may wish to brainstorm with students about ***key words*** to include in an abstract about cytochrome c oxidase including, but not limited to, those found in Teacher Resource— *Key Words to Include When Writing About Cytochrome c Oxidase*. This handout could also be provided to students writing a research report, a scientific poster, or an abstract. The concise writing necessary for an abstract can be very challenging for students, and students may need to write more than one draft to achieve their goal. See also "Anatomy of a Scientific Journal Article" in the *Resources* section below.

    f. Students may write a ***magazine article*** designed to be read by the general public that demonstrates their understanding of the field of bioinformatics. In the article, students should describe the bioinformatics tools used by various professionals to compile and make use of the ever-expanding collections of biological information. The target audience is an adult familiar with basic biology but without knowledge of the tools of bioinformatics. Higher scores could be awarded for discussing applications/careers that were not presented in the class activities. The article should include images that help the reader understand each tool and its potential application. Students may use the screen capture images from previous lesson activities or create new ones. Magazine articles are often written to grab and hold the reader's attention by relating scientific information in the context of an interesting story. Students may create a fictional scenario or characters to help tell the story as long as they are realistic (not futuristic science fiction). Examples of this style of writing are provided in the *Resources* section.

    You may choose to assign different maximum scores, based on the option that students choose. For example, a student who writes her report completely on her own can earn up to an A, but if she uses the template, her maximum score may be a B.

    Posters could be assigned a maximum point value ranging from 50 to 100 points, depending upon the amount of time students are given to complete the assignment and the amount of detail required. Given that scientific posters

contain the same basic sections as a research report (***Title***, ***Introduction***, ***Methods***, ***Results***, ***Figures***, ***Discussion*** and ***References***) a rubric similar to the one for research reports in Teacher Resource—*Student Research Report Rubric* may be used.

A quality abstract assignment could be worth a maximum of 25 points.

- Organization (5 points)
- Mechanics (5 points)
- Amount of information (5 points)
- Quality of information (5 points)
- Inclusion of necessary key words (5 points)

A potential rubric for the magazine article assignment is provided in Teacher Resource—*Student Magazine Article Rubric*.

22. Students will need computer access to include figures (screen capture images of their multiple sequence alignment(s) and/or their phylogenetic tree). The template, Student Handout—*Research Report Template*, can be provided electronically to students who choose to use it, so they can insert diagrams. If computer access is not possible or is extremely limited, students could handwrite their reports and/or draw a portion of their DNA alignment (i.e., a section of 10–15 bases illustrating a key area where the sequences differ, with those differences circled) and a hand-drawn phylogenetic tree.

PART III: Grading the Reports

23. A suggested rubric is provided in Teacher Resource—*Student Research Report Rubric*. Some teachers may wish to provide copies of this rubric to students to help them understand what is required when writing their reports. By including the students' names on the rubric copies, teachers could also use this as a way to provide feedback to each student, circling the appropriate category and score.

24. The rubric in Teacher Resource—*Student Research Report Rubric* suggests a total of 50 possible points for the student research reports. The following categories refer to the report as a whole, and account for 20 of the 50 possible points:

- Organization (5 points)
- Mechanics (5 points)
- Amount of information (5 points)
- Quality of information (5 points)

Five points are also assigned for adequate completion of each of the following individual components of the report:

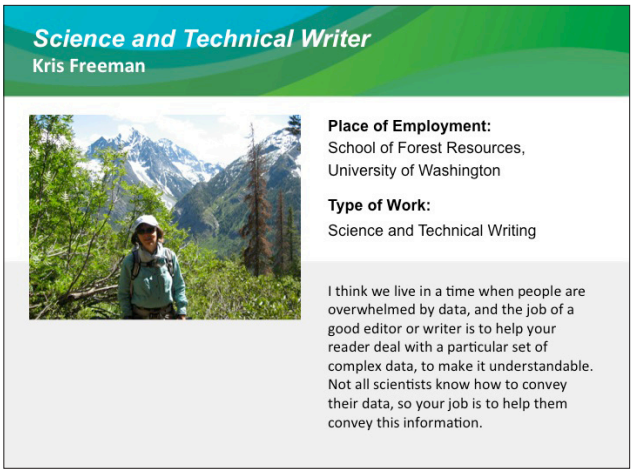
- Introduction (5 points)
- Methods (5 points)
- Results (5 points)
- Diagrams/figures or illustrations (5 points)
- Discussion (5 points)
- References (5 points)

25. A traditional letter grade (A, B, C, D, or F) can be assigned based on the percentage of total points obtained by each student, or the total points can be added to each student's total for the class.

