These portions match the Grant Wiggins and Jay McTighe, Understanding by design, 2nd Ed. Appendix Stages 1-3.

- The Stage 3 calendar, several pages below, is modified to emphasize the project milestones.
- This document accompanies a manuscript for submission to the American Biology Teacher.
- **STUDENTS**: this template is probably too much for you if you've stumbled upon it and are wondering about the senior seminar **syllabus**:
  - Here is a hyperlink to **our tentative syllabus:** http://www.drjreid.com/PDF/Syllabus_senior_seminar.pdf .

Beacon Science Senior Seminar 2006-2007

Brief Summary of Unit, including curricular context and goals:

As described in the manuscript to be submitted to the American Biology Teacher.

- The Rationale section of the manuscript is the explanation, and note the accompanying tables and figures.

Also, see the parent letter for science senior seminar: http://www.drjreid.com/PDF/Senior%20Seminar%20Letter.pdf .

Established Goals:

- Beacon student goals are shown in Table 1 of the ABT manuscript.
- Goals that match project 2061 science goals are shown in Table 3.

What essential questions will be considered?	**What understandings are desired?**
• How is the scientific method different, if at all, when applied to the conducting of science research? • Is pseudoscience science? • How does mentorship and collaboration benefit scientific outcomes? • What content can a student identify and determine is essential for their completion of a science project? • How are different problems in science approached differently? • What are the stages and methods for communicating science? • How is a technical paper written?	***Students will understand that…*** • The scientific process is not "linear" and is re-approached during research. • That collaboration is an essential aspect for designing experiments, conducting research, and organizing an entire science project from start to finish. • That scientific knowledge is somewhat broad, very deep, and essential for the completion and defense of a quality science project. • That technology is useful for the analysis of data and the communication of scientific ideas. • That scientific and technical writing requires unique organizational skills and knowledge.

What key knowledge and skills will students acquire as a result of this unit?	
Students will know…	***Students will be able to…***
• Key terms—control, error, experimental repeatability, causality, association, future studies, rationale, statistically significant, imagination. • The answers to 30 sophisticated scientific questions they generate mostly themselves. • The science content covered in previous science courses. • The stages of writing a technical paper in science. • That science is the product of individual interest and diligence while attempting to solve problems.	• Analyze the merit of a science project • Explain a project using PowerPoint • Field questions about the project • Write a complete technical paper in science • Make recommendations for others with respect to their development and organization of scientific research • Use technology to communicate scientific results. • Generate their own scientific hypothesis. • Critique science projects with respect to their scientific merit.

Stage 2—Determine Acceptable Evidence

What evidence will show that students understand?

Performance tasks:

The final paper—the final 10 page paper is the result of formulating a scientific hypothesis, conducting the relevant research, displaying the results, interpreting these results, discussing the results in context of the existing scientific understandings about the topic, and recommending future studies.

The final presentation—the final PowerPoint presentation is the result of the same criteria as described for the final paper. However, the oral presentation includes the opportunity to field questions, to present data to one's peers, and requires students to hone additional communication skills.

What other evidence needs to be collected in light of Stage 1 Desired Results?

Other evidence:

(e.g. tests, quizzes, prompts, work samples, observations)

Participation—students participate in the regular classroom, an online-forum, and complete written homework assignments.

Milestones—the completion of the hypothesis and literature review precedes the completion of the summative final paper and oral presentation. Routinely, students will be asked to explain their "works that are in progress" to other students in the class.

Knowledge checks—the status of the 30 question list is monitored throughout the semester. Students should incrementally increase the size of the question list (all 30 questions should be asked by the end of the course), and the answers should be improving in quality as the questions are revisited.

Student Self-Assessment and Reflection:

These are questions for students to reflect upon, and the seminar teacher can raise these:

1. What is the quality of my 30 questions?
2. Do I agree with my mentor's opinion about my science project?
3. Am I able to contribute to other students science projects?
4. Have I been moving at an appropriate rate during the semester?
5. Is my project farther along than other students? Is it okay that I am farther ahead or behind because my study is unique?
6. Do I think my science project is of merit? If I've come up with a better idea, when should I adjust, and when should I commit?

Assessment Task Blueprint

What understandings or goals will be assessed through this task?
The spirit of Beacon is explained only when the culture of portfolio education is fully understood. As we reach for this culture—one of supporting each other, while completing projects of merit (merit: when they are believed to be useful and helpful for ourselves and others) and substantive learning experience—we reach for the quality of understanding that is the sprit of Beacon. The ultimate goal is for students to be independent, supported learners that bring new and relevant information to the plate. A further goal is for students to be creative, and to use the information they have assimilated in ways that are useful for mankind. At Beacon, we hope that these endeavors will instill a yearning to maintain this quest for knowledge and helpful product as students enter the world after high school.

What criteria are implied in the standards and understandings regardless of the task specifics? What qualities must student work demonstrate to signify that standards were met?	
• Standards goals were addressed in the established goals section, above (see Tables 1 & 2 of the ABT manuscipt). • **Communication goals:** these are described in the ABT manuscript tables 1 & 3, and figure 4 • **Data quality goals:** these are described in the ABT manuscript tables 1 & 3, and figure 4	• **Knowledge goals:** these are described in the ABT manuscript tables 1 & 3, and figure 4 • **Merit goals:** these are described in the ABT manuscript tables 1 & 3, and figure 4 •

Through what authentic performance task will students demonstrate understanding?
Task overview: Students will complete an original, self-designed science research project of merit. Using the ABT article language: • Each unique student-generated research project is reported in a paper of about 10 pages in length. • Each student also creates a PowerPoint presentation that accompanies the paper. • This portfolio-based performance task is presented to both the senior seminar teacher, and to another assessor who is a science teacher.

What student products and performances will provide evidence of desired understandings?	
• Regular participation and engagement in class activities • Written literature review • Written final project paper • Oral presentation	• Second opinion: quality of project paper and presentation as viewed by an outside assessor • Science teacher-mentorship (a large part of the participation grade). • The parent letter has the grading breakdown.

