Introduction to Laying the Foundation through Experimental Design
## Periodic Table of the Elements

<table>
<thead>
<tr>
<th>1</th>
<th>H</th>
<th>1.0079</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>He</td>
<td>4.0026</td>
</tr>
<tr>
<td>3</td>
<td>Li</td>
<td>6.941</td>
</tr>
<tr>
<td>4</td>
<td>Be</td>
<td>9.012</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>10.811</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>12.011</td>
</tr>
<tr>
<td>7</td>
<td>N</td>
<td>14.007</td>
</tr>
<tr>
<td>8</td>
<td>O</td>
<td>16.00</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>19.00</td>
</tr>
<tr>
<td>10</td>
<td>Ne</td>
<td>20.179</td>
</tr>
<tr>
<td>11</td>
<td>Na</td>
<td>22.99</td>
</tr>
<tr>
<td>12</td>
<td>Mg</td>
<td>24.30</td>
</tr>
<tr>
<td>13</td>
<td>Al</td>
<td>26.98</td>
</tr>
<tr>
<td>14</td>
<td>Si</td>
<td>28.09</td>
</tr>
<tr>
<td>15</td>
<td>P</td>
<td>30.974</td>
</tr>
<tr>
<td>16</td>
<td>S</td>
<td>32.06</td>
</tr>
<tr>
<td>17</td>
<td>Cl</td>
<td>35.45</td>
</tr>
<tr>
<td>18</td>
<td>Ar</td>
<td>39.948</td>
</tr>
<tr>
<td>19</td>
<td>K</td>
<td>39.10</td>
</tr>
<tr>
<td>20</td>
<td>Ca</td>
<td>40.08</td>
</tr>
<tr>
<td>21</td>
<td>Sc</td>
<td>44.96</td>
</tr>
<tr>
<td>22</td>
<td>Ti</td>
<td>47.90</td>
</tr>
<tr>
<td>23</td>
<td>V</td>
<td>50.94</td>
</tr>
<tr>
<td>24</td>
<td>Cr</td>
<td>52.00</td>
</tr>
<tr>
<td>25</td>
<td>Mn</td>
<td>54.938</td>
</tr>
<tr>
<td>26</td>
<td>Fe</td>
<td>55.85</td>
</tr>
<tr>
<td>27</td>
<td>Co</td>
<td>58.93</td>
</tr>
<tr>
<td>28</td>
<td>Ni</td>
<td>58.69</td>
</tr>
<tr>
<td>29</td>
<td>Cu</td>
<td>63.55</td>
</tr>
<tr>
<td>30</td>
<td>Zn</td>
<td>65.39</td>
</tr>
<tr>
<td>31</td>
<td>Ga</td>
<td>69.72</td>
</tr>
<tr>
<td>32</td>
<td>Ge</td>
<td>72.59</td>
</tr>
<tr>
<td>33</td>
<td>As</td>
<td>74.92</td>
</tr>
<tr>
<td>34</td>
<td>Se</td>
<td>78.96</td>
</tr>
<tr>
<td>35</td>
<td>Br</td>
<td>80.90</td>
</tr>
<tr>
<td>36</td>
<td>Kr</td>
<td>83.80</td>
</tr>
<tr>
<td>37</td>
<td>Rb</td>
<td>85.47</td>
</tr>
<tr>
<td>38</td>
<td>Sr</td>
<td>87.62</td>
</tr>
<tr>
<td>39</td>
<td>Y</td>
<td>88.91</td>
</tr>
<tr>
<td>40</td>
<td>Zr</td>
<td>91.22</td>
</tr>
<tr>
<td>41</td>
<td>Nb</td>
<td>92.91</td>
</tr>
<tr>
<td>42</td>
<td>Mo</td>
<td>92.91</td>
</tr>
<tr>
<td>43</td>
<td>Tc</td>
<td>92.91</td>
</tr>
<tr>
<td>44</td>
<td>Ru</td>
<td>101.1</td>
</tr>
<tr>
<td>45</td>
<td>Rh</td>
<td>102.91</td>
</tr>
<tr>
<td>46</td>
<td>Pd</td>
<td>106.42</td>
</tr>
<tr>
<td>47</td>
<td>Ag</td>
<td>107.87</td>
</tr>
<tr>
<td>48</td>
<td>Cd</td>
<td>112.41</td>
</tr>
<tr>
<td>49</td>
<td>In</td>
<td>114.82</td>
</tr>
<tr>
<td>50</td>
<td>Sn</td>
<td>118.71</td>
</tr>
<tr>
<td>51</td>
<td>Sb</td>
<td>121.75</td>
</tr>
<tr>
<td>52</td>
<td>Te</td>
<td>127.60</td>
</tr>
<tr>
<td>53</td>
<td>I</td>
<td>126.91</td>
</tr>
<tr>
<td>54</td>
<td>Xe</td>
<td>131.32</td>
</tr>
<tr>
<td>55</td>
<td>Cs</td>
<td>132.91</td>
</tr>
<tr>
<td>56</td>
<td>Ba</td>
<td>137.33</td>
</tr>
<tr>
<td>57</td>
<td>*La</td>
<td>138.91</td>
</tr>
<tr>
<td>58</td>
<td>*La</td>
<td>178.49</td>
</tr>
<tr>
<td>59</td>
<td>Pr</td>
<td>140.91</td>
</tr>
<tr>
<td>60</td>
<td>Nd</td>
<td>144.24</td>
</tr>
<tr>
<td>61</td>
<td>Pm</td>
<td>145.00</td>
</tr>
<tr>
<td>62</td>
<td>Sm</td>
<td>150.41</td>
</tr>
<tr>
<td>63</td>
<td>Eu</td>
<td>151.96</td>
</tr>
<tr>
<td>64</td>
<td>Gd</td>
<td>157.25</td>
</tr>
<tr>
<td>65</td>
<td>Tb</td>
<td>158.93</td>
</tr>
<tr>
<td>66</td>
<td>Dy</td>
<td>162.50</td>
</tr>
<tr>
<td>67</td>
<td>Ho</td>
<td>164.93</td>
</tr>
<tr>
<td>68</td>
<td>Er</td>
<td>167.25</td>
</tr>
<tr>
<td>69</td>
<td>Tm</td>
<td>168.93</td>
</tr>
<tr>
<td>70</td>
<td>Yb</td>
<td>173.04</td>
</tr>
<tr>
<td>71</td>
<td>Lu</td>
<td>174.97</td>
</tr>
<tr>
<td>72</td>
<td>Th</td>
<td>226.02</td>
</tr>
<tr>
<td>73</td>
<td>Ra</td>
<td>227.03</td>
</tr>
<tr>
<td>74</td>
<td>U</td>
<td>238.03</td>
</tr>
<tr>
<td>75</td>
<td>Np</td>
<td>237.05</td>
</tr>
<tr>
<td>76</td>
<td>Pu</td>
<td>239.05</td>
</tr>
<tr>
<td>77</td>
<td>Am</td>
<td>243.05</td>
</tr>
<tr>
<td>78</td>
<td>Cm</td>
<td>247.05</td>
</tr>
<tr>
<td>79</td>
<td>Bk</td>
<td>247.05</td>
</tr>
<tr>
<td>80</td>
<td>Cf</td>
<td>251.05</td>
</tr>
<tr>
<td>81</td>
<td>Es</td>
<td>252.05</td>
</tr>
<tr>
<td>82</td>
<td>Fm</td>
<td>257.05</td>
</tr>
<tr>
<td>83</td>
<td>Md</td>
<td>258.05</td>
</tr>
<tr>
<td>84</td>
<td>No</td>
<td>259.05</td>
</tr>
<tr>
<td>85</td>
<td>Lr</td>
<td>260.05</td>
</tr>
</tbody>
</table>