Closure

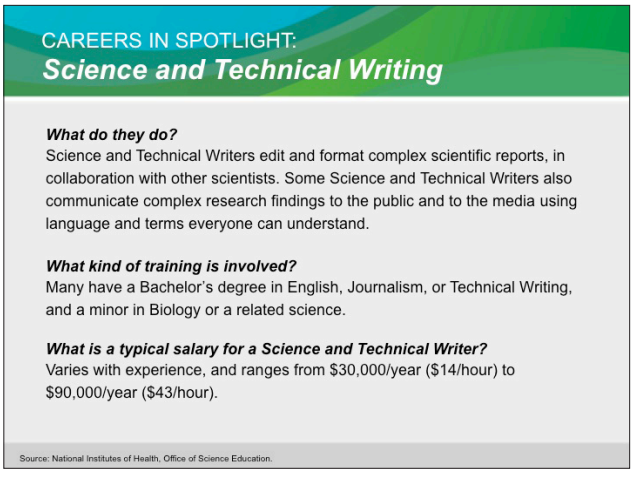
26. Summarize today's lesson:
    - Students have learned how to communicate their research findings in the form of a research report.
    - Scientists communicate their results to each other through published research reports in scientific journals. These published reports promote scientific collaboration and the advancement of scientific knowledge, as many experiments are based on results from other scientists' work.

27. Lastly, show ***Slide #9***, which returns to the picture of the science and technical writer from ***Slide #1***.



Writing Reports: ***Slide #9***

28. Show ***Slide #10***, which provides job information for a science and technical writer. Review this information with students.



Writing Reports: ***Slide #10***

29. Ask students, "What more do we know about science and technical writers after today's lesson?" Point out that that all scientists publish their research results in scientific journals. However, these publications can be challenging for non-scientists to understand. Science and technical writers communicate scientific findings to the media and the general public, and help scientists edit research reports.

30. Ask students to answer *Science and Technical Writer Question #2* on their *Careers in the Spotlight* Handout, which has students explain how this lesson has changed their understanding of the kind of work a science and technical writer does.

31. Ask students to also answer *Science and Technical Writer Question #3* on their *Careers in the Spotlight* Handout, which has students explain how a science and technical writer might use bioinformatics in his work.

32. Tell students to keep their *Careers in the Spotlight* Handout available for future lessons.

Extension

Have students create a poster using the poster template from the Bio-ITEST webpage. More detailed instructions are provided in Student Handout—*Making Scientific Posters in PowerPoint*. Hold a poster session and invite other students, staff members, teachers, and maybe even parents to view and learn about students' work.

Posters can be printed at copy centers like FedEx Office®, or printed on 8-1/2" x 11" paper by going to the ***File*** menu in PowerPoint and selecting ***Print***. From the ***Print*** menu, check the box ***Scale to Fit Paper***.

If printing posters is cost- or logistically-prohibitive, students could make posters using conventional poster board, printing or writing each section (***Introduction***, ***Methods***, ***Results***, etc.), onto 8-1/2" x 11" paper and gluing each section to the poster board.

Teacher Resource—*Key Words to Include When Writing About Cytochrome c Oxidase* includes a list of words and terms that students may find helpful when writing a research report, scientific poster, or abstract (see also *Part II*, Step #21 above). Teachers could provide this list to students and ask them to add to it as appropriate, or teachers may find it helpful to use the list as part of an in-class brainstorming exercise with students early in the writing process.

Glossary

Data-driven research: Using bioinformatics tools to analyze large datasets in order to generate predictions and testable hypotheses.