By what criteria will student products and performances be evaluated?	
• Regular participation and engagement in class activities • Quality of written literature review • Quality of written final project paper • Quality of oral presentation	• Second opinion: quality of project paper and presentation as viewed by an outside assessor • Quality of interaction with science teacher-mentor

Bullmaster-Day rubric. I have adopted the rubric designed by Dr. Marcella Bullmaster-Day from her curriculum and instruction design course at Teachers College, Columbia University to help explain the senior seminar curriculum. I have modified the rubric to explain course goals. A reader may also use the rubric as an index to understand the curriculum.

Criteria:	Goal:	Where to look in Reid's documents (there are 3 documents—the ABT manuscript, a Wiggins and McTighe template, and a course Handbook:	
Rationale: Why should this particular student population learn this particular body of concepts and skills? Upon what learning theories and research is the course/unit based? 20 Points	Rationale statement clearly explains the context and need for the course/unit. Theoretical/ research foundations are clearly articulated. Statement demonstrates exceptional insight.	• See the beginning and entirety of the ABT manuscript. • Some description is present in the template. • Arguments for the curriculum can be made because of: a portfolio education philosophy, the national and NY state science standards, the culture of many portfolio schools, the character of the senior year, and the need for an improved and "deeper" science education.	
Big ideas and essential questions for whole course/unit 20 Points	Big idea and essential questions are exceptionally clear and appropriate. Essential questions focus on the big idea. Overarching and topical essential questions are included.	• Big Ideas are chunked in the manuscript. • For the whole course/unit, see the template below. • Table 1 of the ABT manuscript has student goals. • The big idea is that when students derive and conduct their own substantive research project, the experience will: 1) transfer into other learning areas and domains of skill development, 2) provide an authentic experience of the scientific endeavor, and 3) provide a foundation for improved lifelong learning.	
Learning goals for whole course/unit: What will students know and be able to do? 20 Points	Learning goals in the form of state standards or locally developed goals are clearly delineated. Knowledge and skills to be demonstrated by students are clearly delineated and appropriate.	• Learning goals are within the beginning of the template. • Goals for each day or series of days are in the WHERETO and curriculum plan at the end of the template. • Learning goals are also described within the paper figures. • These include writing skills, science knowledge, technology skills, communication skills, organizational skills, and science research technique.	
Summative assessment for whole course/unit: What performance task or tasks will provide acceptable evidence that students have met learning goals? 20 Points	Summative performance task or tasks are clearly described, including assessment criteria. Summative assessment is exceptionally well aligned to the learning goals.	• Summative assessments are listed in the template, but they are also bolded in the curriculum plan at the end of the template. • Students will present their completed science project as a presentation to both the senior seminar class and later to another science teacher. Also, students will complete a research paper.	

Criteria:	Goal:	Where to look in Reid's documents (there are 3 documents—the ABT manuscript, a Wiggins and McTighe template, and a course Handbook:	
Pre-assessment for whole course/unit: How will you gauge students' prior knowledge and identify any important misconceptions? 20 Points	Pre-assessment method is appropriate for gathering information about students' initial understanding and competence in relation to the learning goals. Pre-assessment method will discern misconceptions and is exceptionally well suited to gathering useful information efficiently.	• Pre assessments include the first homework assignment, and continuing homework assignments. • The real "pre-"assessment is the first homework assignment and the hypothesis sheet that must be signed by the mentor. • Preconceptions about science are discussed during the ongoing course dialogue, the meeting with mentors, and in the regular homework. • The student report is a continuum of the pre-assessment.	
Formative assessments throughout the course/unit: By what means will you gather evidence along the way that students are moving toward the learning goals? 20 Points	Course/ unit plan includes a variety of informal and formal assessment methods to be used within the course for purposes of monitoring student learning and making appropriate modifications or adaptations to instruction. Formative assessments are exceptionally appropriate for gathering useful information.	• These include the homework assignments that are milestones. The due dates for these are indicated in the curriculum plan. • These formative assessments are primarily found in the student handbook. • The project is constantly monitored for progress, and the anecdotal reporting system (a teacher-generated report about the learning habits and progress of each student) is described. See the Template Day 4, and Day 7. • The early preparation of the literature review	
****Materials and resources** for the whole course/unit (Same as Curriculum Resource File to be also deposited into the ClassWeb Resource folder) 50 Points	Course/unit plan includes an exceptionally thorough list of materials and resources to use with students and materials and resources that serve as background information for the teacher.	• The materials and resources list that is provided online (http://www.drjreid.com/PDF/Student_Materials.pdf), which is linked to day 5 in the curriculum plan are the available resources for the students. • The use of computers, an online electronic forum, the student handbook, tailored ordering of materials, and student-provided materials are resources for students. • A computer projector and a networked hard-drive are also very important, as is an email account for all students and the teacher. • The need for these materials and resources is noted in various places in the curriculum plan, the ABT manuscript, and the class handbook. • Previous student papers and projects, copies of the Student Journal Beacon Science, and example titles for projects (Table 2 of the ABT manuscript) are resources for students and teacher in order to stimulate thought to derive science project ideas. • The handbook is a classroom, student and educator resource: http://www.drjreid.com/PDF/Seminar_Packet_web.pdf . • http://www.drjreid.com is a resource for students. • Materials, such as Pasco measurement devices, are recommended in the tips for teachers sections in the ABT manuscript. See ABT manuscript Figures 2 and 3.	

Criteria:	Goal:	Where to look in Reid's documents (there are 3 documents—the ABT manuscript, a Wiggins and McTighe template, and a course Handbook:	
Course/unit outline: What is the scope and sequence? 40 Points	Outline lists session/ lesson topics with learning goals, guiding questions, major activities, and formative assessments for each. Outline is exceptionally coherent and builds from lesson to lesson toward the learning goals. Guiding questions relate to essential questions and big ideas, activities and formative assessments are appropriate.	• The scope and sequence is provided by the curriculum plan at the end of the template. • Scope is further explained in the ABT manuscript. • Guiding questions are listed daily in the curriculum plan below. • The Wiggins and McTighe learning plan below is a lesson plan, with important areas expanded upon for better explanation where necessary, and as a method for creating a later edition of the curriculum.	
Sample lesson plan(s) 40 Points	Lesson plan(s) clearly delineate 1) lesson objectives in terms of what students will know and do, 2) guiding questions, 3) materials and resources, 4) opening activity to activate prior knowledge/ engage interest, 5) methods for presenting new information/ concepts/ skills, 6) opportunities for guided and independent practice activities with feedback, 7) formal or informal assessment methods, 8) extension activities. Lesson plan(s) demonstrate exceptional understanding of instructional design and implementation.	• I have written the entire page template below as a lesson plan. Some lesson plans require teacher-specific knowledge, but advice for tailoring all lessons is provided throughout the ABT manuscript, seminar handbook, and seminar template. • The ABT manuscript is designed to support individualized lesson planning.	

