Integration of Sciences

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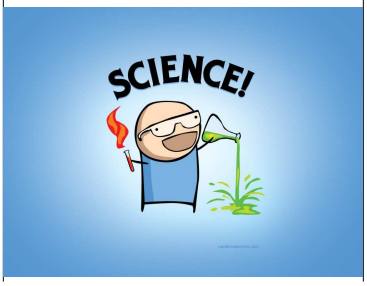
An Analytical Chemist, a Biochemist, an Animal Scientist, and an Oncologist Walk into a Lab…No Joke

INSIDE THIS ISSUE:

An Analytical Chemist, a Biochemist, an Animal Scientist, and an Oncologist Walk into a Lab…No Joke



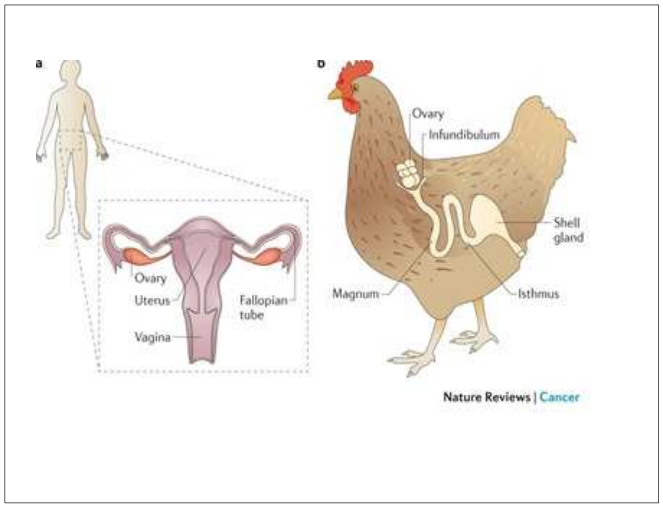
Scientists, Ovarian Cancer, and the Search for Biomarkers

Scientists are fighting cancer on many different fronts. These battlegrounds range from trying to determine causes and genetic predispositions/factors, to finding or creating effective treatments, to elucidating meaningful diagnostic techniques and tools.

With all of the diagnostic tools available to doctors and scientists – MRIs, PET scans, CT scan, etc. – it may be hard to believe that determining whether someone has cancer or not is difficult, but it is indeed the case. This is in part because imaging tools are not nearly as clear as most laypeople think, but also because cancer is far more differentiated that many people realize. Cancer is different from type to type (liver cancer vs. lung cancer), between subtypes (there are several types of ovarian cancer), and from case to case.

To address the difficulties in diagnosing any disease, cancers included, scientists try to determine biomarkers. Biomarkers are chemicals that occur naturally in living systems that vary depending on the health of the organism. A diseased organism may produce more or less of a particular compound that can be measured. In many cases these biomarkers can also be used to determine the efficacy of treatments.

Finding these biomarkers, though, can also prove difficult. They do not necessary exist in the same amount in each person or each animal, so they have to be studied in particular individuals over time. Studying people in this way is not usually feasible – in part because most people will not want to be part of this kind of investigation, and in part because scientists do not know which people to study (i.e. who will get the disease). This leads to the importance of finding useful animal models. Of course, the use of animal models also has its own set of issues.



Similarities between human ovaries and hen ovaries are among reasons that the hen is used as an animal model for

Specialization & Collaboration in Scientific Investigations

As our knowledge has progressed and our technological tools have become more advanced, scientists have had to specialize more and more. There are too many skills and a predominance of information that prevent an individual person from being an effective "generalist" anymore. Hence, we have analytical chemists and molecular biologists (and even specialization within those fields).

Real world problems, though, do not follow these boundaries. Therefore these specialists need to bring their expertise together to address them. They each have roles, but they must work together as a team and communicate effectively in order to conduct meaningful investigations.

"Teamwork divides the tasks and multiplies the success."

~Anonymous

Team Description

Your investigation team will be composed of an analytical chemist (a measurement scientist), a biochemist, an animal scientist, and an oncologist. These scientists must work together to solve real world problems, just like you will have to work together to fulfill the expectations of this project.

The team will have topics to research together and products related to them to generate. The description of these team requirements follows on the next two pages.

Additionally, each team member will have several individual avenues that they are required to investigate and several products that they will have to construct.

The descriptions of the individual requirements of team members fulfilling different roles are given on pages 4-7.

Ultimately, the team members will be asked to bring both full-team aspects and individual aspects together to assemble and submit a unified team project.

As part of the final grade for the project, team members will submit a self and peer review, so please keep that in mind and make sure that you fulfill all the duties of a true team member.

The team will also submit a Works Consulted & Cited page for the team requirements.

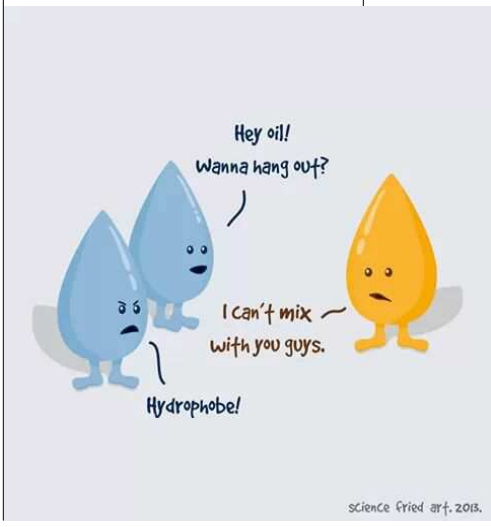
Team Requirement #1: History of Mass Spectrometry

The first part of the team requirement is an investigation of the history of mass spectrometry. The person filling the role of the Analytical Chemist (see page 4) will be compiling more research on the types, techniques, and uses of mass spectrometry today, but the team will collectively conduct research into how it developed over time (and see how it connects to several topics that we have previously discussed in class).

Questions to be addressed (and do not feel limited to these) include: 1) Who developed it first and when?, 2) How did it originally work and how has that changed over time?, 3) How was it used and how did that change over time?

Product: After conducting the necessary research, the team will create an infographic that effectively and communicates all of the pertinent information.

Infographic production tools are listed on page 8 and grading criteria are given on the project rubrics handout.



Team Requirement #2: Polarity vs. Non-polarity and Hydrophilicity vs. Hydrophobicity

One topic related to this research that we have discussed in class is polarity and non-polarity (and related to this — hydrophilicity and hydrophobicity). As a team you will have to familiarize yourselves further with these concepts.

Product: Once the team is familiar and comfortable with the ideas, they will create a cartoon or comic strip to illustrate the concepts (an example is provided to the left). Additionally, there will be a one-two paragraph explanation of how the cartoon/comic strip illustrates the concepts.

It is strongly suggested that the team uses one of the cartoon/comic strip production tools listed on page 8 to make the product, but hand-drawn ones will also be accepted as long as they meet the criteria.

Grading criteria are given on the project rubrics handout.

Team Requirement #3: Longitudinal Studies

There are many types of investigations and studies. One type is basic research—for the most part what you are doing during this project. Another type is called a longitudinal study.

Longitudinal studies are generally associated with social science studies but they can be applicable and important in the natural sciences as well.

Product: After researching what longitudinal studies are and identifying the important aspects of them, the team will devise two different longitudinal studies. One will be a study on the students of the class and one will be designed as a study on the people at the school. We will most likely NOT be actually conducting these studies – the designs are to ensure understanding of the methodology involved, so be creative (and yet appropriate)!

The designed studies must have discussions of methodologies in both cases – discuss what is being studied, why it is being studies, how it is being studied (along with controls and other scientifically appropriate ideas).

Grading criteria are given on the project rubrics handout.

