Introduction:
Very little has been done at the high school level with our school forest. My schedule has not allowed for lesson planning outside of my core classroom curriculum until this summer. I have developed these lesson plans for my advanced biology students who will have the opportunity to utilize the forest this summer before the school year begins.

The following five lesson plans are set up as five steps for implementing our forest with the following goals:

1) Familiarize the entire school community with our forest.
2) Develop a long term database and plan for our forest.
3) Inspire students to create a research project using the forest.

Step/Lesson #1:
General forest area familiarization and species identification. (Summer)
Forest mapping and species identification (Winter)

Step/Lesson #2:
Forest stand measurements.

Step/Lesson #3:
Corse woody debris and decomposition.

Step/Lesson #4:
Forests, soils, and earthworm ecology

Step/Lesson #5:
Student research project; develop and plan.

After these steps/lessons have been implemented, it is my hope the list below represents some of the achievements that will stand out as exceptional student accomplishments.

- A school forest webpage on the school website.
- A school forest information bulletin board organized in the school.
- A school forest management plan developed to present to the administration.
- Students eligible to apply for a Tree Farm Scholarship.
Lesson 1a: General Forest Area Familiarization and Species Identification. (Summer)

**HSSCE Content Expectations:**

B2.4A Explain that living things can be classified based on structural, embryological, and molecular evidence.

B2.5i Relate cell parts/organelles to their function.

B2.4 B Describe how various organisms have developed different specializations to accomplish a particular function and yet the end result is the same.

B1.1C Conduct scientific investigation using appropriate tools and techniques (e.g., selecting and instrument that measures the desired quantity – length, volume, weight, time interval, temperature – with the appropriate level of precision).

**Materials:**

**Procedure:**

#1) **Student Invitations:**

Students are expecting a non-mandatory project day to be scheduled sometime in August. Students have been receiving assignments via postal service or e-mail based on their summer reading assignment *A Sand County Almanac* by Aldo Leopold. We will find this text extremely useful when working with and learning from our school forest.

Student invitation attached below.

#2) **Welcome:**

Meet as a class at the Viking Sign on the highway. Explain to students our purpose for this meeting. Identify any safety hazards. Field any questions students may have about the school forest.

#3) **Forest Tour:**

Take students on a walking tour around the perimeter of the forest for familiarization. Explain some of the highlights and stand types of the forest along the way.
Identify some of the major species of trees using a summer dichotomous key from the *Michigan Trees* text as an example. Students will collect major specimens for herbarium in the classroom. Depending on the number of students, collect approximately 4 to 5 different flora specimens per student.

#4) Plant Press Project:

Back at the vehicles after the tour; prepare specimens for mounting using a plant press. Species will not be identified until the next classroom meeting. End of the first day.

#5) Mounting Field Specimens:

Students will key the species they collected from the forest. A number of identification keys will be provided.

Students will mount and label specimens for classroom herbarium collection. All materials will be provided including a standardized example for labeling specimen boards.

#6) Make a Dichotomous Key:

Students will collectively compose a dichotomous key for the major specimens currently in the classroom herbarium. This first key will be a working key, modified each time students make new collections in the forest. Eventually, our lab will have a good working key to the flora species in Baraga’s School Forest for both summer and winter seasons. End of second day.

Since this field work was not mandatory, there is no formal assessment for this lesson. It is my hope that the students who participate will find reward in the experience and not in a formal grade.

**Lesson 1b: General Forest Area Familiarization and Species Identification. (Winter)**

#1) Winter Tree Identification:

Students will meet at the forest on a Saturday morning in February.

We will go over the difference between summer and winter dichotomous keys. Students will spend time near there benchmarked study sites identifying trees using twigs and bark characteristics.

Students will collect specimens for herbarium, winter examples.
#2) School Forest Mapping Project:

In cooperation with the technology department, we will snowshoe the perimeter of the forest with GPS Units in order to collect data to display on ArcView GIS technology. Students will also collect GPS Points of their benchmarked study plots (Lesson #2). With this data, students can create an updated map of the forest for display in the project plan, school bulletin board and website.

#3) Mounting Field Specimens:

Students will key the species they collected from the forest. A number of identification keys will be provided.