On the next page, I return to the Wiggins and McTighe template design.

Stage 3—Plan Learning Experiences

WHERETO merged with the planning of learning experiences.

What sequence of teaching and learning experiences will equip students to engage with, develop, and demonstrate the desired understandings? Use the following sheet to list the key teaching and learning activities in sequence. Code each entry with the appropriate initials of the WHERETO elements.
(From page 197: W—where, why the unit is headed; H—hook and hold attention; Eq—equip students; R—rethinking, reflection, revision; E—opportunities for student evaluation & self-assessment; T—tailoring for individuality; O—organizing for deep understanding).
I have used these codes, as recommended by Wiggins and McTighe, for the first 4 sessions, below.

Abbreviations: HW = homework. HB = Handbook. Day = 1 of 32 1 hour-long teaching sessions.

Regarding Wiggins & McTighe, and the design of this template, which is hopefully useful as a resource for myself and other teachers. *I have combined the Wiggins & McTighe* WHERETO *elements into my 32 session schedule below, and I provide some reflections which may help other teachers consider their unique resources and timeframe. These reflections are certainly helpful to me with respect to my own teaching of the course. Another teacher who has also taught senior seminar found they needed to adapt some aspects of the curriculum for their own teaching style, and adjustments are necessary and expected. With respect to other readers, this template won't be intelligible without a thorough reading of the ABT manuscript. If you need the manuscript at this time, email me at* schwebac@yahoo.com *for a version of my current draft. Recognize that laboratory activities do not happen during the classes that I've described here. I spend up to 4 hours each week with my students outside of class supporting their research activities. I find this time spent LESSENS my grading time, because papers are much easier to read when the student is there to discuss them, although not all students participate in these meetings. The course* ***handbook*** *has also been posted online, and is referenced in this plan. Handbook pages are marked as :* HB page #.

Regarding computers and technology. *I have written these learning experiences with the expectation that my entire course is scheduled in the computer lab. The class doesn't always need to be in the computer lab, but I prefer the constant access to the online forum, projector, internet, and computers with student files. Lessons that would be difficult to arrange without access to computers are marked COMPUTERS. Our computer lab is networked to other computers at our school, and we have an internet FTP portal Lessons that require a computer (internet-connected) and projector are marked as PROJECTOR..*

Look for these in this learning plan: *Central goals, guiding questions, goals (session goals).*

Session:

1 ***What senior seminar is, including a model presentation.*** *PROJECTOR*
Guiding Questions:
- What is science (a big question that will only be answered in part)? W, H, Eq, R, O
- How do we approach the creation and completion of our own research projects? T, Eq, R, O
- What does a senior seminar project look like? O, H, Eq

Goals:
- Students begin to consider what science is as process. W, H, Eq, R, O
- Students understand what the major objectives of the course are. O

Materials needed:
- Student Handbooks & copies of the Beacon Science magazine.
- Handbooks, so that pages 31-35 can be used for data analysis and discussion (see Day 13). Handbooks should be assembled with graph paper after handbook page 32
- An example student PowerPoint presentation file.

- Senior seminar **handbooks** and letters are given out. [This is online, see http://drjreid.com/senior_science_capstone.htm] E, W
  - *I also issues copies of* ***Beacon Science****, a student publication, to the class. It is a good idea to begin archiving student papers after the course is finished for the first year.* W, O
  - Students should be aware of the **rubric** HB 39. O, W

- Questions for conversation: **What is science**, why do we believe in it? Why do we revere Einstein? What are our perceptions of science? And, leading to our discussion of umbrellogy later [discussed in the ABT manuscript], how do we know when something is scientific, what do we look for? H
- Be the student—give a senior seminar **presentation**, as if the instructor is a student. H
- Show students what the final senior seminar **paper** looks like. HB 5 W, E, O
  - Assign HW 1, which is a Beacon Science article study. HB 4 T, E

2 What mentorship is; brainstorming a project idea.

Guiding Questions:

- What is mentorship in science, and why is this necessary? W
- What is the timeline of senior seminar? W
- What are we interested in researching as a class and as individuals? W, R, T

Goals:

- Students are assigned mentors and understand what mentorship is.
- Begin to understand what all of our interests in life—as these interests relate to science—are.
- Organizationally, we are starting to see what should be accomplished by when.

Materials needed:

- Mentorship assignment sheets which match science-teacher mentors with students.
  - Reminder: the assessors cannot be mentors of the same student.

- Pick up parent **letters**. HB 3 W
- Explain the **mentorship** concept, identify who the mentors are for each student, and explain the requirements. HB 20
  - Mentorship sheet is on HB 21 W
  - Discuss: How do we benefit from the advice of others? Are we successful without the opinions of others? H, W
- Discuss the course milestone dates, and what it means to construct a science project.
  - Activity: Build a **calendar** in a file that is saved to a group folder with each class. W, Eq
- Introduce the **standup lab-meeting** concept—Activity: students stand, and present information. START: "Today, we'll be telling each other about our scientific interests." The teacher will take notes. W, T, H
  - Students begin their forum threads online (described in ABT manuscript). T
  - Students begin working on their HWs needed for their mentors to sign (See HB 21) T,E

3 Brainstorming continued—webquesting an idea.

Guiding Questions:

- What are we interested in researching, as a class and as individuals (continued)? T
- Which of us have similar interests? T, H
- What is the general structure and scope of the final senior seminar paper? O

Goals:

- Finish getting to know everyone's interests. T
- For everyone to gain a more solid understanding of everyone's scientific interests. T, H
- To foster student collaboration. T, H
- For students to begin writing and answer questions that belong to their list of 30 questions. R, O
- For students to use their HW's as tools to support their final project. R, O

Materials needed:

- Class list to jot reminders down about student ideas.
- Extra copies of the Beacon Science magazine.