### Lanthanide Series:

| 58 | Ce  | 140.12 |
| 59 | Pr  | 140.91 |
| 60 | Nd  | 144.24 |
| 61 | Pm  | 145.00 |
| 62 | Sm  | 150.41 |
| 63 | Eu  | 151.96 |
| 64 | Gd  | 157.25 |
| 65 | Tb  | 158.93 |
| 66 | Dy  | 162.50 |
| 67 | Ho  | 164.93 |
| 68 | Er  | 167.25 |
| 69 | Tm  | 168.93 |
| 70 | Yb  | 173.04 |
| 71 | Lu  | 174.97 |

### Actinide Series:

| 90 | Th  | 232.04 |
| 91 | Pa  | 231.04 |
| 92 | U   | 238.03 |
| 93 | Np  | 237.05 |
| 94 | Pu  | (244)  |
| 95 | Am  | (243)  |
| 96 | Cm  | (247)  |
| 97 | Bk  | (247)  |
| 98 | Cf  | (251)  |
| 99 | Es  | (252)  |
| 100| Fm  | (257)  |
| 101| Md  | (258)  |
| 102| No  | (259)  |
| 103| Lr  | (260)  |
Science

Module 1
Introduction to Laying the Foundation through Experimental Design
Introduction to Laying the Foundation through Experimental Design

Welcome! .................................. iii
LTF Belief Statement .................... iv
Learner Outcomes ........................ v
Tour of the Website ....................... 1
Barbie® Doll Bungee Jumping .......... 3
Strategies in the Classroom .......... 12
Green Beans, The Wonderful Fruit ... 13
Strategies in the Classroom .......... 25
The Pendulum Swings ............... 26
Strategies in the Classroom .......... 37
Airbags .................................. 38
Chemistry Review ....................... 40
Strategies in the Classroom .......... 47
Can Mosquitoes Transmit Hepatitis? .. 48
Acknowledgements ...................... 64
Process Skills Progression Chart .... 65
Appendix
Module Descriptions ..................... A1
Laying the Foundation Website .... A9
LTF Online Forum for All Educators A10
Consent and Release Agreement ... A11

Copyright © 2012 Laying the Foundation®, Inc., Dallas, Texas. All rights reserved. Visit us online at www.ltftraining.org.
Welcome!

On behalf of the Science Team, we want to welcome you to your first day of LTF training. It is our goal to provide you with an experience that exceeds your expectations and impacts your teaching for the betterment of students.

Over the course of this twelve-day training program, you will have the opportunity to participate in rich discussions with other science colleagues about the strategies, methods, and materials that can be employed in your classroom to increase student achievement and produce scientifically literate students. In addition to meaningful discourse, you will also have the opportunity to participate in hands-on activities that have been chosen to model rigorous and relevant instruction in your science classroom.

We believe that careful and strategic scaffolding of both content and process skills is at the heart of a successful academic science program. Building successful students starts in the middle grades and progresses throughout the high school years. In this first day of training, our intention is to give you a glimpse of this progression through the lens of experimental design.

Today you will participate in a series of activities designed to show how students can progress from designing a simple experiment to analyzing data and deriving mathematical models. The activities you perform today will not all be relevant to your particular classroom topics—those will be addressed in subsequent modules. You may even be asked to think outside of your content comfort zone today; that is our intent. We want you to put yourself in the student’s shoes and go on a fast-paced ride from 6th grade science to high school physics.

During today’s training, ask yourself these questions:

• What science process skills are being addressed in this lesson?
• How do the skills needed for this lesson reinforce and extend the skills from previous lessons?
• How have the instructional strategies modeled by the trainer enhanced the learning experience?

In Module 2 through Module 12, you can expect to take a closer look at content and activities that will enhance your particular science course. Our training has been carefully planned to give you an opportunity to both observe masterful teachers in action as well as provide useable, classroom-ready activities that can be easily incorporated into your curriculum.

We encourage you to visit us online at www.ltftraining.org and explore the lessons and assessment tools that we offer. There you will find valuable resources that can push your students to go further, explore deeper, master problem solving skills, and become more scientifically literate adults ready for college coursework.

Have a great training day, and please let us know if we can be of assistance.

The LTF Science Team
LTF Belief Statement

Accomplished, dynamic teachers are knowledgeable in their content and confident in their abilities to prepare students for higher education. They create classrooms in which students:

• Engage intellectually to develop conceptual understanding
• Generate their own ideas, questions, and propositions
• Interact collegially with one another to solve problems
• Employ appropriate resources for inquiry-based learning

LTF’s teacher training program offers meaningful support to teachers as they construct these effective classrooms. Through tested content materials and research-based instructional strategies, LTF enables and encourages them to:

• Choose significant and worthwhile content and connect it to other knowledge
• Use appropriate questioning strategies to develop conceptual understanding
• Clarify to students the importance of abstract concepts and “big questions”
• Use formative assessments to improve instruction and achieve higher goals
• Guarantee equitable access for all students to information and achievement
Introduction to Laying the Foundation through Experimental Design

Description

This is the first module of any science training series, and is presented to a mixed audience of middle school and high school teachers. It explores the resources available through LTF and emphasizes the philosophies and strategies we employ.

Participants will develop the concept of experimental design by performing selected activities from the biology, chemistry, physics, and middle grades courses.

Learner Outcomes

The participants will:

- Demonstrate an understanding of the LTF philosophy
- Perform relevant labs and activities, and participate with in-depth discussions that illustrate and promote rigor in the science classroom
- Analyze the objectives of the AP exam
- Demonstrate an understanding of the science process skills and how they relate to classroom activities
Introduction to Laying the Foundation through Experimental Design

Lessons and Assessments
Tour of the Website
Places I Would Like to Revisit

Public Area (Home)

Secure Area

My LTF

Lessons & Overviews

Assessments

Additional Materials & Resources
What Is Pre-AP?

Pre-AP is…

Pre-AP differs from regular classes…

Pre-AP is not…

*Advanced Placement and AP are registered trademarks of the College Entrance Examination Board. The College Board was not involved in the production of this product.*
Barbie® Doll Bungee Jumping
Graphing and Extrapolating Data

About this Lesson

Through this activity, students will gain an appreciation for simulations and the beauty of mathematics in science by determining the relationship between the number of rubber bands and the jump height that will allow a safe bungee jump for Barbie®.

This lesson is included in the LTF Module 1.