Students will mount and label specimens for classroom herbarium collection. All materials will be provided including a standardized example for labeling specimen boards.

#6) Make a Dichotomous Key:

Students will collectively compose a winter dichotomous key for the major specimens currently in the classroom herbarium. This first key will be a working key, modified each time students make new collections in the forest. Eventually, our lab will have a good working key to the flora species in Baraga’s School Forest for both summer and winter seasons.
Dear Biology Students,

I hope your summer is well and that you are taking advantage of a well deserved break. I also hope you are looking forward to the upcoming school year as much as I am.

As promised, I am sending you the first of four assignments from the Leopold readings. I expect that you have found this text to be much different than the technical writing found in your science textbooks. I chose this for our summer reading because it is an enjoyable book of nature observations recorded by one of the most famous and beloved naturalists/conversationalist of all time. Aldo Leopold changed the way our country looked at the landscape. He directly influenced policy which managed natural resources, especially forests, in the 1930’s. If you have ever visited the Porcupine Mountain Wilderness Area for example, most acres of old growth forests still remain because of the personal work of Aldo Leopold.

Leopold was not strictly a proponent for preservation. Conservation and sustainable use of natural resources were at the forefront of his land ethic. As you have read, Leopold recorded and struggled with many ethical issues dealing with resource management. For example, he enjoyed woodcock hunting, but did not harvest limits so that “there be no dearth of dancers in the sunset sky”. Conservation and management ideas of Leopold are still in use today.

You may be surprised to find us reading a text written by a “philosopher”. We could just as well study this book in an American English course. The philosopher in Leopold makes his writing enjoyable; but the biologist in us can draw out examples of ecology, genetics and evolution. Our task with these four assignments will to identify examples we learned in general biology. We will begin to describe these examples at the next level.

In addition to these assignments, as a class we will be having a non-mandatory meeting in our school forest on August X. We will also meet in the classroom on August Y. Our purpose will be explained when you arrive. Please see the flyer included in this document for the details. Again, these meetings are non-mandatory; however, I would really like to see most of you there.

I understand that some of you may have disagreed with having to acquire the summer text yourself. I would have felt the same way in high school. However, one of our many tasks is to prepare for college where you will be required to purchase all classroom materials yourself. Not all the resources you will have to buy will be so treasured. If you are going into a biology field, I urge you to keep this book in your personal library to be read again. Everything we do in this course has a strict purpose. Please contact me by e-mail if you have any questions. Thank you for taking this class. I am very much looking forward to working with you again.

Sincerely,

Mr. Johnston
Baraga High School: Summer 2011

Attention: Biology Students

What: Non-mandatory class meeting.

When and Where: Tuesday, August xth, 2011. 5:00 pm to 8:00 pm.
At the school forest, on the highway by the Viking sign.

When and Where: Tuesday, August Yth, 2001. 4:00 pm to 7:00 pm.
Baraga High School Laboratory.

Purpose: Introduction to the School Forest and Project Planning.

You may want to bring the following to the field if it is convenient:
Dress for the weather. We will work in the field in the rain unless there are
thunderstorms and or high wind.

Please contact me if you have any questions. If you can’t make one or any of the
meetings, please don’t worry about it. I understand you may have a lot going on this
summer. This will be one of many trips to the field this year.
Lesson 2: Forest Stand Measurements

HSSCE Content Expectations:

B1.1A Generate new questions that can be investigated in the laboratory or field.

B1.1C Conduct scientific investigation using appropriate tools and techniques (e.g., selecting and instrument that measures the desired quantity – length, volume, weight, time interval, temperature – with the appropriate level of precision).

B1.1D Identify patterns in data and relate them to theoretical models.

B1.2E Evaluate the future career and occupational prospects of science fields.

Materials:
DBH Tapes, 100’ Measuring Tapes, Biltmore Sticks, Wooden Stakes, Flagging, Notebooks, Data Collection Sheets, Calculators, Microsoft Excel,

Procedure:

#1) Collecting Data in the School Forest:

Students have spent one solid day on tree identification. I would like students to add to our herbarium and forest key each time we visit the forest while working on other projects. This lesson will allow all students to collect real world scientific data in the field.