START: Noting everyone's interest's takes 2 sessions. Finish this initial note-taking today. H, T

- Who is interested in some of the project ideas that other students have? Why? Do you think these are good questions? Would some students be able to work together on their projects? Eq,
  - Introduce the concept of being **consulting scientists**. How is it that scientists work together? How can we emulate this behavior? What roles do we take? How do we usually provide advice to each other in our other classes? H, Eq, R

Activity: students **webquest** together. Eq, R, E

- No computers today? Use an old stack of Science magazines, and give a few to students meeting as consulting scientists, and have them find articles that are interesting to them.

Assessment: Check off and quickly look at completed homework 1 in the student booklets. E

- Introduce the concept of **30 questions**. See ABT manuscript for details. O, E
- **Packets have homework** in them…each homework assignment is marked by the week. HB 42-46. O, E

- Use **Beacon Science**—what do these papers look like—what do students suppose the authors were thinking about when they decided upon their research question? Is Sofia's article written the way we expect scientific papers should be written? A good article for contrast is Melinda C.'s, Beacon Science V1. Contrast the Lizzette Matos paper. HB 28-30. HB 5-16. Eq
- EXTENSION. Reading the NY Science Times, or a Science Brevia article may have it's place today, depending on the class size and how far along we are with knowing everyone's interests. See the ABT manuscript. T, Eq, H

Assessment: Students are meeting with mentors. Students who haven't met should be asked about this.

4 Concept mapping an area of interest.

Guiding Questions:

- How do we discover ideas that are from our knowledge and our interests in science? W, O, H
- What is pseudoscience? R, O
- What are some criteria of science as will apply for senior seminar? R, O, W

Goals:

- To use concept mapping to help 1 or 2 students discover a project, and for other students to experience the generation of a hypothesis. Eq
- To foster a debate about pseudoscience. H, R, O
- To provide students some guidelines about acceptable science (Rutledge's published 9 points, see the ABT manuscript). Eq, R, O

Materials needed:

- Rutledge's 9 points about what we should agree science is (see ABT manuscript).
- Scientific paper for discussion and contrast to the umbrellology article.

- A fore-note: Discuss homeworks as process. Teacher goal: start writing anecdotals.
  Remind students that they can email their mentors if they are having difficulty contacting them.
- START: **Concept maps** are visual representations of each students central area of interest, with branches that explain why the area is of interest, with connections to the hypothesis. Expected results will soon be attached to the concept map. I "spider" a students area of interest and have the class make a few contributions with respect to what is researchable on the whiteboard. H, T, W
- Teacher goal: students with human research proposals need special approval.
- **Umbrellology** lesson and discussion. HB 16. W, R, O
  - Activity: One way to handle the discussion is with a "Popcorn readings approach"; ending with the questions on HB 17 and: Is psychology science?
  - Contrast a scientific paper. Have students walk through the data and consider other potential meanings.
  - Provide students with a copy of Rutledge's 9 points about what science is (see ABT manuscript).

5 The senior seminar literature library. COMPUTERS, PROJECTOR

Guiding questions:

- Where and how can students find scientific literature?
- How are files moved between computers using FTP?
- Can students find a few sources that the instructor improves of?

Goals:

- Students will be able to find articles relevant to their science project.
- Students will be able to use the computers to move files as needed.
- Students will be aware of the materials available list, and begin to consider the materials they will need as a check to ensure that the project is feasible.

Materials needed:

- Begin giving articles that are specific to student interests if the instructor has stumbled across these.
- Science Times (my school receives copies of the NY Times, but Nytimes.com will suffice).

- Students are frequently still searching for ideas—this is directed reading about student interests.
  - Goal is to provide interesting **articles to students**, and have them consider potential projects.

- I have scanned or archived .pdf articles that I keep on a **shared hard-drive** that is networked to any computer in the school. Also, I have scanned a semester of student final papers that students have access to. Because all papers are submitted to **turnitin.com** (see HB 40), we have minimized plagiarism problems.
- **Journal use**, e.g. Science magazine arises. HB 25
  - Show students how to use pubmed.com, google scholar, NY science times, Science News, American Family Physician, Scientific American, and their library cards.
- Explain **use of the computers**, if necessary. If irregularly meeting in the computer lab, show students where the HB in the packet is with respect to FTP. HB 23
- Finding ideas on **drjreid.com**. See ABT manuscript; use http://www.drjreid.com/senior_science_capstone.htm
  - Show students where the **materials available list** is: http://www.drjreid.com/PDF/Student_Materials.pdf

- EXTENSION. Reading the NY Science Times, or a Science Brevia article may have it's place today—depending on the class size and how far along we are with respect to knowing everyone's interests. (See the ABT manuscript stage 1).

6 Solidifying the hypothesis.

Guiding questions:

- What were the hypothesis of other students?
- Has another student had a hypothesis that is similar to each students current hypothesis idea?
- How can students use another student's paper to focus their own writing and ideas?

Goals:

- Students will be able to find a previous student research paper that is relevant to their science project.
- Students will be given advice about their project idea in class.
- Students will be aware of the week 3, week 4 and week 5 homework assignments and deadlines.

CENTRAL GOAL: students will have a hypothesis formed by the end of this week.

"Students, remember--all of your work is a means to the same end—your reading becomes your writing, your homework assignments become your paper and project."

- **Paper check out** lesson—I keep a box of student papers from the year before, and announce titles to the class. Students are given about 20 minutes to look at papers that are of interest to them over.
- Also, I keep a list of previous **student project titles** nearby. I hope to organize these by category this year.
- The last paragraph of the Lizzette **Matos paper** is discussed, and we discuss the merit and soundness of her hypothesis. HB 8
- To close the lesson, students work on their homework assignments. I've found it best to introduce the week 3, 4 and 5 together, now, so that students can work between these. HB 42, 43, 44.

Assessment: teacher feedback to students on the forum or blog after class.

7 Writing the literature review and word splash for project ideas (helps students struggling for an idea):

Guiding questions:

- Does outlining assist the writing of a technical paper?
- Where am I (as a student) with respect to my project idea?
- Can project ideas stem from brainstorming?

Goals:

- Students will identify 5 major areas to write about for their literature reviews.
- Students will post a brief statement about their own progress report on the forum (this could be done on paper).
- Students will help a student brainstorm an idea for a project.