Team Requirement #4: Ethical Considerations of Animal Studies

The team member filling the role of the Animal Scientist (see page 6) will be investigating in more depth what animal models are and how they are selected. For this requirement, as a team, you will focus more on the ethical considerations related to the study of animals. This is a complex topic and in many cases is presented by members of the media in a way that elicits strong emotional and visceral responses. These responses are not inherently bad, but sometimes emotions cloud our ability to see the complex nature of such issues. You will determine the major ethical ideas pertinent to all sides of this issue.

Product: Once you have determined the pertinent ethical ideas you will write a script for a 5-7 minute debate about the topic. You can include a moderator as part of the debate, if you wish. Then you will act in and film the debate. You will submit the script and the video as your products for this requirement.

Grading criteria are given on the project rubrics handout.

Team Requirement #5: Collaboration between Scientists

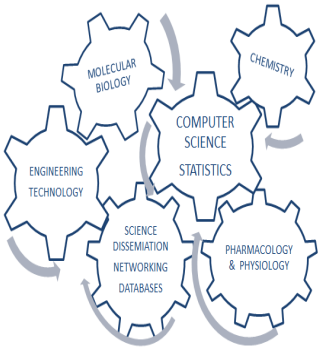
As a team you will discuss how each scientist has an important role to play in the endeavor to better diagnose cancer, and you will also figure out the challenges of working in this type of group. You should address these questions (*at least*): 1) How do these different scientists communicate with each other and why might that be difficult? 2) Does there need to be a leader and, if so, who should be the leader? 3) What other issues might teams of experts from different fields experience while working together?, 4) What other specialists would be helpful to have on this team?

Product: The team will create an illustration (like the gears in the diagram (to the right) - that shows how different scientists each have the own important role, but also how they have to work together to make the scientific process work. (You cannot use gears as your illustration since that was the example).

You will also produce a short write-up answering the questions above and discussing how your illustration illuminates the separate roles and the interconnectedness of the scientists.

Grading criteria are given on the project rubrics handout.

"Individual commitment to a group effort — that is what makes a team work, a company work, a society work, a civilization work."
~Vince Lombardi

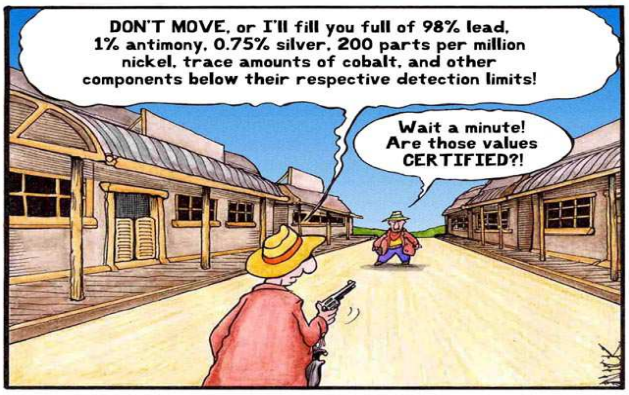


Analytical Chemist

The student filling the role of the analytical chemist (sometimes these chemists refer to themselves as "measurement scientists") will investigate what analytical chemistry is as a field of study and the major objectives of the field as a whole.

The student will research the techniques of analytical chemistry most related to this overall investigation (mass spectrometry and liquid chromatography), but they will also explore other analytical chemistry techniques that might be pertinent to this or other research.

After completing the pertinent research the student filling this role will make a Tellagami animation illustrating the main focus of an analytical chemist. This student will also write a 3-4 page paper addressing the questions given below as well as anything else they find important and appropriate related to the topic. The student will also produce a "free choice" illustration on the topic and also provide a Work Cited page that has at least 5 different resources.



Analytical Chemists in the Wild West

Questions to Address

"Measure what is measurable, and make measurable what is not so."

~Galileo Galilei

1. What is an analytical chemist? What is the primary focus of analytical chemistry?

2. What is mass spectrometry? How does it work?

3. What are the different types of mass spectrometry available currently? How are they different?

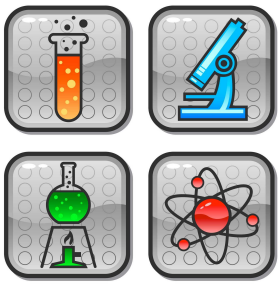
4. What is chromatography?

5. What is liquid chromatography and how is it used in tandem with mass spectrometry?

6. What other techniques are common to analytical chemistry?

7. What role(s) does the analytical chemist play in this overall investigation?

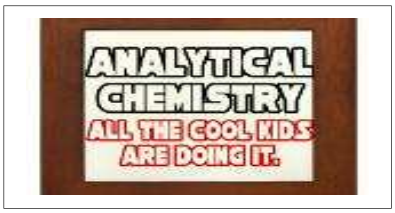
Products & Requirements



1. Make a Tellagami animation that illustrates the main points of what an analytical chemist does. It should have a background that is appropriate for an analytical chemist.

2. A 3-4 page paper discussing the answers to the given questions (above) and anything else deemed appropriate.

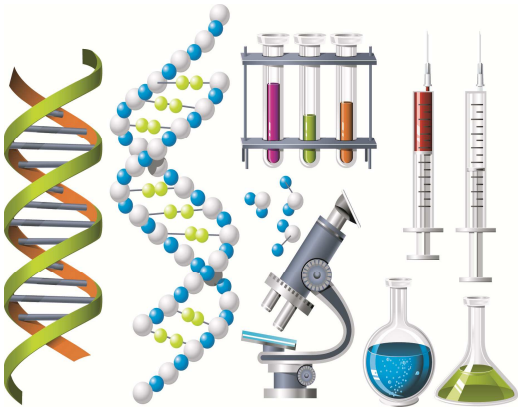
3. An illustration (student choice – can be a drawing, a Venn diagram, a graphic organizer, or any other meaningful illustration) demonstrating the role and importance of the role of the analytical chemist.



4. A Works Cited page with at least 5 different resources.

Consult the project rubrics handout for more specific information on requirements, grading expectations, and deadlines.

BIOCHEMIST

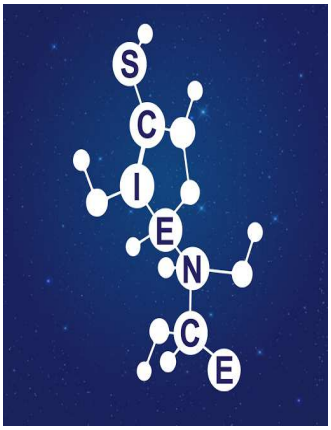


The student filling the role of the biochemist will investigate what biochemistry is as a field of study and the major objectives of the field as a whole.

The student will research the goals and methods that makes up the field of biochemistry and what techniques are most frequently employed by biochemists.

The student will focus on glycans (since they are central to this investigation) but also investigate genomics and proteomics.

After completing the pertinent research the student filling this role will make a Tellagami animation illustrating the main focus of a biochemist. This student will also write a 3-4 page paper addressing the questions given below as well as anything else they find important and appropriate related to the topic. The student will also produce a "free choice" illustration on the topic and also provide a Work Cited page that has at least 5 different resources.



QUESTIONS TO ADDRESS

1. What is a biochemist? What is the primary focus of biochemistry?

2. What are some chemical processes that are particularly important in biological systems?

3. What is genomics? What are the major applications of the study of genomics?

4. What is proteomics? What are the major applications of the study of proteomics?

5. What are glycans and glycomics? What are the major applications of the study of glycomics?

6. What are certain types of biochemical substances more challenging to study than others?

7. What role(s) does the biochemist play in this overall investigation?

"Very few scientists acquainted with the chemistry of biological systems at the molecular level can avoid being inspired."