Objectives

Students will:

• Work in teams to gather and graph data, generate a manual fit line, and an equation for their line
• Students will practice making predictions from a linear equation and will test those predictions

Level

Middle Grades: Nature of Science

Common Core State Standards for Science Content

LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, A Framework for K–12 Science Education, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>(LITERACY)</td>
<td>Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>RST.9-10.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(MATH)</td>
<td>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>A-CED.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(MATH)</td>
<td>Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>A-CED.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Teacher Overview – Barbie® Doll Bungee Jumping**

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MATH) S-ID.6a</td>
<td>Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) S-ID.7</td>
<td>Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(LITERACY) RST.9-10.9</td>
<td>Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem.</td>
<td>Apply</td>
<td>II</td>
</tr>
</tbody>
</table>

**Connections to AP**


*Advanced Placement and AP are registered trademarks of the College Entrance Examination Board. The College Board was not involved in the production of this product.*

**Materials and Resources**

*Each lab group will need the following:*
- meter stick
- Barbie® doll
- rubber bands

**Assessments**

The following types of formative assessments are embedded in this lesson:
- Visual assessment of measuring techniques used within the lesson
- Visual assessment of Barbie® bungee jumping

The following assessments are located on the LTF website:
- 2005 6th Grade Posttest, Free Response Question 1
- 2007 7th Grade Posttest, Free Response Question 1
- 2011 8th Grade Posttest, Free Response Question 1
Teaching Suggestions

The task of this activity is to determine the relationship between the number of rubber bands and the jump height that will result in a safe yet thrilling jump for Barbie®. The doll must be allowed to come as close to the floor as possible without sustaining any “injuries.” You can ask students to bring in their own dolls or action figures. Each group works with just one doll.

Students should make at least three trials when dropping their doll from each height and then use the average. Instruct students to test-drop several times to practice taking readings. Students will need to plot their data and develop a mathematical equation to extrapolate and predict how many rubber bands will be required for their next jump. Refer to the Foundation Lesson, “Graphing Skills,” for assistance with graphing.

Consider dropping Barbie® from a balcony, stadium bleacher, gym bleacher, or band director’s platform. Do not tell the students where the test jump will be made, only its height. You may want to vary the location from period to period to foil cheating attempts. This is especially important if you will be performing the jump on a subsequent day.

The athletic staff usually has a very long tape measure that will simplify the measuring task. If a long tape measure is not available, use a long string with a small amount of weight tied to the end. Lower the string to the ground until the weight just touches, mark the length on the string, and then use a meter stick to measure the string.

An extension of this activity would be to give students the heights in feet and inches so they must apply dimensional analysis to successfully convert the given height to meters. Refer students to the Foundation Lesson, “Numbers in Science,” for help with dimensional analysis.

Buy plenty of rubber bands. Two-pound boxes from an office supply store work well.

Be aware that after several uses the rubber bands will permanently deform or stretch, and this may affect the accuracy of the prediction. Let students discover and cope with this complication in any reasonable way. Some of them may consider pre-stretching the rubber bands, or replacing the old rubber bands with new ones frequently, or replacing the old rubber bands for the final test jump only.
The stretch of a rubber band is dramatically different from the stretch of a spring. A spring is elastic—it obeys Hooke’s law, and it stretches and unstretches the same way. Instead, a rubber band shows hysteresis—it unstretches very differently than it stretches, and it certainly does not follow Hooke’s law (see Figure A). Rubber bands are not elastic.

![Figure A. Rubber band stretch](image)

For further information about the behavior of rubber bands, there is an extensive lesson in the physics activities named “Hysteresis” that studies this behavior of materials and includes a change in temperature as they change shape.

Although rubber bands are not truly elastic and do not have a definite spring constant or “stretch constant” as used in this lab, this activity serves a useful purpose in developing data gathering, graphing, inquiry, and data analysis skills.

**Acknowledgements**

All references to Barbie imply the Barbie® doll or action figure. BARBIE is a registered trademark used with permission from Mattel, Inc. © 2008 Mattel, Inc. All Rights Reserved.
Barbie® Doll Bungee Jumping
Graphing and Extrapolating Data

Team members have been hired to work for the Psycho Entertainment Company. This company provides rock climbing, sky diving, extreme skateboarding, and hang gliding adventures to the public. The current market research indicates that the company should add bungee jumping to its list of entertainment services.

As part of the preliminary research, the management assigned teams the task of working out the details of the jump that will ensure a safe yet thrilling experience. The company has several sites planned for bungee jumping and each site is at a different height.

Purpose

To ensure a safe and thrilling jump, you will determine the relationship between the jump height and the number of rubber bands used to make the bungee cord. You must allow your doll to come as close to the floor as possible without sustaining any “injuries” or “fatalities.”

Materials

Each lab group will need the following:

- meter stick
- Barbie® doll
- rubber bands

SAFETY ALERT!

» Use extreme caution during the “jumps.”
» Wear safety goggles throughout this activity.
Student Activity – Barbie® Doll Bungee Jumping

Procedure

1. Use one rubber band to secure the doll’s ankles together and to serve as a point of attachment for the bungee cord. Use a small rubber band to tie back the doll’s hair if it is not already in a ponytail.

2. Construct a bungee cord composed of 2 rubber bands and attach it to the band on the doll’s ankles. The doll should fall freely from a standing position, plunging head-first throughout this activity.

3. Test drop the doll several times to practice taking readings. Repeat this jump two more times, for a total of three trials.

4. Create a data table to record the trials, the number of rubber bands in the bungee cord, and the drop distance. Remember that you will be adding up to a total of 6 rubber bands, and that you will need to record an average maximum drop distance.

5. Add a rubber band to your attached bungee cord. Drop your doll three times using the new cord, and record the data.

6. Repeat Step 5 until you have used a total of 6 rubber bands. Additional trials may be performed if time permits. You may have to devise a way to take measurements that are longer than 1.0 meter.

7. Calculate the averages and record them in your data table.

8. Use the space provided to construct a graph of the average drop distance versus the number of rubber bands. Use a straight edge to draw a line in such a way that an equal number of points lie above and below the line of manual fit.

9. Develop an equation for this line in \( y = mx + b \) format and record it on your data sheet. Remember that to calculate the slope of the line, use the equation

\[
\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}
\]

The y-intercept \((b)\) can be found by extending this line backward until it crosses the y-axis.

10. Use your equation to predict how many rubber bands will be needed for the doll to perform a safe yet thrilling jump from the height of the location that your teacher specifies. Your teacher will set the boundaries for both the doll’s safety and her “thrill factor.”

11. Create a bungee cord based on the number of rubber bands you predicted in Step 10, and attach it to the doll. When directed by your teacher, proceed to the drop zone and test your prediction.
Data and Observations

Data Table

Graph
Conclusion Questions

1. Write the equation for the line you developed on your graph.

2. What is the significance of the $y$-intercept in your equation?

3. What is the significance of the slope?

4. Use your equation to predict how many of your rubber bands would be needed to allow Barbie® a successful yet thrilling jump from a height of 100.0 feet. Show all calculations in the space provided.
5. Barbie’s® boyfriend wants to bungee jump and have some fun, too. Barbie® loans her bungee cord to her boyfriend but warns that this may not be a safe plan. Why may it be a bad idea for anyone else to use Barbie’s® bungee cord?