- Activity: **Outlining** the literature review; begin using **HW week 5** (due in the 5th week) HB 44
  - Use HB 24 (an explanation of the literature review format)
  - What 5 central questions (which belong to the 30 questions) are being used to write the literature review?
    - Goal: students can learn to shed less-great questions for the better ones, and saving the others for later.
    - History: students struggle with the writing of the **problem statement**. Ask students individually: why is this issue a problem or important for us to learn about?
- Activity: your **anecdotal**…post on the forum what I (the teacher) should say about the progress of your hypothesis. *Anecdotals are progress reports at Beacon that are given to student, advisor, and parent. They form a record of student progress in all courses. I use this progress report as a formative assessment for my students.*

- Teacher goal: email advisors and mentors if students are struggling with an idea.
- Activity: **Word Splash→**project ideas. With 20 minutes left in class, splash 1 word (e.g. Nutrition), then talk about potential projects. (5 minutes splash, 5 minutes conversation). With 10 minutes left, engender small group conversations with student consulting-scientists: students with similar interests are paired for conversation. All students in the group contribute to the 1st persons need for a project idea.
- Assessment: **Collect** signed mentorship sheets. Teacher goal: feedback ASAP.

8 Literature for the literature review. COMPUTERS, PROJECTOR

Guiding questions:
- What were the hypothesis of other students?
- Has another student had a hypothesis that is similar to my current hypothesis idea?
- How can I use another student's paper to focus my own writing and ideas?

Goals:
- Students will be able to use google scholar to find literature.
- Students will be aware of other journal sources to find literature.
- Students will be aware of the week 3, week 4 and week 5 homework assignments and deadlines.

Student preparation for class:
- Bring sources to class for approval if any have been found.

Materials needed:
- Bring a few books off your classroom shelf to provide to students with respect to their interests.
- Bring a sign-out list so that you'll get your books back. A clipboard for this is a good idea.
- Mentorship sheets and student homeworks to return to students.

- START: Reading the NY Science Times, or a Science *Brevia* article is necessary today. See the ABT manuscript. H
- Activity: project a web search using **google scholar**. Eq,
  - Activity: Give students the remainder of the **class to write** so that students can be talked to individually about the progress of their writing, and to help students derive ideas for them to write about. In the computer lab, I help students complete **HW week 5** (HB 44) and ensure that the 5 content areas that students will be researching to write about are content rich and content appropriate. I do give some suggestions about what they could write about.
  - *Important: limit **Wikipedia** citations to 2 per paper. Students need **10 quality citations**. Two citations must be **original scientific journal articles**. Because much of the literature requires expert knowledge, **review articles** are useful. Some students will search for a book on amazon.com if they are in the market for one. By giving students time to work on these searches while the activity is monitored by the instructor, this is a great way to approve of quality literature.*
  - Explain HB 24 (a re-explanation of the lit review), Walk through an explanation of HB 26 (format and referencing),
  - What 5 central questions (which belong to the 30 questions) are being used to write the literature review?
  - Teacher goal: some students should have begun their experimental research.
  - Assessment: graded homeworks are returned with comments. The mentorship sheet is returned with comments.

9 Prediction of the data sets

Guiding questions:
- Can we "see" our hypothesis by drawing predicted data on the board and on paper?
- How do 2 data-sets tell a story together?
- How can I use another student's paper to focus my own writing and ideas?

Goals:
- Students will be able to find a previous student research paper that is relevant to their science project.
- Students will be given advice about their project idea in class.
- Students will be aware of the week 3, week 4, and week 5 homework assignment rationale and deadlines.

- START: ask a student to volunteer their project idea, and help the student draw anticipated data-sets on the whiteboard. Students in the class will be asked to help. Ask: what is your hypothesis? How will these data appear as results from your experimentation? How long will the research persist (time is often an axis of a graph)?
  - The 2nd data set. Questions to ask:

- To some degree, this is an extended activity of day 4—concept mapping—except the focus is about drawing predicted data sets. By drawing the dataset before the experiment is conducted, students are better able to articulate their hypothesis and experimental plan.
    - Help a student predict their data set, by discussing what the data might look like with the class. By asking a student to help the teacher draw the data on the board, this is a good way to help a student solidify a hypothesis, providing the student is on to something. This active, deliberate engagement with specific students is the nature of the productive science laboratory meeting.
    - Use of the homework to help guide what all students 2 data sets might look like HB 42
    - Show (again) where the **materials available list** is: http://www.drjreid.com/PDF/Student_Materials.pdf .
    - Students should also be aware of HW Week 6, **hypothesis revised** HB 45
    - Any extra class time is for students to write.

Assessment: be aware of the quality and status of each student's project idea.

10 Report Generation.

CENTRAL GOAL: Students have their project experimentation underway by the end of this week.

Guiding questions:

- What were the hypothesis of other students?
- Has another student had a hypothesis that is similar to their current hypothesis idea?
- How can a student use another student's paper to focus their own writing and ideas?

Goals:

- Students must analyze whether they have chosen a suitable project that is appropriate for the time-frame of senior seminar.
- Students will generate a report that is framed around the central question of their project.

Student preparation for class:

- Students should be aware of the days activities before-hand so that they have the activity in mind.

Materials needed:

- I prefer to conduct this activity in the computer lab so that students can type and print their reports by the end of the period.

- Activity: Students are given the hour to do the follow writing exercise, which is given to the instructor for feedback.
- Start: the following 3 questions are placed on the board, for students to respond to using the class forum.
- Board question 1: What is the question that is the crux of your hypothesis?
- Board question 2: What methods will you use to answer your question?
- Board question 3: Where will you obtain the necessary materials?
    - Assessment: I write on the reports after the students print them out (or, hand write them). Then I zerox these reports and attach them behind the students anecdotal (alternatively, I double-side the anecdotals and these reports after I write notes to the students. The resulting book that I can quickly make with the zerox machine is my student reference book for the rest of the semester, and this is a quick crib-sheet for giving students advice about their projects.
    - This activity always takes the students the full hour and leaves me with the opportunity to speak with students about their project ideas. It is important to get to each student during the class.
    - Keep a list of materials that the school should provide for the students.
    - Ensure students know when the literature review is due. [Due day 15].

Assessment: Due: Hypothesis Revised homework. Use/see HB 45. This homework is signed by the mentor before handing this in. Students improve their hypothesis and return to their mentors for returned to their mentors for their signature.