~Donald Cram

PRODUCTS & REQUIREMENTS

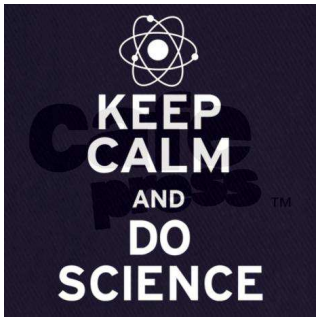
1. Make a Tellagami animation that illustrates the main points of what a biochemist does. It should have a background that is appropriate for a biochemist.

2. A 3-4 page paper discussing the answers to the given questions (above) and anything else deemed appropriate.

3. An illustration (student choice – can be a drawing, a Venn diagram, a graphic organizer, or any other meaningful illustration) demonstrating the role and importance of the role of the biochemist.

4. A Works Cited page with at least 5 different sources.

Consult the project rubrics handout for more specific information on requirements, grading expectations, and deadlines.



ANIMAL SCIENTIST

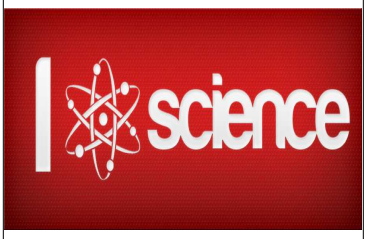
The student filling the role of the animal scientist will investigate what animal science is as a field of study and the major objectives of the field as a whole.

Animal science is not the same as veterinary science (although many veterinarians get their undergraduate degrees in animal science), so the student filling this role needs to distinguish between the two fields and concentrate on animal science.

The student will investigate how different animals are chosen for different experiments and why. The student will also investigate how the animals are cared for during experiments and what happens to them after experiments.

After completing the pertinent research the student filling this role will make a Tellagami animation illustrating the main focus of an animal scientist. This student will also write a 3-4 page paper addressing the questions given below as well as anything else they find important and appropriate related to the topic. The student will also produce a "free choice" illustration on the topic and also provide a Work Cited page that has at least 5 different resources.

"Some people talk to animals. Not many listen though. That's the problem."
~ A.A. Milne



QUESTIONS TO ADDRESS

1. What is an animal scientist? What is the primary focus of animal science?

2. What is an animal model and how are appropriate ones selected? Why were chickens chose for this particular investigation?

3. What are knockout mice (and other knockout species)?

4. How are knockout species made and for what purpose?

5. How are animals in experiments cared for?

6. How do animal scientists use controls in their experiments?

7. What role(s) does the animal scientist play in this overall investigation?

Not what is really meant by knockout mice.

PRODUCTS & REQUIREMENTS

1. Make a Tellagami animation that illustrates the main points of what an animal scientist does. It should have a background that is appropriate for an animal scientist.

2. A 3-4 page paper discussing the answers to the given questions (above) and anything else deemed appropriate.

3. An illustration (student choice – can be a drawing, a Venn diagram, a graphic organizer, or any other meaningful illustration) demonstrating the role and importance of the role of the animal scientist.

4. A Works Cited page with at least 5 resources.

Consult the project rubrics handout for more specific information on requirements, grading expectations, and deadlines.

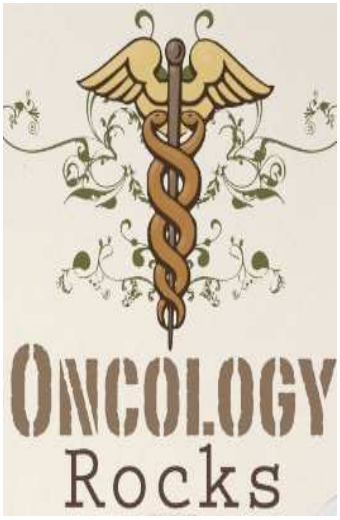
ONCOLOGIST

The student filling the role of the oncologist will investigate what oncology is as a field of study and the major objectives of the field as a whole.

Oncologists are actually medical doctors, so they are a bit different than the other roles in this project. They might be seen as being on the "front lines," but there is research just as important going on behind the scenes as well.

The student investigating this role will look into facets of oncology, but will also have to research into some epidemiological issues as well (epidemiology is branch of medicine that deals with the incidence, distribution, and possible control of diseases).

After completing the pertinent research the student filling this role will make a Tellagami animation illustrating the main focus of an oncologist. This student will also write a 3 -4 page paper addressing the questions given below as well as anything else they find important and appropriate related to the topic.



The student will also produce a "free choice" illustration on the topic and also provide a Work Cited page that has at least 5 different resources.

QUESTIONS TO ADDRESS

1. What is an oncologist? What is the primary focus of oncology?

2. What is cancer?

3. What are some major different types of cancer? What are some important statistics related to these different types?

4. How are cancers detected and diagnosed?

5. What are some treatments for cancers? What do these treatments actually do?

6. What are the different stages of cancer and what is the importance of designating stages?

7. What role(s) does the oncologist play in this overall investigation?

"When someone has cancer, the whole family and everyone who loves them does too."

~Terri Clark

PRODUCTS & REQUIREMENTS

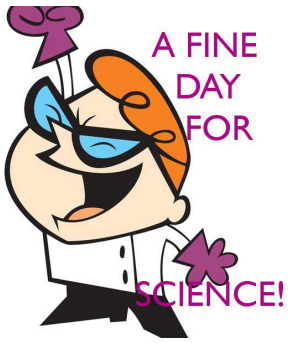
1. Make a Tellagami animation that illustrates the main points of what an oncologist does. It should have a background that is appropriate for an oncologist.

2. A 3-4 page paper discussing the answers to the given questions (above) and anything else deemed appropriate.

3. An illustration (student choice – can be a drawing, a Venn diagram, a graphic organizer, or any other meaningful illustration) demonstrating the role and importance of the role of the oncologist.

4. A Works Cited page with at least 5 resources.

Consult the project rubrics handout for more specific information on requirements, grading expectations , and deadlines.



Statistics on Ovarian Cancer

Estimated New Cases in 2014	21,980
% of All New Cancer Cases	1.3%
Estimated Deaths in 2014	14,270
% of All Cancer Deaths	2.4%

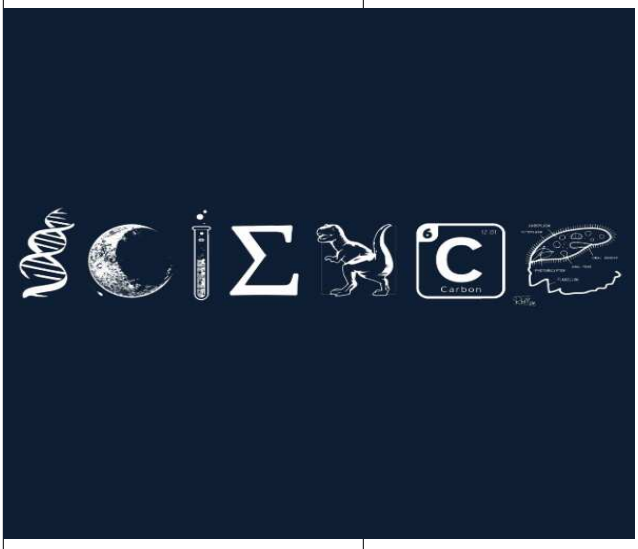
http://seer.cancer.gov/statfacts/html/ovary.html

STUDENT REFLECTIONS & SELF AND PEER EVALUATIONS

The last part of your project will be a reflection. You will write a 1-2 page (double-spaced) paper about the experience of working on the project. Make sure to *at least* address the following questions: 1) What was the most interesting thing that you learned during the experience? Why? 2) What was the most important thing that you learned? Why was it the most important? 3) What was the most difficult aspect of the project? Why? 4) What was the easiest aspect of the project? Why? 5) What would you like to investigate and learn more about? Why? 6) What could be done to improve the project/experience? Why would that be an improvement? You can also make comments beyond these questions.