In a classroom setting, ask students how a forester might characterize or describe a forest. Make a collective list of student ideas on the board. Guide students. Make sure the list includes tree species, tree age, height, width/diameter, health, basal coverage, canopy density, understory species, diseases, parasites, wildlife species, insect species, average seasonal temperatures, seasonal length, precipitation levels, snow depths, soils and topography.

On our next forest trip, we will concentrate on tree measurements. We will collect tree measurements in order to characterize or forest. We plan to measure the following data: over story tree species, over story tree density, over story tree height, over story tree diameter, understory tree species, and understory tree density.

#2) Student Journal:

Please compose a one page journal in response to the following prompt:
What features of a forest determine the data we plan to collect?

#3) Instruction on Forest Management: (Classroom)

Our forest includes two main types of stands: a planted red pine stand north of M-35 and a hardwoods stand south of M-35. Advanced biology typically has 20 total students.

Study Sites:

I plan on having 10 groups of 2 students.
I plan on each group being responsible for one over story red pine site north of the highway and one over story hardwoods site south of the highway.
I plan on each group being responsible for one understory red pine site north of the highway and one understory hardwoods site south of the highway.

According to the suggested Forest Measurement Directions from Michigan Technological University Forestry Department:

Red Pine over story sites should be measured for 1/20th of an acre, (26.33’ radius).
Hardwood over story sites should be measured for 1/10th of an acre, (37.24’ radius).
Understory sites should be measured for 1/500th of an acre, (5.26’ radius).

GPS Coordinates will be recorded for each site. Sites will be benchmarked for future data collection. GPS Coordinates can be used to map sites on our school forest mapping project conducted by our Technology Department (future lesson).

Over Story Tree Species Identification:

Once your study sites have been identified, you will begin recording data within your plots. You are responsible for identifying the tree species you are measuring. We will use our current key to the flora of Baraga School’s Forest (student created) to identify the tree species. I will also be roaming with additional tree keys to help you identify the species if you have any questions.

Explain some of the characteristics of the trees we expect to measure:
-red pine, white pine, jack pine, red maple, sugar maple, red oak, white ash, white paper birch, yellow paper birch and aspen.
Over Story Tree Density:

Hand out the data sheets to each student. Identify where the tree species will be recorded. Record data for each tree with a diameter equal to or greater than four inches at breast height. The number of trees in your plot will allow us to calculate tree density.

Over Story Tree Diameter:

We only have a couple dbh tapes and Biltmore sticks. These tools are calibrated to make forestry measurement data collecting efficient.

We will use the equipment we have to collect the data we need, and convert the numbers latter in lab when it is convenient. The supplies I do have for each group include regular measuring tapes and meter sticks. We will convert these numbers in the lab when it is convenient.

Normally, the dbh tape can be used to measure the diameter of a tree at breast height, just make sure you are reading the correct side of the tape. We will use a normal tape measure to record a number. It won’t be correct, but it is a standardized way to collect data and this number can be converted using a dbh tape in the lab. Use PowerPoint Slide from MTU to demonstrate.

A Biltmore stick can also be used to measure tree diameter. Use PowerPoint Slide from MTU to demonstrate.

Over Story Tree Height:

Tree height can be estimated using a Biltmore stick. We must build our own.

Stand exactly 66’ back from the tree and hold the Biltmore stick 25” from your body. Align the bottom of the Biltmore stick with the bottom of the tree and record the number on the Biltmore stick that aligns with the top of the tree. This number will be converted into tree height in the lab.

Understory Tree Species and Understory Tree Density:

For each understory plot, simply identify and count the number of tree less than four inches in diameter. Simply count and tally the number of understory trees in your plot.
#4) Instruction on Forest Management: (Outside)

Take students to a small woodlot close to the school and re-teach the procedures from above. Record mock data. Ensure each student understands how to conduct the plot surveys, understands the data they are to collect, and is comfortable using each tool.

#5) Building Biltmore Sticks:

In the lab, using the two Biltmore sticks I have, students will make their own for field use. Students will take regular meter sticks, tape them up with masking tape, then make new marks matching the Biltmore stick.