6. A student determines that 300 rubber bands are necessary to allow Barbie® a successful and thrilling jump from a height of 30 meters. He then decides to accessorize Barbie® by attaching a heavy-duty scuba outfit to the doll. The scuba outfit includes flippers, goggles, and an air tank that combined weigh roughly half of Barbie’s® original weight. How will this additional weight affect his prediction of 300 rubber bands? Justify your answer.
Barbie® Doll Bungee Jumping

Strategies in the Classroom

1. How does this activity support investigative and problem-based approaches to learning?

2. What concepts were emphasized in this activity?

3. What additional skills can students review within the context of this activity?

4. What higher-order thinking skills are necessary to complete this activity?

5. What other questions could you ask that would increase the rigor of this activity?

6. Would there be any benefit to have students manually graph their data in addition to using a graphing calculator?
Green Beans, The Wonderful Fruit
Using Scientific Measurement

About this Lesson
This inquiry-based activity provides students with the opportunity to make independent choices as they collect data, and is an excellent introductory activity to the biology lab and equipment. This lesson is included in the LTF Module 1.

Objectives
Students will:
• Select appropriate tools, make metric measurements, and confirm variation within a sample of plant seed pods
• Design their own data table to record data and generate appropriate graphs
• Use two different pod samples to determine averages for pod length, pod mass and pod volume and compare their sample averages to class averages

Level
Biology

Common Core State Standards for Science Content
LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, A Framework for K–12 Science Education, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>(LITERACY) RST.9-10.3</td>
<td>Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) A-CED.2</td>
<td>Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.</td>
<td>Apply</td>
<td>II</td>
</tr>
</tbody>
</table>
Connections to AP*

AP Biology: This lesson addresses concepts contained in Big Idea 1 and 4 in the revised AP Biology curriculum under the following sections: 1.A.2.d and 4.C.2.a.

*Advanced Placement and AP are registered trademarks of the College Entrance Examination Board. The College Board was not involved in the production of this product.

Materials and Resources

Each lab group will need the following:

- balance
- beaker, 250 mL
- beaker, 600 mL
- calculator
- graduated cylinder, 100 mL
- graduated cylinder, 50 mL
- graduated cylinder, 500 mL
- paper towels
- ruler, clear metric
- string, approx. 20 cm
- 6 green beans
- 6 snow pea pods

Assessments

The following types of formative assessments are embedded in this lesson:

- Visual assessment of selection of equipment and measuring techniques used within the lesson
- Sharing class data

The following assessments are located on the LTF website:

- Short Lesson Assessment: Green Beans, the Wonderful Fruit
- Nature of Science Assessment

Teaching Suggestions

Students are expected to make many independent choices as they collect the data for this activity. To start, they must select the appropriate measurement tools. You should put out a variety of linear measurement tools and volume measurement tools from which they must choose.

Encourage students to share data with other groups to increase their sample size and validity. Some students may have difficulty coming up with the volume displacement method. Ask leading questions rather than telling them the correct procedure. Hopefully, after determining the volume for a couple of pods using this laboratory skill students will work together to find a faster method. At this point, they may ask for a larger graduated cylinder so they can measure the entire sample for displacement and then divide by the number of pods. Have several beakers and graduated cylinders of varying sizes ready, and be sure to remind them of the low level of accuracy achieved by measuring volume using the graduations on the outside of the beaker. They will probably apply the “whole sample” procedure when determining the average mass.

You will have to continually press students to write down the steps used in their procedure but this is excellent practice for writing free response essays in which they will be expected to detail procedures.
This activity requires students to prepare four data tables. Often students have been given a pre-labeled data table and may struggle with how to arrange their data into a useful format. You will want to discuss the attributes of a quality data table prior to this activity. Avoid the temptation of setting up the data table for students. Have scratch paper handy for them to use in planning the format of their table. This will be particularly necessary as they modify their procedures to reflect “whole sample” data collection. Emphasize that if using the “whole sample” method, their data table must still include their initial and final measurements and not just the averages. Additionally, emphasize the importance of differentiating between what is measured and what is calculated. For instance, initial and final volumes are measurements whereas net volume is not measured but instead calculated.

Students must think through the design of the graphs in this activity. A review of independent and dependent variables may be necessary. Students are asked to take data from two of their tables and create graphs.

Snow peas make a good choice for a second type of seed pod. The produce and frozen foods sections of the grocery store should provide sources of whole seed pods. You may prefer to have students measure two different types of seeds rather than pods. For example, you could substitute pinto beans and black-eyed peas for the pods.

Project Table A as shown for groups to record their averages.

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Average Pod Length</th>
<th>Average Pod Mass</th>
<th>Average Pod Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green Bean</td>
<td>Snow Pea</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class Averages</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Green Beans, The Wonderful Fruit
Using Scientific Measurement

Darwin’s theory of natural selection included the observation that individuals in a population of any species vary in many inheritable traits. Darwin realized that this variation is what makes natural selection possible. Offspring will resemble, but not be identical to, each other and their parents.

The variation found among species members may provide some members with a slight advantage. This advantage can lead to an increase in that variant within the population. Some of the variation within a species is measurable. For example, one tree may be slightly taller at maturity than its sibling. One dog may be milliseconds faster than its litter mate. This small speed advantage may make the dog able to catch the rabbit first, avoid starvation, and thereby live long enough to reproduce. Variation is essential to the survival of a species in an ever-changing ecosystem.

Purpose

In this activity, you will work with a partner to select the appropriate tools to make metric measurements. You will collect the data needed to determine the averages for pod length, pod mass, and pod volume of two different species of plant pods. You will then design your own data table, record the data, and generate appropriate graphs for communicating the data.

Materials

Each lab group will need the following:

- balance
- beaker, 250 mL
- beaker, 600 mL
- calculator
- graduated cylinder, 100 mL
- graduated cylinder, 50 mL
- graduated cylinder, 500 mL
- paper towels
- ruler, clear metric
- string, approx. 20 cm
- 6 green beans
- 6 snow pea pods

SAFETY ALERT!

» Do not eat or drink in the laboratory.
Procedure

Part I: Variations in Pod Length

1. Design a data table in the space labeled Table 1 on your student answer page. Your table should include places to record the length of six green bean pods, the average length of green bean pods in your sample, and the class average green bean pod length.
2. Obtain six green bean pods and select the tools that you will use to measure the pods’ length.
3. Measure the length of the pods and record this data in Table 1.
4. Determine the average pod length for your sample and record this value in Table 1.
5. Share your average with the other groups in the class as your teacher instructs.
6. Design a data table in the space labeled Table 2 on your student answer page. Your table should include places to record the length of six snow pea pods, the average length of snow pea pods in your sample, and the class average snow pea pod length.
7. Obtain six snow pea pods and select the tools that you will use to measure the pods’ length.
8. Measure the length of the pods and record this data in Table 2.
9. Determine the average pod length for your sample and record this value in Table 2.
10. Share your average with the other groups in the class as your teacher instructs.

Part II: Variations in Pod Mass

1. Design a data table in the space labeled Table 3 in which you will record the average pod mass based on your green bean sample, the average pod mass based on your snow pea sample, and the class pod average for both types. Your data table should contain any measurements taken as you determine the average pod mass for each type of pods.
2. Collect the mass data and record it in Table 3.
3. Share your average green bean pod and snow pea pod masses with the class as your teacher instructs.
4. In the space marked Graph 1 on your student answer page, construct a graph of the data found in Table 3. Be sure to include all of the appropriate parts of a graph.
**Part III: Variations in Pod Volume**

1. Devise a method for determining the volume of each of your green bean pods. Record the steps you will follow in the space provided on your student answer page.

2. Design a data table in the space labeled Table 4 on the student answer page. Your table should include places to record the volume of six snow pea pods and six green bean pods, the average volume of snow pea pods in your sample and the average volume of green bean pods in your sample, and the class average snow pea pod volume and green bean pod volume.