After the completion of the project you will also get a chance to assess your own performance and the contributions of the other team members. This evaluation score will be incorporated into the grades for the project.

TOOLS TO USE



Infographic Tools for the History of Mass Spectrometry:

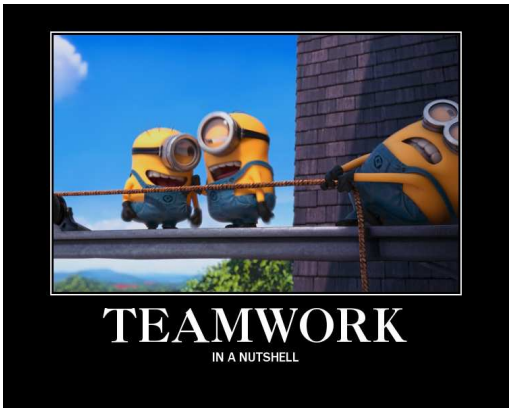
- http://piktochart.com/
- http://infogr.am/
- http://create.visual.ly/

Cartoon/Comic Strip Tools for Polarity/Non-Polarity Product:

- http://www.toondoo.com/
- http://www.readwritethink.org/files/resources/interactives/comic/
- http://www.makebeliefscomix.com/Comix/

Tellagami Animation for the Individual Roles:

- https://tellagami.com/ (you will have to download the app on an apple product or google product to use it—ask the teacher if you need a device)



This is not what we are aiming for here.

Brian Cartiff's Kenan Lesson Plan #1

Section of Lesson	
Title (Required)	***An Analytical Chemist, a Biochemist, an Animal Scientist, and an Oncologist Walk into a Lab…No Joke***
Introduction (Required)	***Cancer is a disease that has touched most people's lives in one way or another. Despite repeated claims by media sources that we are close to a cure, for many types of cancer we are not significantly closer than we were twenty years ago. One reason for this is that cancer is not just one disease – it is a group of them, and they may respond to different treatments differently. Another reason is because many forms of cancer, like ovarian cancer, are particularly hard to diagnose, and therefore hard to treat. The difficulties in diagnosing ovarian cancer arise from several factors: 1) it is highly differentiated – there are several places that the cancerous cells can originate and sometimes (about 1 in 10 cases) it is unclear where they originated, 2) in many cases the symptoms to not become apparent until the cancer is well-advanced, 3) it is often misdiagnosed as irritable bowel syndrome (IBS), diverticulitis, acid reflux, a urinary tract infection, or just related to changing menopausal status, 4) imaging tests are not conclusive, and 5) there are no current clinical screening tests that are conclusive. These issues unfortunately mean that most women are not diagnosed with ovarian cancer until it is in late-stage development. The five-year survival rate drops 20-30% with late stage diagnoses, so it is critical to improve the diagnostic capabilities.*** ***Currently, one avenue of investigation into better diagnosis is through the elucidation of biomarkers, and one of the more promising set of biomarkers are glycans. Glycans are carbohydrates (sugars) that have attached to other molecules (usually proteins or lipids). Glycans can be studied with analytical tools like mass spectrometers.*** ***During this lesson students will learn about these analytical tools, as well as glycans and their structural and behavioral nature. They will also become familiar with cancers and how they develop – specifically ovarian cancer – and the difficulties in diagnosing them. They will learn about biomarkers and about how different animal models can be used to study diseases in humans and how those particular animal models are selected.*** ***In this project, much of the learning responsibility is placed on the individual students within the project team, and also on the team acting as a cooperative unit. Students will be provided with some basic background and will have some avenues to investigate and present as a team (polar vs. nonpolar compounds and surface area, hydrophilicity vs. hydrophobicity, the history of mass spectroscopy, the advantages and disadvantages of longitudinal studies, the specialization of scientific fields, and the importance of collaboration between experts in different scientific fields. They will also be assigned individual roles (as different scientists – an analytical chemist, a biochemist, an animal scientist, and an oncologist) and have to investigate topics related to those fields. They will each be provided with guiding questions to address, but the investigations will also be open-ended so that students can pursue different angles and information within the confines of their assigned role.*** ***The project will be initiated at the beginning of the second quarter of a semester course and students will have 8 weeks to work on it. To introduce the topic the***

Brian Cartiff's Kenan Lesson Plan #1

	class will have a discussion/debate about animal testing (the most controversial part of what they are investigating). This will be conducted in part for the teacher to assess prior knowledge, but primarily to pique student interest. Most of the rest of the project will be student research which will eventually result in several products (papers, Tellagami animations, and infographics) summarizing their findings.
Real Science Application (If Applicable)	***The Human Genome Project has mapped and sequenced DNA, which can help us understand diseases including genotyping of specific viruses to direct appropriate treatment, identification of oncogenes and mutations linked to different forms of cancer, and the design of medication and more accurate prediction of their effects. It may also lead to advances in forensic applied sciences, among many other possibilities. Students are probably familiar with our attempts to map human DNA. They may, however, be less aware of that scientists are trying to map proteins (the field of proteomics) and glycans (glycomics). These goals may be every bit as important as the Genome Project. At this point in time proteomics is a bit more advanced that glycomics, but both are thought to have tremendous prospects in addressing diseases. Glycans and proteins can both be studied through the analytical techniques of liquid chromatography (helping with their separation) and mass spectrometry (determining their relative abundance in a sample).*** ***This lesson/project focuses on the attempts of teams of scientists trying to track glycans in chicken sera during longitudinal studies in an attempt to see if any glycans might serve as biomarkers for the development of ovarian cancer. Chickens are one of the few species other than humans that spontaneously develop ovarian cancer and they do so at a relatively high rate – making them ideal animal models for the disease.*** ***Tracking the glycans is done primarily through a combination of liquid chromatography (which helps separate them) and mass spectrometry (which shows the abundance of the different glycans based on their masses) – these systems are referred to as LC-MS systems. This type of analysis can be challenging, though, because in order to analyze the glycans, they have to separate (and they are all highly soluble, which complicates things) and they have to be charged in order for the mass spectrometer to measure them (and they do not ionize readily). It has been determined that tagging the glycans with nonpolar reagents (i.e. bonding them to nonpolar molecules through a derivatization reaction) will assist in addressing both of these issues. However, determining the best derivatization tag is still a work in progress. Testing some new reagents for the efficiency was part of my research program.*** ***Ultimately, analytical chemists, biochemists, synthetic chemists (who make the new derivatization reagents for testing), molecular biologists, animal scientists, and oncologists are working on these projects to see if we can make positive strides in our war against cancer.***

Brian Cartiff's Kenan Lesson Plan #1

Curriculum Alignment (Required)

NC Essential Standards

Content Area	Grade Level	NC SCS
Chemistry	10-12	Chm.1.2.2
Chemistry	10-12	Chm.1.2.4
Chemistry	10-12	Chm.3.2.6

Common Core Standards

Content Standard
CCSS.ELA-LITERACY.RST.11-12.1
CCSS.ELA-LITERACY.RST.11-12.4
CCSS.ELA-LITERACY.RST.11-12.6
CCSS.ELA-LITERACY.RST.11-12.7
CCSS.ELA-LITERACY.RST.11-12.8
CCSS.ELA-LITERACY.RST.11-12.9
CCSS.ELA-LITERACY.RST.11-12.10
CCSS.ELA-LITERACY.WHST.11-12.1.C
CCSS.ELA-LITERACY.WHST.11-12.1.D
CCSS.ELA-LITERACY.WHST.11-12.2.A
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CCSS.ELA-LITERACY.WHST.11-12.4
CCSS.ELA-LITERACY.WHST.11-12.5
CCSS.ELA-LITERACY.WHST.11-12.8
CCSS.ELA-LITERACY.WHST.11-12.9