Resources

The **Purdue Online Writing Lab (OWL)** offers more information for students about writing and bibliographic formatting: http://owl.english.purdue.edu/

The online tutorial "**How to Read a Scientific Paper**" (in particular the "How?" and "Anatomy" sections) offers an excellent introduction to the reasons for writing scientific research reports and how to read scientific papers. The tutorial can be found online at: http://www.lib.purdue.edu/phys/assets/SciPaperTutorial.swf

"**Teaching the Anatomy of a Scientific Journal Article: Three Activities Engage Students in the Process of Science**" by Schinske, Clayman, Busch, and Tanner. 2008. *The Science Teacher*. Includes: article figure analysis, analysis of an abstract, and independent journal article composition.

EdSteps collects, rates, and publishes student work samples allowing teachers to compare and rate student work. Available online at: http://edsteps.org/CCSSO/Home.aspx

Rubistar is an online tool that allows teachers to quickly make detailed rubrics for scoring student work. It is free to registered users at: http://rubistar.4teachers.org/

Examples of science writing for the general public (for the magazine article writing assignment):

Palca, J. "Screening Embryos for Disease." *NPR*. December 20, 2009. Accessed December 1, 2011 from: http://www.npr.org/templates/story/story.php?storyId=6653837.

Bernton, H. "Bellingham brothers get experimental gene therapy in attempt to save their sight." *The Seattle Times*. September 6, 2010. Accessed December 1, 2011 from: http://seattletimes.nwsource.com/html/localnews/2012827431_genetherapy07m.html.

Credit

The abstract assignment and key words exercise were adapted from materials provided by Bio-ITEST field test teacher Tamara Caraballo, Glacier Peak High School.

The magazine article assignment and rubric were adapted from materials provided by Bio-ITEST field test teacher Adam Waltzer, Eastside Preparatory High.

Freeman, Kris. Personal Interview. 1 September 2010.

The Rubric was developed with the assistance of Rubistar (http://rubistar.4teachers.org). Copyright 2000-2008, ALTEC at University of Kansas.

6 Writing Research Reports

Student Researcher Background:

A ***scientific research report*** is designed to share what you have done with other scientists. All of the reports and publications in databases like PubMed at the NCBI were published by scientists in the spirit of sharing data, promoting scientific collaboration, and advancing scientific knowledge. Ideally, your report will tell other scientists what you did, why you did it, and what you found. Your report should explain how other scientists could repeat your experiments and confirm your findings. To write your report, refer to your notes on Student Handout—*The Process of Genetic Research* for each lesson.

Research reports include the components outlined below.

I. Title

The title of your study, which helps readers understand its purpose, such as: "Evolutionary Relationships among Canine Species," or "Using DNA Barcoding to Study Dogs and Wolves."

II. Introduction

This section includes:

- Your ***research question*** and your ***hypothesis***, which is the purpose of your study.
- A brief ***background*** on what you are studying, such as the organism(s) you are working with, and their common and scientific names.
- What you hoped to find. You can use the ***If-and-then*** format (***If*** my hypothesis is correct ***and*** I perform this experiment, ***then*** I would expect to see…).

You can draw on your own knowledge of the organisms you studied, as well as what you have learned through your research. Good references for background information about the organisms studied include Wikipedia (http://www.wikipedia.org) and the Encyclopedia of Life (http://www.eol.org).

Example Introduction Section

My research was inspired by the research question: Are dogs and coyotes more closely related than dogs and wolves? If dogs and coyotes are more closely related, and we analyze the DNA sequences of all three animals' COI *barcode genes, then we can determine which species are most closely related.*

III. Methods

This section includes:

- What ***data*** you collected or what gene(s) you studied and why.
- What ***bioinformatics tools and databases*** you used and why.
- What ***analyses*** you performed and why.