11 Consulting science writing partnerships.

Guiding questions:

- What were the hypothesis of other students?
- How can students productively write and organize their experimental plan with the help of a consulting scientist?
- How can students effectively incorporate the suggestions from their partner and the seminar instructor into their paper?

Goals:

- Students will outline their papers.
- Students will be given the opportunity to discuss their homeworks-in-progress with the instructor.

Student preparation for class:

- Bring sources to class for approval if any have been found.
- Be aware that literature reviews need to be of high quality for the next session, when we peer review.

Materials needed:

- Bring a few books off your classroom shelf to provide to students with respect to their interests.
- Lists of student presentation dates.
- Bring a sign-out list so that you'll get your books back. A clipboard for this is a good idea.
- Mentorship sheets and student homeworks to return to students.

- Students are given time to write their literature reviews, because peer review (when other students look over a peer's literature review) is the next meeting.
- Provide students with their presentation dates, so that they know when they will be presenting.
- Re-explain the need to present, and take questions.
- A good day to model a student's data, if the need is there.

12 Peer review of literature reviews.

Guiding questions:

- What were the hypothesis of other students?
- Has another student had a hypothesis that is similar to my current hypothesis idea?
- How can I use another student's paper to focus my own writing and ideas?

Goals:

- Students will be able to use google scholar to find literature.
- Students will be aware of other journal sources to find literature.
- Students will be aware of the week 3, week 4 and week 5 homework assignments and deadlines.

Student preparation for class:

- Bring sources to class for approval if any have been found.
- Student reminder: final projects require **evidence** with respect to experimental outcomes: these may include photographs, teacher-witnessed data, or another form of evidence that both student and teacher agree upon.

Materials needed:

- Bring a few books off your classroom shelf to provide to students with respect to their interests.
- Bring a sign-out list so that you'll get your books back. A clipboard for this is a good idea.
- Mentorship sheets and student homeworks to return to students.

- During the entire session, students are expected to have brought a very good copy of their literature review for editing by other students. Start: Student partners (frequently consulting scientists, other times friends if the review will be constructive) edit the paper and leave feedback. The use of the web is encouraged for students who have minimal knowledge about what is being written about. It is best to partner students with interests and projects that are as similar as possible.
  - Assessment: Edited copies are checked at the end and throughout the period to note student contributions; these drafts are due for a participation grade when the literature reviews are due.
  - Extension: students struggling with their writing and haven't brought a strong literature review draft are directed to work on their homeworks if these are incomplete; use HB 42-46.

13 Good-data exercises # 1

Guiding questions:

- How do we plan a team experiment (the experiment is ice-core sampling in Antarctica)?
- How do we consider time as a variable with research planning?
- What is standard deviation and error bars?

Goals:

- Students will be able to generate a graph from raw data that is the result of a team-collection endeavor.
- Students will discuss all the interpretations of the graph that they generate, and this analysis will form a foundation for scientific results section and a discussion section.

Materials needed:

- Handbooks, so that pages 31-35 can be used for data analysis and discussion. Handbooks should be assembled with graph paper after handbook page 32.
- White board, multiple-colored markers for students to construct a graph on the board with.
- The good data handout is found both in the Handout (HB 31-35) and the excel guidelines are found on http://drjreid.com/seminar_documents.htm as "The Good Data Handout 1". These handouts are needed for both day 13 and day 14.

- Start: In today's lesson, students will take a trip to Antarctica for ice-core sampling. I ask students to picture themselves in 3 teams within the room, and I arbitrarily designate a captain for each team. However, all 3 teams have the task of working together. Then, I draw a map of Antarctica on the board for our discussion.
  - I use HB 31-32 for the Antarctica explanation.
  - Science content. Concepts addressed in the conversation: An explanation of ice core sampling, a revisitation of the concept of global warming (previously learned about), carbon dating, ice deposition, glacial melting vs. sea-ice melting, and **sampling** [ensues].
  - We discuss how we could collect adequate data on our expedition.
  - Each team Determines how many samples to collect (I remind them of the expense and need for analysis).
    - We agree that students will sample different regions of Antarctica, and collectively we agree on the rational behind sampling at points such as A, B, and C. One point is intended to represent the **Larsen ice shelf**, which rapidly collapsed into the sea. The data is arranged to indicate a more rapid accretion of CO_2 in the ice shelf.
      - Have students read about the ice shelf on Wikipedia for a moment, if the computers are there.
  - All students then plot the data that is on HB 32, on scrap paper within the handbook. [This handout works well, but I plan to make a higher quality one this year].
  - Students also plot these data on the board, using different colors for each location that we agreed upon.
  - We then discuss which data points we "believe". The data is organized so that some averages will have larger **standard deviations**. Students then draw the **error bars**, so that we can discuss range about the mean.
  - Assessment: for participation, students will have drawn their own graphs, and listed their own interpretations, as these compare to the group-constructed graph on the whiteboard.

14 Good-data exercises # 2—excel and graphing *COMPUTERS, PROJECTOR*

CENTRAL GOAL: By the end of this week, all students have given the instructor paper versions of their literature review.

Guiding questions:

- Can students make graphs from data that has been averaged, and with calculated standard deviations, using Microsoft Excel?
- What happens when the standard deviations of an experiment are greater, comparing a similar experiment?
- Does increasing the sample size decrease the effect of an outlier?

Goals:

- Students will be able to independently create graphs using Excel.
- Students will be calculate averages and standard deviations using Excel, and know the meaning of "error about the mean."
- Students will archive their excel files for assistance when graphing their own data.

Student preparation for class:

- Students should consider how their own data will appear when graphically represented.
- 30 questions lists are due today, 15 questions and answers are expected. Answers should each be a few sentences.

Materials needed:

- HB 33-35 ; projector and computer so that the class can simultaneously construct the Excel file in the handbook.

- Students use the HB data to build their own excel graphs in class. Start: I project and model the use of excel, and students produce the same graphs. Then, students can save the file for when they work on their own projects. We go back to this file, which allows us to have a graph to copy and paste into excel, and also for when students are adding their own data to other graph types.
  - The end product are excel graphs that include calculated averages and standard deviations.
  - See HB 33-35 --
- Assessment: ***Midterm—collect 30 questions lists, which should be about ½ complete.*** E, R, O

15 How to assemble the 9 page paper: discovery of life on mars?

Guiding questions:

- What is the shape and format of the final paper, which is the format of a scientific journal?
- What tenses and headings are used in technical writing?
- What organization strategies should students use when writing their final papers?