Next Generation Science Standards

Standard
HS-ETS1-3
HS-PS1-1

Learning Outcomes (Required)

- *Students will express their ideas clearly both verbally and in writing.*
- *Students will understand why scientists have to specialize to such a large degree.*
- *Students will understand and communicate reasons why it is important for scientists to collaborate to solve real world problems.*
- *Students will understand the role of technology in analytical chemistry.*
- *Students will understand the specialized goals of different fields of science, namely analytical chemistry, biochemistry, animal science, and oncology.*
- *Students will use Web 2.0 and 3.0 tools (Infographics, Tellagami, Aurasma, among others) to learn and communicate their findings about analytical chemistry, biochemistry, animal science, and oncology during the course of their investigations.*
- *Students will work collaboratively to produce a coherent, well-supported, and meaningful product.*
- *Students will compose several different research papers that are focused and supported.*

Time Required and Location (Required)

10-15 minutes for Introductory "Kahoot!" quiz (click on "Kahoot!" for link) on cancer (Engage activity).

25-30 minutes for a class discussion/debate on the ethics and necessities of animal testing (Explore activity).

30 minutes during class time to introduce and go through the different aspects of the project on day 1.

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	1-2 days (or more, time permitting) of class time can be given for research and/or team planning. Since this is a project, the amount of time given during class time can be determined at the discretion of the teacher, but some planning time for students (and oversight time for the teacher) would be valuable at the beginning of the project. If time is being allocated for research, then it would be helpful to either have computers/Chromebooks available in the classroom or to arrange to take the class to a computer lab/media center. The rest of the 7-8 week project will be completed outside of class time.
Materials Needed (Required)	*Teacher List* • *Glycans, Hens and Ovarian Cancer PowerPoint (file attached)* • *Project Rubrics* • *Student Score Sheets* • *Safe Use Internet Contract* *Student List* • *Project Newsletter* • *Project Rubrics* • *Computers/Chromebooks for each student to do research*
Safety (required)	*Since this is a research project, there are not many safety issues. Students should have filled out a Safe Use Internet Contract at the beginning of the school year.*
Student Prior Knowledge (Required)	*This project is designed as a multi-week investigation into the integration of different fields of science. Students will be familiar with sugars (from biology), with the concepts of bond and molecular polarity (from earlier on in the chemistry course) and the basic ideas of scientific investigations.*
Teacher Preparations (Required)	• *Become familiar with the major ideas of the topics involved (the Glycans, Hens, and Ovarian Cancer PowerPoint should help).* • *Become familiar with infographics and the different websites that allow people to make them, so the teacher can advise students.* • *Become familiar with Tellagami, Infographic, Toondoo applications.* • *If necessary, reserve computers/Chromebooks/computer lab for class research time.*
Activities (Required)	***Engage:*** **Give Kahoot! quiz on cancer and scientific studies. (10-15 minutes)** ***Explore*****: Conduct a class discussion on the necessities and ethics of animal testing in scientific studies. This is to elicit prior knowledge and also to get students to realize that it is a complex issue. They will be addressing the topic in a couple of different ways during the rest of the project. This discussion serves as a precursor and the controversial nature of the topic should enable a lively discussion. Since it is controversial, though, the teacher should be careful to set some ground rules at the beginning of the discussion and emphasize that we are trying to have a reasonable and calm discussion about the issue rather than emotional, highly charged one. (25-30 minutes)** ***Explain:*** **This part is not the traditional "explain" step as students will be completing this primarily through research (although consulting with the teacher is also encouraged). Students will conduct research according to the accompanying newsletter (also titled "An Analytical Chemist, a Biochemist, an Animal Scientist, and an Oncologist Walk into a Lab…No Joke"). (7-8 weeks, outside of class)**

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	Elaborate: **The elaborate portion will be taking place simultaneously with the explain part. Students will take the investigative research and convert those ideas into the products specified in the "An Analytical Chemist, a Biochemist, an Animal Scientist, and an Oncologist Walk into a Lab…No Joke" newsletter. (7-8 weeks, outside of class)** ***Evaluate:*** **The products of the project will be evaluated according to the project rubrics, which are discussed below.**
Assessment (Required)	***See the following rubrics in the separate rubrics document:*** 1. ***Rubric for History of Spectrometry Infographic*** 2. ***Rubric for Polar vs. Non-Polar Cartoon/Comic Strip*** 3. ***Rubric for Proposed Longitudinal Studies*** 4. ***Rubric for Ethical Considerations of Animal Studies Video & Script*** 5. ***Rubric for the Collaboration between Scientists Illustration and Explanation*** 6. ***Team Works Consulted & Cited Rubric*** 7. ***Individual Role Tellagami Animation Rubric*** 8. ***Individual Role Paper Rubric*** 9. ***Individual Illustration Rubric*** 10. ***Individual Works Cited Rubric*** 11. ***Student Reflection Rubric*** 12. ***Student Self & Peer Evaluation Rubric (will be scored by the students on the team)***
Critical Vocabulary (Required)	***Analytical chemistry:*** *the study of the separation, identification, and quantification of the chemical components of natural and artificial materials* ***Animal model:*** *a living, non-human animal used during the research and investigation of human disease, for the purpose of better understanding the disease process without the added risk of harming an actual human* ***Biochemistry:*** *the study of chemical processes within and relating to living organisms* ***Biomarker:*** *a measurable indicator of some biological state or condition* ***Glycan:*** *a general term for sugars found in glycoproteins or glycolipids* ***Glycobiology:*** *the study of the structure, biosynthesis, and biology of saccharides (sugar chains or glycans) that are widely distributed in nature* ***Liquid chromatography:*** *technique in analytic chemistry used to separate the components in a mixture, to identify each component, and to quantify each component* ***Mass spectrometry:*** *an analytical technique that produces spectra of the masses of the atoms or molecules constituting a sample of material* ***Oncology:*** *branch of medicine that deals with cancer*
Community Engagement (Required)	• **Sharing student work or projects (can include sharing student work through apps (Tellagami) and posting student work on the school website** • **Guest speakers (an oncologist or biochemist could come speak about what they do)**

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Extension Activities (Optional)	• **Because of the controversy regarding animal testing/modeling, one extension might be to have a debate at a larger level – school-wide or between this class and another class (it could be between two classes that completed this project or between one that did and another class (like a biology class).** • **A large part of the theme of this project is the focus on the collaboration between scientists in different specialized fields. As extension activities this theme can be discussed or incorporated into other lessons – for example, a lesson plan on "flight" could involve an investigation and discussion on the roles of physicists, aeronautical engineers, and material scientists (among others) or a lesson plan on global warming could involve a discussion about the roles of meteorologists, climatologists, atmospheric chemists, oceanographers, marine biologists, geologists, environmental scientists, and petrochemists (among others).**
Modifications (Optional)	• **The format is the key to adapting this assignment. It is about the integration of sciences, but teachers should feel free to substitute different types of scientists for those listed here depending on the overall topic (for example a project in a physics class on flight could have a collaboration between a physicist, an aerospace engineer, a material scientist, and a meteorologist).** • **Guest speakers can include: professors at nearby universities, scientists from the community, other teachers at your school who used to work in industry, graduate students.** • **If the thought of having a debate on animal testing is intimidating, that aspect can be skipped. However, since at no point does the teacher have to indicate that one side of the debate is correct, it is desirable to at least have a discussion on the topic (since animal testing actually occurs and not having the discussion/debate seems to just be ignoring that).**
Alternative Assessments (Optional)	• **If a modification like the one mentioned above is done, then the teacher will need to adapt the newsletter, but the grading rubrics will not change greatly.**
Supplemental Information (Optional)	**Key words for a Google search (in case links don't work):** • **Ovarian Cancer, Integration of Sciences, Analytical Chemistry**
Comments (Optional)	• **This project was developed based on the Kenan Fellowship Externship "Reinvigorating the War Against Cancer" conducted with Dr. David Muddiman and his team at the W.M. Keck Mass Spectrometry Laboratory at N.C. State. The investigations and experiments that they are conducting are not simple and they fit outside most of the curricular standards for high school science. They also involve the coordination with many other scientists in different fields. Because of these things it was deemed most appropriate to make this lesson plan an extensional project (taking place, for the most part, outside of class time) as a mini-version of the study I helped conduct during my time on Dr. Muddiman's team. Students have to collaborate (just like the scientists) but they also have their individual roles to fill (again, like the scientists). They have to create products from their work and share them with a greater audience.**