#6) Collecting Forest Measurements:

Distribute all equipment and data sheets to each group.

Take students to the forest.

Walk each group to their study sites north of M-35 in the red pine stand. Roam between groups to ensure data is collected well.

Once all students are done, walk each group to their study sites south of M-35 in the hard woods stand. Roam between groups to ensure data is collected well.

Head back to school.

#7) Data Calibration, Entry and Calculations:

In the lab, students will align their diameter measurements up to the two dbh tapes I have and record accurate diameter at breast height data on their data sheets.

In the computer lab, students will download a prepared Excel file with programmed calculations, and enter their data in the file. Files with completed data will be e-mailed back to the instructor and collectively pooled for a long term database. Data will be publically posted on the School Forest Website when completed.

The pooled data from the entire class will be made available for all students to use in their formal lab report.

#7) Assignment:

Students will be assigned a formal lab report. The assignment and grading rubric is attached to this lesson.
Baraga School Forest Measurements Report:

**Directions:** Our lab in the school forest allowed us to collect biological management data that can be used to project the health and sustainability of our forest. This lab report will give you the opportunity to analyze your compiled work and come to some conclusions that characterize our forest.

Please use these directions to format your report.

**Introduction:** At least two paragraphs which introduce our work and our purpose for collecting measurement data in our school forest.

**The Question:** One paragraph which addresses two questions you are attempting to answer. You may come up with your own questions; however, please use the data to support your method of inquiry.

**Hypothesis:** One paragraph devoted to your hypotheses.

**Methods and Materials:** At least three paragraphs describing the procedure and materials you used.

**Data Analysis and Results:** Includes your groups raw data and the classrooms compiled data. Please use the data to construct two different models/graphs to display your data attempting to either support or fail your hypotheses.

**Discussion:**

Does your work support your hypothesis? Please explain.

Compare the school forest north and south of the highway. Use the numbers to compare the red pine stand to the hardwoods stand.

**Conclusion:**

Two or three paragraphs which attempt to summarize your project.

Attempt to surpass the expectations: How does your work project the health and sustainability of our forest?

**Due Date:** This assignment will be due on _______________________________. A copy of the scoring rubric is found on the back of this page. Please come see me if you need any assistance. In addition, you may turn your finished paper in by _______________________________. I will read your work without recording a grade. I will make marks and notes for your final editing effort before the original due date. You can make the corrections and receive a better grade (perhaps 100% if you made all corrections). Please come see me if you need any assistance.
Baraga School Forest Measurements Report

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Additional Comments: Total:
Lesson 3: Coarse Woody Debris and Decomposition

HSSCE Content Expectations:

B1.1A Generate new questions that can be investigated in the laboratory or field.

B1.1 B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and or the dependence on underlying assumptions.

B1.1 E Describe a reason for a given conclusion using evidence from an investigation.

B1.1C Conduct scientific investigation using appropriate tools and techniques (e.g., selecting and instrument that measures the desired quantity – length, volume, weight, time interval, temperature – with the appropriate level of precision).

Materials:
School Forest, meter sticks, winter dichotomous keys, improvised respirometers, Calcium hydroxide, balances, GPS units, data sheets, clip boards and other field equipment

Procedure:

#1) Student Journal:

Students: Please compose a journal entry in response to the following prompt-

*Of what importance ecologically are dead trees?*

#2) Coarse Woody Debris- Instruction:

When trees reach the end of their life cycle, they become dead organic(carbon) biomass.

Depending on how the tree died (disease, old age, wind, lightning, flooding, etc.), the biomass may become a standing snag which produces habitat for many cavity nesting birds, mammals, insects, lichens and other microorganisms. They also produce free standing perches for birds of prey.

Eventually, the snag will accumulate on the forest floor as coarse woody debris.

Coarse woody debris(CWD), like snags, create habitat for other organisms. CWD also plays an important role in the niche of a winter forest as pathways for weasels, fishers,
pine martin and bobcats in deep winter snow. Many carnivore habitat indexes include CWD size and abundance measurements in their calculations.