3. Collect the volume data and record it in Table 4.

4. Share your average green bean pod and snow pea pod volumes with the class as your teacher instructs.

5. In the space marked Graph 2 on your student answer page, construct a graph of the data found in Table 4. Be sure to include all of the appropriate parts of a graph.
### Data and Observations

<table>
<thead>
<tr>
<th>Table 1: Length of Green Bean Pods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Length of Snow Pea Pods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
### Table 3: Average Green Bean Pod and Snow Pea Pod Mass

<table>
<thead>
<tr>
<th>Mass</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4: Average Green Bean Pod and Snow Pea Pod Volume

<table>
<thead>
<tr>
<th>Volume</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analysis

Steps Used to Determine Volume of Green Bean Pods
Analysis (continued)

1. What is the range of length variation for the green bean pods in your sample?

2. What is the range of length variation for the snow pea pods in your sample?

3. Is your green bean pod length average the same as the class average? Explain the reason for your answer.

4. How much variation is there when you compare the average pod volumes in your green bean and snow pea samples to that of the class?

5. How much variation is there when you compare the average pod masses in your green bean and snow pea samples to that of the class?
Student Activity – Green Beans, The Wonderful Fruit

Analysis (continued)

Graph 1: _________________________________________ (title)

Graph 2: _________________________________________ (title)
Conclusion Questions

1. Does your green bean sample show variation in mass, length, and volume? Support your answer with data.

2. If you were told that an unidentified bean was 115 mm long, would you predict that this bean is most likely a green bean or a snow pea? Explain.

3. If you were randomly given a green bean of the same variety used in this activity, what would you predict its mass to be? Explain.
Green Beans, The Wonderful Fruit
Strategies in the Classroom

1. How does this investigation help students see the importance of selecting the proper tools for measurement?

2. What struggles might students encounter in the development of their own data tables, and how can we support them?

3. What skills did this activity require of students? Which of these were new skills and which were skills that were reinforced?

4. How does this investigation prepare students for inquiry labs?

5. What ideas did you get from this activity that could be used elsewhere?

6. Considering the variance in the beans, how reliable is your individual data in its predictive power? What are some advantages/disadvantages when collecting class data? Are there some other ways to streamline the data gathering and sharing?
The Pendulum Swings
Happiness Is A Straight Line

About this Lesson

Although usually considered as a part of a unit on simple harmonic motion, this activity is presented as a lab to develop the student’s skills in laboratory design, graphing technique, data organization and analysis, and linearization.

In Part I, students are given the opportunity to investigate the relationship between the mass, amplitude, and length of a pendulum and its period. In Part II, students will predict the length of a pendulum given a particular period after linearizing the data.

This lesson is included in the LTF Module 1.

Objectives

Students will:

- Investigate the relationship between the mass, amplitude, and length of a pendulum and its period
- Determine that the period is independent of the mass and amplitude of the pendulum but varies with the square root of the length
- Build a pendulum of the appropriate length given a particular period

Level

Physics

Common Core State Standards for Science Content

LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, A Framework for K–12 Science Education, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>(LITERACY) RST.9-10.3</td>
<td>Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) A-CED.4</td>
<td>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm’s law V = IR to highlight resistance R.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>Code</td>
<td>Standard</td>
<td>Level of Thinking</td>
<td>Depth of Knowledge</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>(MATH) A-CED.2</td>
<td>Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(LITERACY) RST.9-10.7</td>
<td>Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) S-ID.6a</td>
<td>Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) S-ID.6b</td>
<td>Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) S-ID.6c</td>
<td>Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a linear function for a scatter plot that suggests a linear association.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) S-ID.8</td>
<td>Compute (using technology) and interpret the correlation coefficient of a linear fit.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) S-ID.7</td>
<td>Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) F-LE.5</td>
<td>Interpret expressions for functions in terms of the situation they model. Interpret the parameters in a linear or exponential function in terms of a context.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(Literacy) RST.9-10.7</td>
<td>Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(LITERACY) W.4</td>
<td>Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.</td>
<td>Apply</td>
<td>II</td>
</tr>
</tbody>
</table>
Teacher Overview – The Pendulum Swings

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MATH) N-Q.1</td>
<td>Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.</td>
<td>Apply</td>
<td>II</td>
</tr>
</tbody>
</table>

Connections to AP*

1. Newtonian mechanics F. Oscillations and gravitation 1. Simple harmonic motion (dynamics and energy relationships) 3. Pendulums and other oscillations

*Advanced Placement and AP are registered trademarks of the College Entrance Examination Board. The College Board was not involved in the production of this product.

Materials and Resources

Each lab group will need the following:

- meter stick
- protractor, with hole
- scissors
- stopwatch
- string
- tape, masking
- 3 washers, 2 in.

Assessments

The following type of formative assessment is embedded in this lesson:

- Visual assessment of the measuring techniques used within the lesson.

The following assessments are located on the LTF website:

- Short Lesson Assessment: Pendulum
- Circular Motion, Oscillations, and Gravitation Assessment
- 2008 Physics Posttest, Free Response Question 1

Teaching Suggestions

This activity is a guided-inquiry laboratory exercise culminating in a Physics Olympics activity in which students will be given a period and asked to calculate and construct a pendulum of the appropriate length using the pendulum equation they have derived. The students are asked to find the relationship between the period of a pendulum and the mass, amplitude, and length of the pendulum.
In discussing the lab design, you should ask leading questions that enable students to decide how to collect the data, which variable to control (the independent variable), and which graphs to construct. Some examples of leading questions would be:

- What is the period of a pendulum, and what is the best way to measure it?
- What are some considerations regarding precision as you use a stopwatch to measure the period of the pendulum?
- What is the amplitude of a pendulum, and what is the best way to measure it?
- How would you determine the relationship, if any, between the mass on the end of a pendulum and the period of the pendulum?
- How can you be consistent in measuring the length of the pendulum when you change the mass?

A detailed procedure is not provided for the students. They will listen to your oral directions and develop a written procedure when they write their laboratory report.

*Verbally Explain the Following Procedure*

At each lab table, the students should find the equipment listed under Materials and Resources. Have the students determine and record the mass of each washer.

Decide how much of a proper procedure you would like to demonstrate based on the ability and experience of your class. A proper procedure would include:

- Measure the length of the pendulum from the point at which the string is attached to the clamp vertically down to the center of mass of the pendulum bob (Figure A).
- Measure the time it takes for the pendulum to swing 10 times (as opposed to only 1 time) and divide the time by 10 to get an average time (period) for one complete swing. The timer should start the stopwatch after one complete swing rather than when the pendulum is first released.
- Measure the amplitude of the swing in degrees by centering the protractor at the point at which the string is tied to the clamp and pulling the pendulum back to a known angle. If desired, this angle can be used to find the horizontal amplitude (distance) from the equilibrium position by the relationship
  \[ A = L \sin \theta \]
  where \( A \) is the horizontal amplitude and \( L \) is the length of the pendulum (Figure B).
- Encourage several repeated trials for each different amplitude, mass, and length, and take an average of the time for 10 swings for each set of trials.
- Have students record their data in the three data tables, and use a computer graphing program or graph paper to graph the period against each of the variables they are testing (mass, amplitude, and length).
Data Table 1: Mass Variations
Keeping the same amplitude (10°) and the same length (60.0 cm), measure the period of the pendulum for three different masses (100.0 g, 200.0 g, 300.0 g, or 1, 2, and 3 washers).