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	• To best fit their classes teachers can make the teams smaller by eliminating roles or make them larger (either by assigning multiple students to the same role (teams within the overall team) or by creating new individual roles (like a molecular biologist and/or a synthetic chemist). • Teachers can also eliminate or create new topics for the team's investigation and/or change the products that students are required to make. • A lot of the material connected to the topics in the study may be confusing for students. The teacher needs to be familiar enough with them to help, but the guiding questions have been developed to help guide students to related topics they should be able to comprehend on their own. • Teacher Reflections: ○ I have conducted this lesson only once so far, but I was impressed with what my students created and what they seemed to have learned. Having Dr. Muddiman come in and address my students was a big key – it's been several years since I've had a guest speaker and I have forgotten the impact that a good one can have. Dr. Muddiman will be coming again to address my students this coming semester and I'm also working on having a biochemist (and former student of mine) also come in to speak. ○ I need to do a better job of checking in throughout the process with my students to see if there is any confusion or problems. Also, just to keep them on track since there are many different components to the project. ○ I will be extending the timeline of the project a few weeks based on the suggestions of several students. I will also have several formal check-in dates or deadlines to make sure teams are not procrastinating. ○ To help students stay organized and submit their work in a professional manner, I will be creating team Google doc folders. Students will be able to organize, peer edit, and submit their electronic files through these folders. ○ I participated on several teams because of numbers and I enjoyed this immensely. It also helped me gain a different perspective on how the teams were functioning and what was and wasn't working. I will be continuing to serve in this capacity on future teams. • Student Comments and Reflections ○ Many students were intimidated at the beginning of the lesson plan – particularly with the project aspect. There are many different components and the idea of working in teams is not always attractive to some students. ○ Most students appreciated the project newsletter (one did comment that it was colorful and too distracting), but it was obvious that certain students did not always read it carefully. This was an observation of the teacher, but several students also admitted this in their reflections. ○ The students appreciated the specificity of the rubrics, but found them intimidating as well – most students were not used

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	to having multiple rubrics for one assignment and there are rubrics for each individual aspect of this project. ○ **Students did feel, in general, that they learned a lot throughout the process. In some cases, though, they felt a bit isolated even though there were several group components – they expressed interest in learning about other roles (this may lead to more requirements on peer editing in the future.** ○ **Several students expressed possible new career interests, which was a goal of the lesson plan.** ○ **The vast majority of the students really appreciated Dr. Muddiman's visit and presentation, although they were a bit timid when it came to asking questions (as a class, we may brainstorm possible questions ahead of time in future applications of this lesson).**
Author Info (Required)	Kenan Fellow: **Brian Cartiff** • **Johnston County Middle College High School, Smithfield, NC** • **Chemistry, Earth & Environmental Science, 11-12 grades** • **I have taught in public high schools for 19 years. I have also taught for Duke TIP and Science in the Summer Programs.** • **Briancartiff@johnston.k12.nc.us** Mentor: **Dr. David Muddiman** • **Distinguished Professor of Chemistry; Director, W.M. Keck FT-ICR-MS Laboratory, North Carolina State University** • **The research ongoing in the Muddiman Laboratory is Interdisciplinary by Design with the goal to educate members of the group on the development and application of state-of-the-art instrumentation to solve contemporary, sophisticated, and challenging problems. This includes projects directed at understanding basic biological processes, systems biology of important pathways in lignin biosynthesis, defining unique and trace evidence and chemical signatures of humans with forensic applications, and ovarian cancer biomarker discovery through development of novel and innovative chemical strategies combined with a unique, untapped and power animal model: the domestic hen. I say "my" work above because the education of students comes first and foremost. My career is much more about my students than it is about me. I foster an environment of motivation, drive, excitement, and curiosity and the students feel that and excel, far beyond any science that I could ever "prescribe".** • **I was educated as an Analytical Chemist in graduate school but I was passionate about bridging that knowledge with biology and medicine. I was never formally trained as a biologist, engineer, statistician, or bioinformatician. It was through the building of strong long-term collaborations with open sharing of ideas and bridging gaps that have allowed me to learn these fields and others. Thus, while formal training is key to get started, my willingness and interest of continually making myself intellectually uncomfortable has made me the scientist, educator and professor I am today. I am an absolute believer in collaborative interdisciplinary science and my former students are concrete examples that my approach to education provides fruitful careers in many different fields.**

Brian Cartiff's Kenan Lesson Plan #1

	• dcmuddim@ncsu.edu

July 9, 2014

An Analytical Chemist, a Biochemist, an Animal Scientist, and an Oncologist… - Grading Rubrics

TEAM REQUIREMENT 1: HISTORY OF MASS SPECTROMETRY INFOGRAPHIC

DUE DATE: _____

GRADING RUBRIC – 15 POINTS TOTAL						
	Raw Score					
	5	4	3	2	1	0
Creativity of Infographic	Creativity of Infographic is evident. Graphics and pictures are colorful and visually appealing. Text and graphics work together to present a creative representation.	Creativity of Infographic is evident. Graphics and pictures are colorful and generally visually appealing. Text and graphics mostly work together to present a creative representation.	Creativity of Infographic is mostly evident. Graphics and pictures are colorful and generally visually appealing. Text and graphics work together to present a creative representation for most of the infographic.	Creativity of Infographic is generally lacking. Graphics and pictures are not colorful and not particularly visually appealing. Text and graphics work together to present a creative representation for some of the infographic.	Creativity is not evident. Pictures and graphics are limited and not visually appealing. No obvious connections between the graphics and the text.	No infographic is submitted.
Clarity of the Infographic	Graphics and text are clear. The connections between different components of the infographic are obvious and well-devised.	Graphics and text are clear. The connections between different components of the infographic are mostly clear.	Graphics and text are mostly clear. The connections between different components of the infographic are generally clear.	Some graphics and text are not clear. The connections between different components of the infographic are confusing in parts.	Graphics and/or text are not clear. Connections between the different components of the infographic are mostly or completely confusing.	No infographic is submitted.
Information of the infographic	All the pertinent information about the history of mass spectrometry is present.	Most of the pertinent information about the history of mass spectrometry is present.	A majority of the pertinent information about the history of mass spectrometry is present.	Little pertinent information about the history of mass spectrometry is present.	Very little pertinent information about the history of mass spectrometry is present.	No infographic is submitted.