Example Methods Section

COI *DNA barcode sequences were collected for the following species: domestic dogs (*Canis lupus familiaris*), gray wolves…*

BLAST was used to identify unknown DNA sequences using the NCBI Nucleotide database…

DNA sequences were compared using ClustalW2 and JalView to determine whether there were any sequence differences among the species…

IV. Results

This section includes:

- ***What you found***.
- Any relevant ***figures*** you made, such as screen capture images of your DNA alignment and your phylogenetic tree. Be sure to label each figure, and describe what it means in the text of this section. It may be helpful to circle or highlight any region(s) of the alignment that differ(s). If you do not have access to a computer, figures showing key sections of DNA alignments and phylogenetic trees can be drawn by hand. Be sure to label everything.

Example Results Section

After performing a DNA alignment (Figure 1), I found that the barcode sequences for dogs and wolves were the same. There were five differences in the DNA sequences between wolves and foxes…

V. Discussion

This section includes:

- Your ***interpretations*** and ***conclusions*** about your data. Be sure to relate your interpretations back to your original hypothesis. Remember, it is not important whether your hypothesis was "correct;" it is important to discuss how your results affect your interpretation of your hypothesis.
- What would you do next? What would be a good ***follow-up experiment***? Do you need to revise your original hypothesis?

Example Discussion Section

I expected that dogs and wolves were different species, but actually my results suggested that they were the same species, as seen in the DNA alignment and phylogenetic trees. It would be interesting to analyze the DNA barcode sequences from other dog breeds and other canine species, to see if they are the same, too.

VI. References

If you used any reference materials like books, articles, websites, or interviews (such as in your ***Introduction***), be sure to list them in the ***References*** section. A standard format is called the Modern Language Association or MLA format.

For example, to cite a magazine article like "Scanning Life" from *Lesson Two*, the MLA format would look like this:

Kunzig, Robert. "Scanning Life." *National Geographic*. May 2010. Print.

To cite information from electronic sources, like the Encyclopedia of Life website, important citation information can be found at the bottom of the webpage. The MLA format would look like this:

Paddy Patterson, Cynthia Parr, Tanya Dewey. Editors. "Homo sapiens Linnaeus, 1758". Encyclopedia of Life. Accessed 22 Jul 2010.

For more information about the MLA format, visit the ***Purdue Online Writing Lab*** at: http://owl.english.purdue.edu/owl/resource/747/01/.

Name _____ Date _____ Period _____

6 Research Template Handout

I. Title

II. Introduction

Topic Sentence: My research was directed at understanding how species of taxonomic Class _____ are related to one another.

Sentence 2: I predicted that…
(based on hypothesis from Student Handout—*The Process of Genetic Research*)

Sentence 3: (Background)

Sentence 4: (Background)

Conclusion Sentence:

III. Methods

Topic Sentence: To test my hypothesis, I used several tools to analyze *COI* barcode sequences from my group of species.

Sentence 2: (BLAST and the NCBI Nucleotide database, *Lesson Two*)

Sentence 3: (The Barcode of Life Database, *Lesson Two*)

Sentence 4: (Jalview and ClustalW2, *Lesson Three*)

Sentence 5: (BLAST, phylogenetic trees, *Lesson Three*)

Sentence 6: (ORFinder, *Lesson Four*)

Sentence 7: (Cn3D, *Lesson Five*)

Conclusion Sentence:

IV. Results

Topic Sentence: Using the bioinformatics tools explained above, I found that _____

_____.

Sentence 2: (BLAST and the NCBI Nucleotide database, *Lesson Two*)

Sentence 3: (The Barcode of Life Database, *Lesson Two*)

Sentence 4: (Jalview and ClustalW2, *Lesson Three*)

Sentence 5: (BLAST, phylogenetic trees, *Lesson Three*)

Sentence 6: (ORFinder, *Lesson Four*)

Sentence 7: (Cn3D, *Lesson Five)*

Conclusion Sentence:

Figure 1: **Figure 2:**

V. Discussion

Topic Sentence: My hypothesis was_____ .
(original hypothesis)

Based on my hypothesis, I predicted that _____
(original prediction)

and found that _____.
(conclusion from research)

Sentence 2: (Explain what the results showed about your original hypothesis.)

Sentence 3: (Explain how the results support your new conclusion.)

Sentence 4: (Explain something you were surprised by during your research.)

Conclusion Sentence: A good follow-up experiment would be to_____.