Goals:

- Students should understand the format of the final paper.
- Students will be able to use an example document to shape their own paper.

Student preparation for class:

- Read HB pagess 36-41 before class.

Materials needed:

- Today's conversation requires a whiteboard, where the instructor can sketch example figures that represent the data shown in an example document.

- Start: Using HB's 36-41, I have students read to the class a paper that describes the discovery of life on Mars.
  - This paper is remarkably parallel to actual Cell and Science papers that have discussed these results, except I am able to culture the microbe on Earth. While I don't believe we have discovered life on Mars yet, http://aem.asm.org/cgi/content/full/68/8/3663 (*Applied and Environmental Microbiology*, August 2002, p. 3663-3672, Vol. 68, No. 8) is a good article for discussing data about life on Mars, and the investment of at least $820 million for the Mars Exploration Rovers. Have students look at this article during the lesson. The article that I've fabricated for our study is written in the senior seminar format, and is how a senior seminar student would report the finding of microbial life on Mars from a Meteorite.
    - Begin by having students read the article see HB 36, with a student reading aloud. Questions to ask after their reading of the **abstract** include: *Can we cite in the abstract? Will the article explain what scanning-electron microscopy is? Does the abstract including findings? Does the abstract include a conclusion or argument?*
      - Questions for the **methods** section include: Does it make sense to separate these procedures, as has been done? Why are some of the materials shown to have been acquired from locations parenthetically shown, while we don't explain where other materials were obtained from? (It isn't necessary to do this for items that are easily or routinely obtained.)
      - Questions for the **results** section include: How are figures included in the writing? Are we able to identify portions of figures within sentences? Does the separation of the major findings using headings make sense? (Remember: in the results, we show and say what we see, but we do not interpret these here.)
      - Questions for the **discussion** include: Can we interject the opinion of the authors in this section? Do we restate our findings from the results? (Yes, we do, but we don't have to fully explain everything we see.)
    - The utility of the Mars Rock document is that it provides a clean outline for students to use with respect to writing quality, referencing, use of headings, and language use (including tense and scope).
    - While I think all storied explanations of "how to write" should be organic, this one works well for me. I think other teachers should write their own story which they can support with knowledge and interest.
    - This is certainly the first explanation of the **discussion**, and what we are looking for here. While it is important to emphasize the components, tense, abbreviations, and language of the **methods** (by asking questions, and having students **label** the document with our joint-discoveries about the writing), it is always hard for me to reach the discussion because we wind up drawing the **figures** and what we would expect to see. This is generally where the students are about now…somewhat unsure about how to utilize both **picture data**, which can be actual data (that has to be appropriately sampled), and **graphical data** that accompanies and finishes telling the story that is described by the picture data.
    - Assessment approaching: Remind students that there will be a peer review of their final paper portions (with some beginning of the discussion having been started) on day 18.

16 Reserve lesson (if time allows): an analysis of a doctoral thesis. *PROJECTOR*

This lesson is specific to my own experiences; another lesson might critique scientific articles instead of using a thesis presentation. Frequently, there is a school-wide field trip that knocks a day out of my lesson planning. This is the day that I jettison when this happens. Another alternative would be to invite a scientist to attend and give a lesson about her laboratory research.

Guiding questions:

- What does a doctoral thesis in science look like?
- How are the components of a doctoral thesis similar to the shape of the final senior seminar paper?
- Why is *Mycobacterium tuberculosis* a public health concern, and what is bacterial pathogenesis?

Goals:

- Students will ask intelligent questions about my doctoral thesis, *The carbohydrate surface of M. tuberculosis: antigencity and antibody immunity*.
- Students will post responses to the presentation on the class forum. Each student should practice asking 3 questions about the presentation.
- To capture student interest in graduate scientific research by showing interesting data and settings; in my case this was the inside of a Biohazard-level 3 laboratory.

Assessment: for participation, 3 high-quality questions about the thesis presentation need to be posted on the forum.

17 ***Learning PowerPoint and the senior seminar PowerPoint template.*** *COMPUTERS, PROJECTOR*

Guiding questions:

- What will each students PowerPoint presentation look like?
- What are the components of a senior seminar presentation?
- What are some helpful communicative aspects of PowerPoint?

Goals:

- Students will create a template for their own PowerPoint presentations.
- Students will be able to use computer keyboard shortcuts when making a presentation.
- Students will understand how the PowerPoint presentation is a rubric in and of itself for their senior projects.

Student preparation for class:

- Bring sources to class for approval if any have been found.

Materials needed:

- Bring a few books off your classroom shelf to provide to students with respect to their interests.
- Bring a sign-out list so that you'll get your books back. A clipboard for this is a good idea.
- Mentorship sheets and student homeworks to return to students.

- Start: Beginning with a new, blank PowerPoint file, I show the basics of the program to the classmembers. They pick it up quickly, about 60% of the students have used PowerPoint before, but very few students know how to use shortcuts (such as Ctrl+S, Ctrl+C, Ctrl+V, Alt+Tab to change programs) or how to move images into PowerPoint. I model these activities and ensure that students are able to do this with their own files. By the end of the period, each student should have assembled nearly the same model PowerPoint file. The file should include a graph, a separate space for the second data set that is usually only anticipated at this point in the class, and all the elements of a final presentation.
  - Some essential points that I include in the model presentation are:
    - What images can you use to teach the class in your introduction? The 10 minute presentation isn't everything you are writing about, just the essentials. [I type these into the file, in various ways, to help the students learn PowerPoint.] In the future studies, I type the question: Here, if you were a professional scientist with resources, and you had obtained your results, what would you do next? Why is the beneficial?
- By having students outline their own presentations, they are able to generate an actual file that they can continue working on, and each student learns what the essential elements of the presentation template are.
- The essential elements are Introduction, Hypothesis, Methods, Evidence, Results (2 data-sets), and Future studies. ***The PowerPoint presentation is an excellent way to provide evidence that experimentation was fairly completed by the student.***

Assessment in progress: the quality of the presentation, like the 30-question list, is a constant assessment measure. Monitoring of the presentation quality, the 30-qustion list quality, and the quality of the paper drafts is an outstanding indicator of the project quality.