TEAM REQUIREMENT 2: POLARITY vs. NON-POLARITY AND HYDROPHILICITY vs. HYDROPHOBICITY COMIC STRIP/CARTOON

DUE DATE: _____

GRADING RUBRIC – 15 POINTS TOTAL						
	Raw Score					
	5	4	3	2	1	0
Creativity of Cartoon/ Comic Strip	The cartoon/comic strip is creative, clear and shows obvious planning.	The cartoon/comic strip shows creativity and is mostly clear. It shows some planning.	The cartoon/comic strip shows some creativity but is mostly clear. It shows some planning, but more was needed.	The cartoon/comic strip shows a little creativity, is ambiguous, and shows little planning.	The cartoon/comic strip shows minimal creativity, is not clear, and shows little to no planning.	No cartoon/ comic strip is submitted.
Correctness of the Concept of Polarity and Non-polarity	Polarity and non-polarity are correctly portrayed. Hydrophilicity and hydrophobicity are also correctly portrayed.	Polarity and non-polarity are correctly portrayed.	Polarity and non-polarity are correctly portrayed for the most part. There may be some lack of clarity or a small mistake.	Polarity and non-polarity are correctly portrayed in some way, but there are some mistakes and/or a lack of clarity.	Polarity and non-polarity are incorrectly portrayed.	No cartoon/ comic strip is submitted.
One-two page paragraph Explanation	The explanation explains the concepts of polarity/non-polarity and hydrophobicity/ hydrophilicity correctly and clearly shows how the comic strip/cartoon portrays it.	The explanation explains the concepts of polarity/non-polarity and hydrophobicity/ hydrophilicity correctly and shows how the comic strip/cartoon portrays it.	The explanation explains the concepts of polarity/non-polarity and hydrophobicity/ hydrophilicity correctly but does not show how the comic strip/cartoon portrays it.	The explanation explains some of the concepts of polarity/non-polarity and hydrophobicity/ hydrophilicity correctly but does not show how the comic strip/cartoon portrays it.	The explanation does not explain the concepts of polarity/non-polarity and hydrophobicity/ hydrophilicity correctly.	No explanation is submitted.

TEAM REQUIREMENT 3: LONGITUDINAL STUDIES

DUE DATE: _____

GRADING RUBRIC – 15 POINTS TOTAL						
	Raw Score					
	5	**4**	**3**	**2**	**1**	**0**
First Developed Longitudinal Study (for students in class)	Fully discusses what is being studied, why it is being studied, and how. Methodology is sound.	Fully discusses what is being studied, why it is being studied, and how. Methodology has a minor flaw.	Mostly discusses what is being studied, why it is being studied, and how. Methodology may have a minor flaw.	Partially discusses what is being studied, why it is being studied, and how. Methodology has flaws.	Missing important information about what is being studied, why it is being studied, and how. Methodology has flaws.	No longitudinal study is submitted.
Second Developed Longitudinal Study (for people at school)	Fully discusses what is being studied, why it is being studied, and how. Methodology is sound.	Fully discusses what is being studied, why it is being studied, and how. Methodology has a minor flaw.	Mostly discusses what is being studied, why it is being studied, and how. Methodology may have a minor flaw.	Partially discusses what is being studied, why it is being studied, and how. Methodology has flaws.	Missing important information about what is being studied, why it is being studied, and how. Methodology has flaws.	No longitudinal study is submitted.
Clarity of Writing	The writing for both studies is clear and technically correct. Scientific terms are used and employed correctly. Grammar and spelling are completely correct.	The writing for both studies is clear and technically correct. Scientific terms are used and employed correctly. Grammar and spelling are correct with one exception.	The writing for both studies is clear and technically correct. Scientific terms are used and employed correctly for the most part. Grammar and spelling are correct with a couple of exceptions.	The writing for one study is clear and technically correct, but the other one is not. Scientific terms are not used much and/or are not employed correctly. Grammar and spelling have several issues.	The writing for both studies is not clear and scientific terms are not employed. There are many issues with grammar and spelling throughout.	Neither longitudinal study is submitted.

TEAM REQUIREMENT 4: ETHICAL CONSIDERATIONS SCRIPT & VIDEO DEBATE

DUE DATE: _____

GRADING RUBRIC – 15 POINTS TOTAL						
	Raw Score					
	5	**4**	**3**	**2**	**1**	**0**
Ideas Expressed	The ideas expressed in the script and video cover all of the major points of the debate and show how arguments can be made from both sides.	The ideas expressed in the script and video cover most of the major points of the debate and show how arguments can be made from both sides.	The ideas expressed in the script and video cover many of the major points of the debate and show how arguments can be made from both sides.	The ideas expressed in the script and video cover a few of the major points of the debate. Argument presented may be one-sided.	The ideas expressed in the script and video cover a couple of the major points of the debate. Argument presented may be one-sided.	No video or script is submitted.
Coherence and Clarity of the Script	The script is well-written and free of errors. Care and clarity in writing are evident.	The script is well-written and only has one or two errors. Care and clarity in writing are evident.	The script is well-written and only has three errors. Care and clarity in writing are somewhat evident.	The script is not particularly well-written and has a few errors. Care and clarity in writing are somewhat evident.	The script is not particularly well-written and has several errors. Care and clarity in writing are not evident.	No video or script is submitted.
Believability and Quality of Video	Quality of the video and the acting are excellent. Students do not noticeably read from scripts and are believable as experts.	Quality of the video and the acting are good. Students do not noticeably read from scripts and are believable as experts.	Quality of the video and the acting are good. Students noticeably read from scripts at times but are believable as experts.	Quality of the video and the acting are adequate. Students noticeably read from scripts at times and may not be believable as experts.	Quality of the video and the acting are poor. Students noticeably read from scripts at times and are not believable as experts.	No video or script is submitted.

TEAM REQUIREMENT 5: COLLABORATION OF SCIENTISTS ILLUSTRATION & EXPLANATION

DUE DATE: _____

GRADING RUBRIC – 10 POINTS TOTAL						
	Raw Score					
	5	4	3	2	1	0
Illustration	Excellent and clear illustration is provided. Thought and care in producing the illustration are evident. The illustration clearly indicates the concept of collaboration.	A quality and clear illustration is provided. Thought and care in producing the illustration are evident. The illustration clearly indicates the concept of collaboration.	A clear illustration is provided. Thought and care in producing the illustration are generally evident. The illustration indicates the concept of collaboration but may not be completely clear.	An illustration is provided but does not show much thought or care. The illustration does not clearly indicate collaboration.	An illustration is provided but is not clear. The concept of collaboration is not communicated.	No illustration is submitted.
Explanation	The explanation fully addresses the questions asked on the project description sheet and completely explains how the illustration captures the collaboration of scientists.	The explanation mostly addresses the questions asked on the project description sheet and completely explains how the illustration captures the collaboration of scientists.	The explanation mostly addresses the questions asked on the project description sheet and completely explains how the illustration captures the collaboration of scientists.	The explanation addresses a few of the questions asked on the project description sheet and addresses, but does not completely explain, how the illustration captures the collaboration of scientists.	The explanation addresses one or two questions on the project description sheet but does not explain the collaboration of scientists.	No illustration is submitted.

TEAM WORKS CONSULTED & CITED

DUE DATE: _____

GRADING RUBRIC – 10 POINTS TOTAL					
Raw Score					
10	8	6	4	2	0
An appropriate and complete (at least 5 works) Works Consulted/Cited list is turned in. Format	A mostly complete (at least 4 works) Works Consulted/Cited list is turned in. Format is in	A partially (at least 3 works) complete Works Consulted/Cited list is turned in. Format is in	A complete (at least 5 works)Works Consulted/Cited list is turned in. Format is NOT in	An INCOMPLETE (2 or fewer) Works Consulted/Cited list is turned in. Format is NOT in	No Works Consulted/Cited list is turned in.

is in appropriate MLA format.	appropriate MLA format.	appropriate MLA format.	appropriate MLA format.	appropriate MLA format.	