VI. References

6 Making Scientific Posters in PowerPoint

Scientists in many different fields present the results of their experiments in the form of ***scientific posters***. Often, these posters are presented at meetings or conferences, and provide a short summary of the research findings. Unlike a research report or scientific paper, posters are designed to be read quickly (in 5-10 minutes), and cover the key points the scientist wishes to share with others.

Each section of the poster corresponds to a section in your ***Research Report***, including a ***Title***, ***Introduction***, ***Methods***, ***Results***, ***Discussion***, and ***References***. Many scientists also include ***Acknowledgements***, or a special "thank you" to people who helped with the work. Each section is found in its own ***text box*** in the ***poster template*** from the Bio-ITEST webpage: http://www.nwabr.org/curriculum/advanced-bioinformatics-genetic-research, under the ***Resources*** tab.

I. Title

- The title of your study, which helps readers understand its purpose, such as: "Evolutionary Relationships among Canine Species," or "Using DNA Barcoding to Study Dogs and Wolves."
- The primary author of the poster or study is listed first, and is underlined. Other collaborators on the study are also listed. The ***senior scientist*** is listed last, and is the teacher or scientist in whose classroom or laboratory the research was done.
- Location of the study, such as your school or university, is listed below the authors.

II. Introduction

This section includes:

- Your ***research question*** and your ***hypothesis***, which is the purpose of your study.
- A brief ***background*** on what you are studying, such as the organism(s) you are working with, and their common and scientific names.
- What you hoped to find. You can use the ***If-and-then*** format (***If*** my hypothesis is correct ***and*** I perform this experiment, ***then*** I would expect to see…).

III. Methods

This section includes:

- What ***data*** you collected or what gene(s) you studied and why.
- What ***bioinformatics tools and databases*** you used and why.
- What ***analyses*** you performed and why.

IV. Results

This section includes:

- ***What you found***.
- Any relevant ***figures*** you made, such as screen capture images of your DNA alignment and your phylogenetic tree. Be sure to label each figure, and describe what it means in the text of this section. It may be helpful to circle or highlight any region(s) of the alignment that differ(s). If you do not have access to a computer, figures showing key sections of DNA alignments and phylogenetic trees can be drawn by hand. Be sure to label everything.

V. Figures

- Copy and paste images of your multiple sequence alignment(s) and phylogenetic tree.
- Each figure is placed in its own text box.
- At the bottom of each figure, write a title to explain what it means. For example, "Figure 1: Multiple Sequence Alignment of *COI* DNA Sequences from Five Species of Canines."

VI. Discussion

This section includes:

- Your ***interpretations*** and ***conclusions*** about your data. Be sure to relate your interpretations back to your original hypothesis. Remember, it is not important whether your hypothesis was "correct;" it is important to discuss how your results affect your interpretation of your hypothesis.
- What would you do next? What would be a good ***follow-up experiment***? Do you need to revise your original hypothesis?

VII. References

If you used any reference materials such as books, articles, websites, or interviews (such as in your ***Introduction***), be sure to list them in the ***References*** section. A standard format is called the Modern Language Association or MLA format.

VIII. Acknowledgements (optional, but recommended)

- Thank anyone who helped you with your report, such as parents or tutors who helped you with proofreading or editing, or a librarian who helped you find references.

Name _____ Date _____ Period _____

6 Writing a Scientific Abstract about Cytochrome c Oxidase

Abstracts are used in all fields of science, and are an important way to summarize key information in a concise and accurate way. All scientific publications include an abstract summarizing their experimental findings.

Examples of these abstracts can be found in PubMed through the NCBI at: http://www.ncbi.nlm.nih.gov/pubmed. You can perform a keyword search, or search by author, publication year, or topic. Click on the titles of the papers to learn more.

Instructions: Your goal with this scientific abstract is to tell the "molecular story" of cytochrome c oxidase. Your abstract should be ***no more than 250 words*** and should include all of the important information that you have learned about cytochrome c oxidase, including the bioinformatics analyses you performed. Your abstract should be descriptive, clear, concise, and engaging.