#3) The Carbon Cycle:

Among the most important organisms ecologically which call CWD a home are the microorganisms (fungi and bacteria) that begin to decompose the organic biomass.

The organic biomass is a long term storage bank for carbon in the biogeochemical carbon cycle. Trees took up carbon from the air in the form of carbon dioxide. Carbon dioxide in converted into glucose sugar used by the tree for food, and stored as structural cellulose.

As microorganisms (decomposers) structurally tear down the dead organic biomass, they in turn release carbon in the form of carbon dioxide through cellular respiration.

The faster CWD decomposes, the more carbon dioxide is released. The amount of carbon dioxide release can be used to indicate the rate of decay.

#4) Coarse Wood Debris Survey:

Surveying our school forest and estimating the amount of CWD could be used to indicate the health of our forest.

Take students to the school forest. Students will tally and measure CWD in their individual study sites.

Students will find the benchmarks that identify their sites. Students will simply tally the amount of fallen CWD and standing snags with a diameter larger than 6 inches.

Students will also measure the amount of 6 meter sticks in each site. For example, if a sample fallen tree was 12 meters long, students will count two sticks. If a log does not make a six meter interval, students will round down. For example, if a sample fallen tree measure 22 feet, students would record three sticks.

Students will record data in both the hardwood and red pine stands.

#5) Building Respirometers and Study Design:

An improvised respirometer can be used to study the amount of CWD decomposition in the forest.
As decomposers break down dead organic matter in a sample of wood, carbon dioxide is released.

The respirometers contain a known amount of solid Calcium hydroxide (CaOH). Calcium hydroxide reacts with Carbon dioxide (CO₂) gas to form solid Calcium carbonate (CaCO₃) and water according to the following balanced equation.

\[ \text{CO}_2 + \text{CaOH} \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \]

Samples within the respirometers could be measured after certain periods of time in order to compare rates of decay among different species of trees.

Students will build improvised respirometers in the lab. Our respirometer will consist of an empty tuna can with the top removed. The bottom of the tuna can is gorilla glued to a heavy 10” x 12” x 2” treated piece of lumber.

A 10 gram sample of Calcium hydroxide will be massed out and put in weighing trays. A power drill with a large circular bit will be used to boar out a disc shaped cavity in CWD. The weighing tray with Calcium hydroxide will be placed in the cavity, and the inverted tuna can will cover the sample site.

Over time, Carbon dioxide released by decomposers will react with Calcium hydroxide to form Calcium carbonate and water. Final masses can be obtained and compared to analyze different rates of decay.

#6) Decomposition Surveys:

Students will locate newly fallen CWD samples of the following species: White Pine, Red Pine, Sugar Maple, Balsam Fur, White Paper Birch, Red Oak and White Ash.

Students will place three respirometers in each identified study logs. A sample will be recovered and massed over a period of three weeks in order to compare decomposition over time.

Data from the respirometers could be compared to look at decomposition rates among different species of trees.

Obviously, there is a lot if error in this study. Different ages of dead trees will decompose at different rates. The respirometers are not air tight. The chemical reaction is not isolated; it occurs in the presence of the environment. Tree species may be difficult to identify. Students can be tasked with improving the design and accuracy of the study.
Going Further- Stoichiometry:

The quantitative amount of Carbon dioxide that reacted with Calcium hydroxide could be measured using stoichiometry.

We know the amount of Calcium hydroxide used because we massed it out. This mass can be converted to moles of Calcium hydroxide.

We know the mass of Calcium carbonate plus H₂O because we massed out our products.

The products could be put in a drying oven to remove the water. The initial mass of the product minus the final mass of the product would give us the mass of water lost. We now have the mass of our individual products which can be converted to moles.

Using the mole ratio derived from the balanced chemical equation, we can calculate the moles of Carbon dioxide that reacted. Moles of carbon dioxide can be converted to mass in grams.

Going Further- Study Improvement:

Students could be tasked with building a better respirometer.
Lesson 4: Forests, Soils, and Earthworm Ecology

HSSCE Content Expectations:

B1.1A Generate new questions that can be investigated in the laboratory or field.