INDIVIDUAL REQUIREMENT 1: TELLAGAMI

DUE DATE:_____

GRADING RUBRIC – 15 POINTS TOTAL						
	Raw Score					
	5	**4**	**3**	**2**	**1**	**0**
Background	The content-specific background is of high quality and is appropriate for the presentation.	The content-specific background is of acceptable quality and is appropriate for the presentation.	The content-specific background is of poor quality but is appropriate for the presentation.	A student-chosen background is used, but shows little connection to the content.	A student-chosen background is used, but shows no connection to the content.	No content-specific background is provided.
Content	The Tellagami addresses all of the main points of what the particular role (job) entails.	The Tellagami addresses most of the main points of what the particular role (job) entails.	The Tellagami addresses some of the main points of what the particular role (job) entails.	The Tellagami addresses a few of the main points of what the particular role (job) entails.	The Tellagami addresses one of the main points of what the particular role (job) entails.	No Tellagami is submitted.
Quality of Presentation	The presenter speaks clearly and well. Planning is evident.	The presenter speaks mostly clearly and well. Planning is evident.	The presenter speaks mostly clearly and well. Some planning is evident.	The presenter speaks clearly but is confusing in conveying ideas. Little planning is evident.	The presenter does not speaks clearly. Planning is not evident.	No Tellagami is submitted.

INDIVIDUAL REQUIREMENT 2: PAPER

DUE DATE:_____

GRADING RUBRIC – 20 POINTS TOTAL						
	Raw Score					
	5	**4**	**3**	**2**	**1**	**0**
Length Requirements	The paper fully meets the 3-4 page length requirement.	NA	NA	NA	The paper does not fully meet the 3-4 page length requirement.	No paper is submitted.
Writing Quality	The paper has no spelling and/or grammatical errors.	The paper has one or two spelling and/or grammatical errors.	The paper has three or four spelling and/or grammatical errors.	The paper has five or six spelling and/or grammatical errors.	The paper has more than six spelling and/or grammatical errors.	No paper is submitted.
	Raw Score					
	10	**8**	**6**	**4**	**2**	**0**
Content	All of the questions asked in the project description are addressed and the paper goes beyond to address many related and appropriate ideas.	All of the questions asked in the project description are addressed and the paper goes beyond to address some related and appropriate ideas.	All of the questions asked in the project description are addressed and the paper goes beyond to address a few related and appropriate ideas.	All of the questions asked in the project description are addressed.	Not all of the questions asked in the project description are addressed.	No paper is submitted.

INDIVIDUAL REQUIREMENT 3: ILLUSTRATION

DUE DATE:_____

GRADING RUBRIC – 15 POINTS TOTAL						
	Raw Score					
	5	**4**	**3**	**2**	**1**	**0**
Appropriateness of Illustration	The illustration appropriately demonstrates the roles and importance of the particular career.	The illustration demonstrates the roles and importance of the particular career in a mostly appropriate way.	The illustration demonstrates the roles and importance of the particular career in a somewhat appropriate way.	The illustration demonstrates the roles and importance of the particular career in a barely appropriate way.	The illustration does not appropriately demonstrate the roles and importance of the particular career.	No illustration is submitted.
Quality of Illustration	The illustration is of excellent quality and is well-planned and executed.	The illustration is of good quality and shows careful planning and execution.	The illustration is of adequate quality and shows some planning and execution.	The illustration is of adequate quality but does not show much planning or execution.	The illustration is of poor quality and shows little to no planning.	No illustration is submitted.
Content of Illustration	The illustration completely demonstrates the roles and importance of the particular career.	The illustration mostly demonstrates the roles and importance of the particular career.	The illustration demonstrates some of the roles and importance of the particular career.	The illustration demonstrates a couple of the roles and importance of the particular career.	The illustration does not appear related to the roles and importance of the particular career.	No illustration is submitted.

INDIVIDUAL WORKS CITED

DUE DATE: _____

GRADING RUBRIC – 10 POINTS TOTAL					
Raw Score					
10	**8**	**6**	**4**	**2**	**0**

An appropriate and complete Works Consulted/Cited list is turned in. Format is in appropriate MLA format.	A mostly complete Works Consulted/Cited list is turned in. Format is in appropriate MLA format.	A partially complete Works Consulted/Cited list is turned in. Format is in appropriate MLA format.	A complete Works Consulted/Cited list is turned in. Format is NOT in appropriate MLA format.	An INCOMPLETE Works Consulted/Cited list is turned in. Format is NOT in appropriate MLA format.	No Works Consulted/Cited list is turned in.

STUDENT REFLECTION

DUE DATE: _____

GRADING RUBRIC – 10 POINTS TOTAL					
Raw Score					
10	**8**	**6**	**4**	**2**	**0**
A 1-2 page student reflection is submitted that completely and thoughtfully addresses at least the six guiding questions on the project description handout.	A 1-2 page student reflection is submitted that mostly and somewhat thoughtfully addresses the six guiding questions on the project description handout.	A 1-2 page student reflection is submitted that mostly addresses the six guiding questions on the project description handout. The reflection is limited in its scope.	A 1-2 page student reflection is submitted but does not adequately address the six guiding questions on the project description handout.	A student reflection is submitted but does not meet the minimum length requirements.	No student reflection is submitted.

PROJECT COMPLETION

DUE DATE: _____

GRADING RUBRIC – 10 POINTS TOTAL	
Raw Score	
10	**0**
All aspects of the project were submitted by the appropriate due dates and were complete at the time of submission.	Aspects of the project were either submitted late, submitted incomplete or never submitted at all.

10 points of the project grade will be derived from a self and peer evaluation completed at the end of the project.

Total points of project = 170 points
The project grade will count as BOTH a test and a project!

CHEMISTRY – INTEGRATION OF SCIENCE PROJECT – FALL 2014

STUDENT SCORE SHEETS

Name_____

TEAM SCORES

CATEGORY	POINTS ASSIGNED	COMMENTS
HISTORY OF MASS SPECTROMETRY INFOGRAPHIC		
CREATIVITY	_____/5	
CLARITY	_____/5	
INFORMATION	_____/5	
POLARITY COMIC STRIP/CARTOON		
CREATIVITY	_____/5	
CLARITY	_____/5	
EXPLANATION	_____/5	
LONGITUDINAL STUDIES		
1st STUDY	_____/5	
2nd STUDY	_____/5	
CLARITY	_____/5	

ETHICAL CONSIDERATIONS OF ANIMAL TESTING VIDEO/SCRIPT		
IDEAS EXPRESSED	_____/5	
COHERENCE/CLARITY OF SCRIPT	_____/5	
QUALITY OF VIDEO	_____/5	
COLLABORATION OF SCIENTISTS ILLUSTRATION/EXPLANATION		
ILLUSTRATION	_____/5	
EXPLANATION	_____/5	
TEAM WORKS CONSULTED & CITED	_____/10	
TOTAL TEAM SCORE	**_____/80**	

INDIVIDUAL SCORES

CATEGORY	POINTS ASSIGNED	COMMENTS
TELLAGAMI		
BACKGROUND	_____/5	
CONTENT	_____/5	
QUALITY	_____/5	

SCIENTIST PAPER		
LENGTH	_____/5	
QUALITY	_____/5	
CONTENT	_____/10	
ILLUSTRATION		
APPROPRIATENESS	_____/5	
QUALITY	_____/5	
CONTENT	_____/5	
INDIVIDUAL WORKS CITED	_____/10	
STUDENT REFLECTION	_____/10	
PROJECT COMPLETION	_____/10	
PEER & SELF EVALUATION	____/15	
INDIVIDUAL TOTAL	____/95	

TOTAL POINTS _____/175 **PERCENT = _____**