Be sure to include a ***title***. The title should have the name of the molecule and may have a brief description of its function or significance. Also include ***your name*** and the ***name of your teacher***.

Here are some suggested questions to answer that might help you write the cytochrome c oxidase abstract:

1. What type of protein is cytochrome c oxidase? Why are these proteins important in general terms and why is this specific one so important?

2. Where is this protein found and how does this relate to mitochondrial DNA?

3. What is the function of cytochrome c oxidase? This is very important to include! Explain this in scientific terms and then use an analogy that would help a non-scientist understand the function of the protein.

4. How is the cytochrome c oxidase subunit 1 (*COI*) gene used for DNA barcoding, and ***why is this gene in particular*** such a good choice for barcoding?

5. What bioinformatics analyses did you perform as part of your DNA barcoding?

6. What do you know about the structure of this protein and how did you learn that?

7. What evidence do you have that supports the Theory of Endosymbiosis (if you have covered this in class)?

8. What sources did you use? [**Note:** Be sure they are formally cited.]

Name _____ Date _____ Period _____

6 Student Research Report Rubric

DIMENSION	Exemplary 5 Points	Proficient 3 Points	Partially Proficient 1 Point	Developing 0 Point
Organization	Information is very organized with well-constructed paragraphs and subheadings. Report includes all five required sections: Introduction, Methods, Results, Discussion, and References.	Information is organized with well-constructed paragraphs. One or two required sections may be missing or combined with another.	Information is organized, but paragraphs are not well-constructed. Multiple required sections are missing.	The information appears to be disorganized and most or all required sections are missing.
Mechanics	No grammatical, spelling, or punctuation errors.	Almost no grammatical, spelling, or punctuation errors.	A few grammatical, spelling, or punctuation errors.	Many grammatical, spelling, or punctuation errors.
Amount of Information	All required sections are addressed and each contains at least a paragraph of explanation. Total length: Approximately 2–3 pages plus figures.	All required sections are addressed and most contain at least a paragraph of explanation.	All required sections are addressed but contain little explanation.	One or more required sections were not included or contained no explanation.
Quality of Information	Information clearly relates to the main topic of DNA barcoding and the genetic research performed. It includes several supporting sentences in each section.	Information clearly relates to the main topic of DNA barcoding and the genetic research performed. It provides one supporting sentence in each section.	Information clearly relates to the main topic of DNA barcoding and the genetic research performed; however, no details or explanation are given.	Information has little or nothing to do with the main topic of DNA barcoding and the genetic research performed.
Introduction	Introduction includes research question and hypothesis or prediction, and brief background on organism(s) studied, including common name, scientific name, and habitat.	Research question and hypothesis or prediction are included. Little background provided on organism(s) studied.	Research question and hypothesis or prediction are included, but no background on organism(s) studied.	Research question and hypothesis or prediction are included, but no background on organism(s) studied.

DIMENSION	Exemplary 5 Points	Proficient 3 Points	Partially Proficient 1 Point	Developing 0 Point
Methods	Clear, complete and correct explanation of bioinformatics tools used, why the tools were used, and what analyses were performed, including: • **BLAST** (to identify sequences) • **BOLD** (to obtain sequences and taxonomic information) • **ClustalW2/JalView** (to compare sequences and make phylogenetic trees) • **Cn3D** (to view protein structure) • **Explanation of data collected** (*COI* DNA barcode sequences)	List of bioinformatics tools used and data collected, with some explanation of why the tools were used and what analyses were performed.	List of bioinformatics tools used and data collected, with no explanation of why the tools were used and what analyses were performed.	List of bioinformatics tools used and data collected is not provided.
Results	Explanation of results found and what they mean (compared DNA and protein sequences from different species, analyzed relatedness among species studied). Evidence is provided to support interpretation of the data consistent with the results (for example, percent identities and/or BLAST scores, branch lengths in phylogenetic trees).	List of results and some explanation of what they mean.	List of results but little explanation of what they mean.	No results listed.
Diagrams & Illustrations ("Figures")	Two diagrams or illustrations ("Figures") of research results are included (at least a portion of a multiple sequence alignment and phylogenetic tree). The diagrams are accurate, clearly labeled, and referred to in the text.	Two figures are included, but they are not accurate, not clearly labeled, or not referred to in the text. Alternatively, only one figure is included, and it is accurate, clearly labeled, and referred to in the text.	Two figures are included, but no explanation is given. Alternatively, one figure is included, with limited explanation or inaccuracies.	No figures of results are included.