18 ***Peer review of final papers***

Guiding questions:

- What is the status of the papers of other students?
- Are students efficiently shaping their papers to be high quality?
- How is the experimental progress of student projects?

Goals:

- Students will be given the day to review each other's work and to write.
- Students will be have explained the status of their research progress to the instructor while students comment on each others papers.

Student preparation for class:

- Bring data to discuss with the instructor. Bring your paper to have peer reviewed, and to continue writing. Bring specific questions to ask the instructor.

Materials needed:

- Class handbook, so that notes can be made on each student's anecdotal report that is a running progress report.

CENTRAL GOAL: All students will have one complete data set in their manuscript.

- Start: Students are given the day to work on their writing, and are expected to produce drafts of their papers, as was done for the literature reviews on day 12.

Assessment: call parents if student's do not have a data set. Email this information to the advisor and the mentor.

19 The MRI talk. *PROJECTOR*

Guiding questions:

- What does a scientific presentation look like?
- How are the components of a medical science presentation similar to the shape of the final senior seminar paper?
- What is MRI, and could this be used to evaluate a problematic pregnancy?

Goals:

- Students will ask intelligent questions about the presentation: *Value of specific MRI features in the evaluation of suspected placental invasion*.
- Students will post responses to the presentation on the class forum. Each student should practice asking 3 questions about the presentation.
- To capture student interest in graduate scientific research by showing interesting data and settings; in this case the research is about a magnetic resonance imaging study.

- Background and start: I was fortunate enough to co-author a paper that is in press (2006) for the journal Magnetic Resonance Imaging. I think it is a good idea for any science teacher to bring in an area of expertise that they find really fascinating, and present the science behind this. My rationale is to show a PowerPoint presentation, explain data, and give an example for how larger projects conducted by scientists look. The learning goal for the students is largely communicative (they become more comfortable with the idea of standing in front of everyone and presenting their science), but I've found that students learn a lot about MRI itself. I use a presentation of the data that was shown at a national medical meeting. Importantly, the students learn a lot about placental invasion and pregnancy.
  - The students who have previously had MRI's have stories to tell, and it is important to draw these out. E.g., why was the machine making that clicking sound? Were you worried about having any metal with you? How does an MRI work?
    - I wind up talking about T1 and T2 weighting, which has subatomic concepts, which they understand. After my students realize where in the atom I am, I don't think they understand the rest. But, I do believe they learn 1) to gesticulate when giving a presentation, 2) to describe graphs completely, 3) the importance of the introduction to understand the talk, and 4) how similar actual scientific presentations are to what they are doing.

Assessment: for participation, 3 high-quality questions about the thesis presentation need to be posted on the forum.

20 Day for working on PowerPoint files. *COMPUTERS*

- The entire day is an open day for students to work on their PowerPoint files.
- Meet with students as needed during the lesson to help with experimental progress and challenges.

Assessment: speak with students individually about their data, especially students who do not have a solid plan for gathering both data sets. Some students may still be struggling with respect to how the 2nd data-set extends the story of the first; try to help students make decisions about how they should collect appropriate and quality data.

21 PowerPoint final day, and presentation tips. *COMPUTERS* ***PROJECTOR***

Guiding Questions:

- What is the status of the student's PowerPoint files?
- What recommendations do we have for our first students who will present next time?
- For students needing guidance: should we schedule a time to meet?
- Which questions in your 30 questions are your best? Can your answers be used in your PowerPoint?

Goals:

- Students will finish their PowerPoint presentations.
- The creation of a graph using Excel will be modeled again, using the projector.
- The status of the 30 question list will be monitored and recommended questions will be given.

Assessment: for participation, 3 high-quality questions about the thesis presentation need to be posted on the forum.
CENTRAL GOAL: All students have made substantial progress on their PowerPoint presentations, which should appear nearly ready for presentation.

- Meet with the students who will be presenting next session (the first students to go)

22 In-class presentations. *PROJECTOR*

- ***During all in-class presentations, students formulate questions about their classmates research.***

- Activity/Assessment: During the in-class presentations, students log 3 questions about each presentation on the forum. The next presenter is allowed to present only when 3 good questions have been asked by the class, by different students. These oral presentations are in addition to the forum questions.
  If computers are not available, use scrap paper that is collected for each student and stapled into a book. Students are able to view the books made by the class later, and the responses are helpful. Make sure to look for nasty remarks, and ensure that all papers or postings have names attached to the authors.
- Presentations are assessed on the spot, using the rubric (HB 39), which is the same rubric the assessor will use during assessment week.
- Assessment: student contributions to other students, especially on the forum or in the books, is graded for participation.

23 ***In-class presentations.*** *PROJECTOR*

- Teacher goal: assessors should now know who they will be assessing by the end of the year. The administration has worked out a good time for senior seminar assessments to take place, with respect to the other classroom and individual assessments in our portfolio school.
- **Presentation culture:** students are fostering their own learning community during these final presentations…students take the stage with respect to helping each other, and presenting to each other means they are teaching each other about their projects. Ensure that the students clearly explain the science that introduces each project, to encourage students asking powerful questions about the scope, sequence, and quality of the student research, and that students have the opportunity to give suggestions for future research. Students who are struggling are frequently substantially helped by other students who have been more fortunate with their own project outcomes.
- Assessment approaching: with any spare time that may remain in a class (4 presentations per hour is the max), have students work on their 30 questions lists, and help students with both these lists and their final papers.

24 ***In-class presentations.*** *PROJECTOR*
25 ***In-class presentations.*** *PROJECTOR*
26 ***In-class presentations.*** *PROJECTOR*
27 ***In-class presentations.*** *PROJECTOR*
28 ***In-class presentations.*** *PROJECTOR*
29 ***In-class presentations.*** *PROJECTOR*

CENTRAL GOAL: All final papers are due. E, R, O (Assessment.)

- Mention the final checklist sheet HB 40 and that students will learn who their assessor is during the last class.

30 ***In-class presentations (reserved day for stragglers and incompletes).*** *PROJECTOR*

- ***Collect 30 questions lists.*** E, R, O

31 ***30 question's day and scheduling of assessors.***

- Assessment. Students learn who their assessors are, and **schedule** their assessment times on sheets that have been approved by each assessor.