Data Table 2: Amplitude Variations
Keeping the same mass (100 g, or 1 washer) and the same length (60.0 cm), measure the period of the pendulum for three amplitudes (10°, 20°, 30°).

Data Table 3: Length Variations
Keeping the same mass (100.0 g) and the same amplitude (10°), measure the period of the pendulum for five different lengths (20.0 cm, 40.0 cm, 60.0 cm, 80.0 cm, and 100.0 cm).
The Pendulum Swings
Happiness Is A Straight Line

In this activity, you will determine the relationship between the period $T$ of a pendulum and its mass $m$, amplitude $A$, and length $L$. Your teacher will instruct you on how to construct your pendulum. You will make and record measurements throughout this activity, and you will create your own graphs to display your data.

**Purpose**

You will investigate the relationship between the mass, amplitude, and length of a pendulum and its period. From the data collected, you will also apply your graphing skills either manually or by using computer graphing software to generate graphs and find relationships. You will also linearize your data if necessary.

**Materials**

*Each lab group will need the following:*

- meter stick
- protractor, with hole
- scissors
- stopwatch
- string
- tape, masking
- 3 washers, 2 in.
**Student Activity – The Pendulum Swings**

**Procedure**

1. Listen carefully to your teacher’s instructions. You will be asked to describe your actual procedure in your laboratory report.

2. Organize your data according to the three data tables following, and use a computer graphing program or graph paper to graph the period versus each of the variables tested (mass, amplitude, and length). For this activity, keep the period on the y-axis for each graph.

<table>
<thead>
<tr>
<th>Table 1: Mass Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Washers</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Amplitude Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Washers</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3: Length Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Washers</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>
Lab Report

Include the following sections when writing your lab report:

I. Title
II. Purpose
III. Apparatus (labeled sketch)
IV. Procedure
V. Data
VI. Analysis
VII. Conclusion (include the answers to the Conclusion Questions here)
Conclusion Questions

1. What are the variables in this experiment?

2. What data should be recorded for your pendulum?

3. What steps did you take to maximize accuracy and precision, and minimize your systemic error while collecting your data?

4. What effect does varying the mass of the pendulum have on its period? Justify your answer.

5. What effect does varying the amplitude of the swing of the pendulum have on its period? Justify your answer.
6. What effect does varying the length of the pendulum have on its period? Justify your answer.

7. According to your data relating the period of the pendulum to its length, would it be accurate to say that the period of a pendulum is directly proportional to its length, inversely proportional to its length, directly proportional to the square of the length, or directly proportional to the square root of the length? Explain your answer.

8. Add another column to your data table for length variations and square the period. Graph the period squared versus the length. Write an equation that relates the period to the length, and include the value of the slope.
Conclusion Questions (continued)

9. You will be given a period and asked to calculate and construct a pendulum of the appropriate length using the equation you derived. Your teacher will time your pendulum and its period. Use the space provided to calculate the length of your pendulum and to compute your percent error.

10. Use the slope of your straight line and rearrange the equation for a simple pendulum,

\[ T = 2\pi \sqrt{\frac{L}{g}} \]

to determine a value for the acceleration due to gravity, \( g \). Find the percent error between your value for \( g \) and the accepted value of 9.81 m/s\(^2\).
The Pendulum Swings
Strategies in the Classroom

1. How does a graphing calculator or graphing software help students understand the relationships between the variables tested?

2. What misconceptions about the interdependence of variables are exposed by choosing nonlinear and “no effect” relationships? What are some other examples of nonlinear and “no effect” relationships in physics, or science in general?

3. What prior knowledge and skills do students need to be successful in this investigation?

4. How far into the Conclusion Questions might you expect students to get before teacher intervention is appropriate?

5. What part(s) of the scientific method are reinforced by this activity?

6. Did this activity allow students to investigate any mathematical ideas or concepts for themselves rather than just receiving instruction or directions?

7. What are some questions you can ask that require responses beyond surface-level answers?

8. Are there specific aspects of this activity that lead students to higher-level concepts?

9. What are the opportunities in this activity for students to collaborate with other students?

10. How is this activity connected to future learning?
Airbags
Designing a Lab with Gas Laws

About this Lesson
This inquiry-based lesson provides students with the opportunity to make independent choices as they design a simulated airbag using the ideal gas equation and prior knowledge of chemistry.

This lesson is included in the LTF Module 1.

Objectives
Students will:
• Design an airbag with baking soda, hydrochloric acid, and a resealable plastic bag
• Perform calculations to determine optimum quantities to just fill the bag with gas
• Be judged on experimental design, data collection skills, and the accuracy of their calculations

Level
Chemistry

Common Core State Standards for Science Content
LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, A Framework for K–12 Science Education, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>(LITERACY) W.3</td>
<td>Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(LITERACY) RST.9-10.9</td>
<td>Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(MATH) A-CED.4</td>
<td>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm’s law V = IR to highlight resistance R.</td>
<td>Apply</td>
<td>II</td>
</tr>
</tbody>
</table>
Connections to AP*

All AP Science courses—Lab design. AP Chemistry: II. States of matter A. Gases 1. Laws of ideal gases

*Advanced Placement and AP are registered trademarks of the College Entrance Examination Board. The College Board was not involved in the production of this product.

Materials and Resources

Each lab group will need the following:

- aprons
- balance
- beaker, 250 mL
- calculator
- cup, 3-oz plastic
- goggles
- graduated cylinder, 500 mL
- paper towels
- thermometer
- hydrochloric acid, 6 M
- pipette, thin stem
- spoon, plastic
- bag, zipper-lock, pint, freezer
- baking soda

Assessments

The following types of formative assessments are embedded in this lesson:

- Visual assessment of selection of equipment and measuring techniques used within the lesson
- Visual assessment of the accuracy of the calculations based on the plumpness of the resealable plastic bag

The following assessments are located on the LTF website:

- Short Lesson Assessment: Airbags
- States of Matter Assessment
- 2008 Posttest, Free Response Question 1

Teaching Suggestions

This activity is an excellent opportunity to connect real-world chemistry to the classroom. Not only does this activity give students a chance to design a lab, it also provides an entry to discuss consumer chemistry as well as safety in and out of the laboratory environment. There are many excellent resources online, with particularly useful ones listed under Resources. If you do not have classroom access to online content, you may want to print several copies of this website for students to use during the activity.

Students will need to know the barometric pressure. Post this data in a clear, obvious place in the room but do not call deliberate attention to it. Students will need some background with gas laws to use this lesson.

Resources

http://chemistry.wustl.edu/~courses/genchem/Tutorials/Airbags/151_T5_airbags.htm
**Gases**

Prior to completing this activity, we must review a bit of chemistry. The behavior of gases is defined in terms of four main variables: pressure, volume, temperature, and the number of particles (moles). The equation that relates these variables is the **ideal gas equation**, 

$$PV = nRT$$  \hspace{1cm} (Eq. 1)

where 
- $P$ is pressure in atmospheres 
- $V$ is volume in liters 
- $n$ is the number of moles of gas particles 
- $R$ is the gas constant, with a value of 0.0821 L-atm/mol-K 
- $T$ is temperature in Kelvin ($K = °C + 273.15$)

The ideal gas equation can be algebraically rearranged to solve for any variable as long as all of the other variables are known.