DIMENSION	Exemplary 5 Points	Proficient 3 Points	Partially Proficient 1 Point	Developing 0 Point
Discussion	Discussion includes interpretations and conclusions about the data analysis, relating directly back to the Research Question and Hypothesis, and consistent with the data provided. Includes at least one example of a follow-up question or idea for future study.	Discussion includes interpretations and conclusions about the data analysis, but does not relate directly back to the Research Question and Hypothesis and/or is not consistent with the data provided. Does not include at least one example of a follow-up question or idea for future study.	Discussion either does not include interpretations and conclusions about the data analysis, or does not relate directly back to the Research Question and Hypothesis. Does not include an example of a follow-up question or idea for future study.	Discussion of results is not provided.
Sources	All references cited are accurately documented and in the desired MLA format.	All references cited are accurately documented, but a few are not in the desired MLA format.	Few references cited are accurately documented, and many are not in the desired MLA format.	No references are cited.

Rubric created with Rubistar.

Total Score: _____

Name _____ Date _____ Period _____

6 Key Words to Include when Writing About Cytochrome c Oxidase

Below is a list of key words that are useful to include in the ***Introduction*** of a research report and/or in an abstract about cytochrome c oxidase. Additional space is provided to add additional words of your own.

Key Words:	**Additional Key Words:**
ATP synthase	_____
Barcode of Life Database (BOLD)	_____
BLAST (Basic Local Alignment Search Tool)	_____
Cell respiration	_____
Cn3D	_____
Conserved	_____
Database	_____
DNA barcoding	_____
Electron transport chain	_____
Electrons	_____
Endosymbiosis / Endosymbiotic Theory	_____
Enzyme	_____
Evolution	_____
Hydrogen ion	_____
JalView	_____
Mitochondrial DNA (mtDNA)	_____
Oxidation	_____
Oxygen	_____
Phosphorylation	_____
Phylogenetic tree	_____
Potential energy	_____
Protein	_____
Proton pump	_____
Transmembrane	_____
Water	_____

Name _____ Date _____ Period _____

6 Student Magazine
Article Rubric

DIMENSION	Exemplary 5 Points	Proficient 3 Points	Partially Proficient 1 Point	Developing 0 Point
Discussion of Bioinformatics Tools	Clear and complete explanation of the bioinformatics tools used, including: • BLAST • BOLD • ClustalW2/JalView • Cn3D	List of bioinformatics tools used and type of data collected, with some explanation of why the tools were used and what analyses were performed.	List of bioinformatics tools used with no explanation of why the tools were used and what analyses were performed.	No bioinformatics tools are listed or described.
Discussion of Bioinformatics and Careers	More than one potential application of each tool is mentioned and/or a description of an application and profession not discussed in the class activities is included.	Discusses one potential use of each tool by a science professional.	Some tools are mentioned but not all have potential uses by science professionals described.	No tools are listed or described.
Diagrams & Illustrations ("Figures")	More than one diagram or diagrams are particularly helpful in conveying the use of each bioinformatics tool.	One diagram for each tool used in class. Each diagram is explained in the text of the article.	Each tool described does not have an associated diagram or the diagrams are not explained in the text.	Diagrams are not provided.
Mechanics	Article is written in a particularly engaging manner that catches the reader's attention, develops interest and serves as an excellent introduction to the field of bioinformatics.	Article is clearly written with few, if any, grammatical or spelling errors. The article is factually accurate.	Some spelling or grammatical errors and/or factual inaccuracies.	Multiple spelling or grammatical errors and/or factual inaccuracies.
Sources	Supplemental references are cited using MLA format.	References, when used, are cited using MLA format.	References are mentioned/implied but not cited.	No references are mentioned or listed.

Total Score: _____