B1.1C Conduct scientific investigation using appropriate tools and techniques (e.g., selecting and instrument that measures the desired quantity – length, volume, weight, time interval, temperature – with the appropriate level of precision).

B1.1D Identify patterns in data and relate them to theoretical models.

B1.2E Evaluate the future career and occupational prospects of science fields.

Materials:

Procedure:

#1) Leopold Reading:

Before this classroom instruction, have students read Aldo Leopold’s Land Ethic in A Sand County Almanac on pages 201-226.

In your Student Composition notebooks, please compose a one page journal entry in response to the following prompt:

According to Leopold, how is land, such as a school forest, valued?

#2) Forests: More Than Just Trees:

List all of the biotic factors you can think of in our school forest.
(ensure students list earthworms)

List all of the abiotic factors you can think of in our school forest.
(ensure students list soil)

Our purpose in this lesson is to identify that our forest is much more than just the trees and the mammals and birds we see. Our forest is a biological community.
#3) Soils:

Soils that make up a forest are not often thought about. But the type and health of soils, in combination with climate are the ultimate factors that determine the type of species present in a forest.

What do you think of when you think of soils? (Compose a list of student ideas on the board)

How do you think soils are formed?
How do you think the soils around here are formed? (Compose a list of student ideas on the board)

When we think of soils, we have to think in terms of geological time.

Soils in the Upper Peninsula are around 8,000 to 10,000 years old.
Soils in the Lower Peninsula are around 15,000 to 30,000 years old.
What do you think are reason is for this? Determine a possible explanation for the differences in age.

The best explanation includes glaciation. The soils of the lower peninsula have been exposed for many more years. The entire upper peninsula was under water 11,000 years ago.

#4) Horizons:

Ask students how soils are formed. Show students a picture of soil horizons. What factors may form these layers or horizons? (List student responses on the board)

Five soil forming factors are:
Climate
Organisms
Topography
Parent Material
Time

Explain examples of each.

The different horizons are as follows:
O: Organic horizon
E
B
C
Discuss the 5 forming factors and how they contribute to each of the horizons.

#5) Forest Pits:

Ask students the following question:
How would soil horizons differ in the red pine and hardwood stands?

Take students out to the school forest and dig two soil pits. One in the red pine stand and the other in the hardwood stands. Compare pits in both stands.

#6) Earthworm Extraction:

Show students how to extract earthworms near both pits with mustard powder mix. Where there more earthworms in the red pine or hardwood stand?

#7) Bottle Biology:

Collect litter from the two different stands. Store in a two litter bottle and keep moist.

Add an equal amount of earthworms to each bottle.

Make observations and measurements.

#8) Journal Entry:

Think of and list ten good questions that you developed studying soils.

Pick one question out of the ten.

Develop a hypothesis for the question.

How could you design a study to discover answers to test the hypothesis.
Lesson 5: Using Inquiry to Learn About our Forest

HSSCE Content Expectations:

B1.1A Generate new questions that can be investigated in the laboratory or field.

B1.1 B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and or the dependence on underlying assumptions.

B1.1 E Describe a reason for a given conclusion using evidence from an investigation.

B1.1C Conduct scientific investigation using appropriate tools and techniques (e.g., selecting and instrument that measures the desired quantity – length, volume, weight, time interval, temperature – with the appropriate level of precision).

Materials:
School Forest, Guided Inquiry Worksheet, Student Journals

Procedure:

#1) Introduction:

I drove past our school forest this summer, about two miles past the Sportsman’s Club when I saw a small black bear cross the road at dusk. This wasn’t the only bear I’ve seen this summer, but you don’t see them every day. Since I was so close to our school forest, I ask a simple question: do black bears frequent our forest? Rather, is our forest good black bear habitat?

Then we can ask more questions. Is our forest good whitetail deer habitat? Is our forest good fisher habitat? Are there any species of birds that our forest provides unique habitat for? Ultimately, what kind of wildlife call our forest a home?

How would a scientist go about answering this question? The Scientific Method.

This is a typical answer, especially in a general science classroom. However, we are in advanced biology, thus- the process by which we answer questions takes on a more complex process than -(ask a question, develop a hypothesis, design a method for answering the question, analyze the data and come up with a conclusion).
#2) Inquiry:

One of our basic skills as scientists is to ask good questions about the world around us and develop systematic ways of finding answers. This is inquiry—a search for information and explanation, often focusing on specific questions. Today, inquiry drives good science.