**Exercise 1.** Rearrange Equation 1 to solve for $n$, the number of particles in moles.

---

**Mole:Mole Ratios in Chemical Reactions**

Remember that a chemical equation must be balanced to comply with the law of conservation of mass. Atoms cannot be created or destroyed in an ordinary chemical reaction, so the same number and type of atoms must appear on both the reactant and product sides of the equation. This is done using coefficients, and these coefficients create a **mole:mole ratio** that is useful in problem solving.

**Exercise 2.** Balance the following equation by adding the necessary coefficients.

$$___ \text{H}_2 + ___ \text{O}_2 \rightarrow ___ \text{H}_2\text{O}$$ \hspace{1cm} (Eq. 2)

Equation 2 can be expressed in words to say that “two moles of hydrogen molecules will react with one mole of oxygen molecules to produce two moles of water molecules,” or a 2:1:2 ratio.
The equation we will be using for our airbags is
\[ \text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{CO}_2 + \text{H}_2\text{O} \] (Eq. 3)

*Exercise 3.* Is Equation 3 balanced? Write the ratio of \( \text{CO}_2 \) to \( \text{NaHCO}_3 \).

---

**Mole to Mass Conversions**

Moles are useful quantities to chemists because they represent a defined number of particles. However, moles are not useful for measuring because balances do not measure particles—they measure mass. Therefore, mole quantities must be converted to gram quantities if they are to be used for measurement.

The value that relates mass to moles is called the molar mass. The *molar mass* is the value in grams that one mole of particles would weigh if placed on a balance. This handy piece of information comes from the periodic table in the form of atomic masses.

For example, to find the molar mass of water you would add the constituents, as in Table 1.

<table>
<thead>
<tr>
<th>Atom</th>
<th>Number of Atoms</th>
<th>Atomic Mass</th>
<th>Molar Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>2</td>
<td>1.01</td>
<td>2.02</td>
</tr>
<tr>
<td>O</td>
<td>1</td>
<td>16.00</td>
<td>16.00</td>
</tr>
<tr>
<td></td>
<td>1 mol ( \text{H}_2\text{O} )</td>
<td></td>
<td>18.02</td>
</tr>
</tbody>
</table>

*Exercise 4.* Add the atomic masses from the periodic table to find the molar mass of \( \text{NaHCO}_3 \).
Putting it All Together

The assigned task in this activity is to use the reaction of baking soda and hydrochloric acid to produce enough carbon dioxide gas to completely fill a provided resealable plastic bag. Before embarking on the procedure, students must perform calculations to determine the quantity of reactants necessary to complete this task.

Sample Problem 1

Student 1 determines that 2.5 L of carbon dioxide, CO₂, must be produced from this reaction to completely fill a resealable bag. How many grams of sodium bicarbonate, NaHCO₃, would be needed (along with excess acid)? The room temperature today is 25°C and the atmospheric pressure is 0.98 atm.

Step 1: Use the ideal gas equation (Equation 1) to find the number of moles of CO₂ at these conditions of V, P, and T.

Step 2: Use the mole:mole ratio from the balanced equation (Equation 3) to determine the number of moles of NaHCO₃ that would be required to produce this number of moles of CO₂.

Step 3: Use the molar mass of NaHCO₃ to convert the number of moles of NaHCO₃ to grams of NaHCO₃ that must be measured on a balance.

Sample Problem 2

Student 2 determines that 1.5 L of CO₂ must be produced from this reaction. How many grams of NaHCO₃ would be needed along with excess acid? The room temperature today is 22°C and the atmospheric pressure is 1.01 atm.
Airbags
Designing a Lab with Gas Laws

Since model year 1998, all new cars have been required to have airbags on both driver and passenger sides. To date, statistics show that air bags reduce the risk of dying in a direct frontal crash by about 30 percent. Many people believe that the gas used to inflate the bag comes from a compressed air tank. However, the airbags are filled with a gas as the result of a rapid chemical reaction. In this activity, you will simulate this process using a resealable plastic bag and a different but similar chemical reaction.

This exercise tests your ability to design and carry out laboratory experiments. You and your partner will be graded on experimental design, data collection skills, and the accuracy and precision of your results. Clear thought processes and well-written responses will contribute to your success on this assignment. Your written responses must be as clear and as concise as possible. You must follow proper safety procedures.

Purpose

The task is to generate a gas that will just fill a small, resealable plastic bag using baking soda and 6.0 M hydrochloric acid, HCl. The ideal result is to fill the bag to plumpness yet not to overinflate or underinflate the bag; the bag may also contain unreacted chemicals and other products of the reaction.

You will be asked to describe the method you develop to solve the problem. You must complete this assignment (including the report) during the assigned period. You may not share information between groups.

Materials

Each lab group will need the following:

- aprons
- balance
- beaker, 250 mL
- calculator
- cup, 3-oz plastic
- goggles
- graduated cylinder, 500 mL
- paper towels
- thermometer
- hydrochloric acid, 6 M
- pipette, thin stem
- spoon, plastic
- bag, zipper-lock, pint, freezer
- baking soda
Procedure

1. In the space provided, write your hypothesis using an “if-then” format.
2. With your partner, plan a design for your project and record your design on your student answer page. Have your teacher initial your design before beginning work.
3. Carry out your plan, and record your observations.
4. Revise your design. Repeat, and show your teacher the filled bag.

SAFETY ALERT!

» Goggles are required throughout this entire activity.
» The 6.0 M hydrochloric acid is a concentrated acid. Clean up spills by reacting with excess baking soda.
» If hydrochloric acid is splashed on exposed skin, flush with water for 15 minutes and notify your teacher.
» Wash your hands at the end of this activity.
Hypothesis

Description of Plan (Including Calculations)

Teacher Approval of Filled Bag: ___________________________

Observations
Conclusion Questions

1. Write a balanced chemical equation for the reaction used to produce the gas in your simulated airbag.

2. The reaction in this activity is only a simulation for that in a real automobile airbag. Write a balanced chemical equation for the reaction that actually takes place in an automobile airbag. You may need to do some research, and many online resources are available.

3. What was the limiting reagent in your experiment? Justify your answer with data.
Airbags

Strategies in the Classroom

1. What prior knowledge and skills do students need to be successful? At what point in the science vertical team curriculum does this activity fit?

2. How is this activity connected to future learning?

3. How does this activity encourage your students to communicate more clearly?

4. Does this activity link to a non-school context, so that students see its usefulness or purpose?

5. What connections have you made across science content areas in this activity?

6. What kinds of questions do you pose to prompt the thinking of a student who is struggling with an inquiry experiment?
Can Mosquitoes Transmit Hepatitis?
Simulating a Laboratory Experience through a Role-Playing Exercise

About this Lesson
This inquiry-based lesson gives students the opportunity to design a valid experimental procedure to explore a real-world question. Students role play a team of researchers that design a hypothetically valid experimental procedure to test if mosquitoes could transmit hepatitis between primates.
This lesson is included in the LTF Module 1.