Before, using the scientific method was a rigid discipline. However, using inquiry methods allows scientists to conduct science more flexibly. Science shouldn’t be step #1, step #2, followed by step #3. The scientific methods we use with inquiry methods allow scientists to strive to understand nature in new ways. You will find, in your science careers, you will start a project asking a particular question, only to end up asking and answering different questions.

#3) Types of Scientific Inquiry:

Biologists use two types of scientific inquiry: discovery science and hypothesis-based science.

Discovery science is mostly about describing nature.

Hypothesis-based science is mostly about explaining nature.

#4) Discovery Science:

Discovery science, sometimes called descriptive science, describes natural structures and processes as accurately as possible through careful observation and analysis of data.

Observation is the use of the senses to gather information, either directly or indirectly with the help of tools such as a microscope that extend our senses.

Recorded observations are data. There are two main types of data, qualitative and quantitative data.

Qualitative data is descriptive verses numerical. An organism’s behavior would be an example of qualitative data.

Quantitative data is typically recorded as measurements (recorded numbers that are analyzed and organized into charts and graphs).
Discovery science can lead to important conclusions based on logic called induction, or inductive reasoning. Through induction, scientists come to generalizations from a large number of specific observations. “All organisms are made up of cells” is an example.

#5) Hypothesis-based Science:

Discovery science leads to inductions, or generalizations. Hypothesis based science seeks to explain what causes the observation. In science, such inquiry usually involves the proposing and testing of hypothetical explanations (the hypothesis).

A hypothesis is a tentative answer to a well framed question, rather an explanation on trial. A scientific hypothesis leads to predictions that can be tested by making additional observations or by performing experiments.

A type of logic called deduction is built into hypothesis-based science. Deduction contrasts with induction.

In deductive reasoning, our thought process flows in the opposite direction- from the generalization to the specific.

In hypothesis based science, deductions usually take the form of predictions of experimental or observational results that will be found if a particular hypothesis is correct.

Scientists then test the hypothesis by carrying out the experiments or observation to see whether or not the results are as predicted. This deductive testing takes the form of “If…then” logic.

#6) Characteristics of a Hypothesis:

A hypothesis must be testable.
A hypothesis must be falsifiable.

A hypothesis attempts to explain a generalization not by proving that it is correct, rather by not eliminating it through falsification.

No amount of experimental testing can prove a hypothesis beyond a shadow of doubt, because it is impossible to test all alternative hypothesis.

A hypothesis gains credibility by surviving attempts to falsify it while testing eliminates (falsifies) alternative hypothesis.
#7) A Visit to the School Forest:

Take students out to the school forest. Go on a walking tour. Make general observations. Ask students to make observations to record in their notebooks. Develop at least one good scientific observation using induction.

#8) Using Inquiry- Discovery and Hypothesis-Based Science:

Use the Guided Inquiry Worksheet attached to this lesson to develop a scientific project that could be used to test a hypothesis.
Inquiry in the Baraga School Forest

Advanced Biology

Name:_______________________

Date:_______________________

Directions: Please follow the guided worksheet to develop a flexible plan for developing an inquiry project in our forest. Please keep in mind that this worksheet is simply a framework for doing good science. There are no one “right” answer.

Discovery Science-
What is discovery science? How is it different from hypothesis-based science?

What is an induction?

What was one good observation, induction or generalization you made during your time in the school forest today?

Hypothesis-Based Science-
Explain the purpose of a hypothesis. (The question asks for the purpose, not definition. Please respond with an answer different than “the hypothesis is an educated guess”.)

Please develop a hypothesis which attempts to explain the cause of your induction.

Can you develop one or more alternative hypothesis which could attempt to explain the cause of your induction?

What is deductive reasoning? What is the scientific relationship between the hypothesis and deductive reasoning?

Develop an outline which details a plan that could be used to test your original hypothesis. Please include equipment you would need and the type of data (qualitative and quantitative) you would plan to collect.