Objectives
Students will:
- Write a procedure to test their hypothesis regarding the transmission of hepatitis by mosquitoes between primates
- Create a labeled diagram of a laboratory floor plan for the procedure
- Work cooperatively with other team members to design an experimental procedure that is acceptable to everyone on the team
- Give an oral presentation with their research team on the procedure and hypothetical results of their experiment

Level
Middle Grades: Life Science

Common Core State Standards for Science Content
LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, A Framework for K–12 Science Education, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>(LITERACY)</td>
<td>RST.9-10.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.</td>
<td>Apply</td>
<td>II</td>
</tr>
<tr>
<td>(LITERACY)</td>
<td>W.3 Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences.</td>
<td>Apply</td>
<td>II</td>
</tr>
</tbody>
</table>
Teacher Overview – Can Mosquitoes Transmit Hepatitis?

<table>
<thead>
<tr>
<th>Code</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>(LITERACY) RST.9-10.9</td>
<td>Assess the extent to which the reasoning and evidence in a test support the author’s claim or a recommendation for solving a scientific or technical problem.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of Thinking</th>
<th>Depth of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply</td>
<td>II</td>
</tr>
</tbody>
</table>

Connections to AP*

AP Biology: This lesson addresses concepts contained in Big Idea 2 and 3 in the revised AP Biology curriculum under the following sections: 2.D.1.c and 3.C.3.a

*Advanced Placement and AP are registered trademarks of the College Entrance Examination Board. The College Board was not involved in the production of this product.

Materials and Resources

Each lab group will need the following:

- marker, Vis-à-vis®
- overhead transparency

Assessments

The following types of formative assessments are embedded in this lesson:

- Visual assessment of Pre-Lab assignment
- Visual assessment of cooperative skills as students work in teams
- Experimental design assessment
- Oral presentation assessment

The following assessments are located on the LTF website:

- Short Lesson Assessment: Scientific Method Quiz
- Introduction to the Science Classroom Assessment
- 2007 6th Grade Posttest, Free Response Question 2
- 2011 6th Grade Posttest, Free Response Question 1
- 2008 7th Grade Posttest, Free Response Question 1
- 2011 7th Grade Posttest, Free Response Question 1
- 2011 8th Grade Posttest, Free Response Question 1
Teaching Suggestions

This activity is a student inquiry lab simulation designed to be the culminating activity of a scientific method unit. Students role-play as teams of research scientists suggesting possible solutions to the following complex question: Can mosquitoes transmit hepatitis between primates?

Specifically, each group of “researchers” must cooperatively plan and design a hypothetically valid experimental procedure that would test whether or not mosquitoes can transmit hepatitis between primates. On a more general level, this activity allows students to take a very complex scientific question and attempt to hypothetically answer it by reducing it to a series of variables that are all accounted for and controlled by the experimenters in a scientific experiment.

Background Information

Hepatitis is characterized by viruses that cause most cases of liver damage worldwide. The patient becomes ill when the disease impairs liver functions such as detoxifying harmful substances, producing bile to help digestion, and regulating blood composition. Symptoms may include (but are not limited to) nausea, anorexia, fever, malaise, abdominal pain, and jaundice.

There are many types of hepatitis including hepatitis A, hepatitis B, and hepatitis C.

- Hepatitis A is generally transmitted from person to person through contaminated fecal matter or through exposure to fecal contaminated food or water. People who work with nonhuman primates are susceptible to hepatitis A virus infection.
- Hepatitis B is transmitted through contact with infected blood or bodily fluids. In about half of the cases, the source of infection cannot be determined. Hepatitis B is the most infectious blood-borne pathogen known.
- Hepatitis C can also be transmitted through contact with infected blood.

Today, scientists generally conclude there is absolutely no evidence that mosquitoes can transmit hepatitis. There are three reasons generally accepted by scientists to explain why this is true:

- Mosquitoes digest the hepatitis virus.
- Mosquitoes do not ingest enough units to transmit the virus.
- The salivary glands of mosquitoes are separate from the blood-ingesting organ, so they can inject saliva with its anti-coagulating agents into the bite without interrupting the flow of blood.

Background information can be found online at the Centers for Disease Control and Prevention website at [www.cdc.gov](http://www.cdc.gov) and at the National Library of Medicine's MedlinePlus at [www.nlm.nih.gov/medlineplus](http://www.nlm.nih.gov/medlineplus).

Before beginning this activity with students, read through this entire content. Although very rewarding and memorable for both teachers and students, this activity is also very complex.
Suggested Teaching Procedure

Day One

Assign students the Pre-Lab Questions for homework before assigning the research groups and actually beginning the project. The Pre-Lab Questions should be completed individually. This encourages the students to engage their thinking regarding the problem at hand. Each student needs a copy of the Pre-Lab Questions as well as the student instruction pages.

Day Two

When the students return to class, assign them into teams of three with each group representing a team of researchers. In their newly assigned groups, students are to share each others’ procedures and read through each one. The students are to read each procedure for about 5 minutes and then pass it on to the next student in the group, rotating each procedure until all students have read all procedures.

Students should focus their attention on finding not only any hidden variables and potential problems but also on finding good procedural ideas. Students are then to discuss the best points of each proposal, deciding which steps from each procedure are the most scientifically sound and valid. Remind students that they are being graded not only on their scientific knowledge and capability but also on their cooperative skills.

Instruct students to consult the Cooperative Skills Assessment rubric as well the Experimental Design Assessment rubric for expectations. Take the time to review the expectations of behavior assessed in the Cooperative Skills Assessment if you have not previously taken the time to teach these skills in your class.

Day Three

Give each student a copy of the student answer pages. Refer students to the job descriptions described in their student instructions: Procedural Author, Layout Designer, and Materials Manager. Review with the entire class the responsibilities of each job. Students are to select one of the three jobs within the research group. Once the students have committed to a role, each member should record their names on their student answer page. By doing this, each student should know what is required from all participants and all group responsibilities are clearly outlined.

Initiate a discussion among the group members that will begin the procedure outline process. The Procedural Author will keep track of this discussion, outlining the group’s ideas as the procedure develops. The Layout Designer should begin sketching a rough draft diagram of the laboratory room(s) and space needed to accomplish whatever procedure is decided upon. Simultaneously, the Materials Manager will begin listing the materials that will be needed to accomplish the research.

Continue to monitor the groups as they work. Ask the students individually what their jobs are and what is required for that job. Monitor the groups’ discussions and continually ask each group how the procedure they have outlined is valid. Could anyone else follow their procedures and achieve the same results?
Day Four and Day Five

Remind students that there is only a limited amount of time to get the procedure, diagram, and overhead diagram completed and ready to present. Provide each group an overhead transparency and an overhead transparency marker.

Refer students to the three grading rubrics (Cooperative Skills Assessment, Experimental Design Assessment, and Oral Presentation Assessment) that will be used to assign student grades during this project. Go through each set of descriptions on each of the rubrics so students have a very clear picture of what is expected as the project unfolds.

Monitor the students as they prepare the final report, constantly asking questions about the procedures and troubleshooting with the students. Also, an overhead transparency can be created of the sample student-created floor plan diagram in Figure A. Discussion can ensue about what a “good” diagram would look like and what a “not-so good” diagram would look like.

At the end of the Day Five, the written report should be completed, the overhead transparency finished, and the materials list finalized. Depending on how well the class performs, more time can be allowed here.

Figure A. Example of a student-created diagram
Day Six

Move from group to group and carefully look at each procedure and experimental layout diagram. Assign hypothetical results (new cases of hepatitis or no new cases of hepatitis) for each group as you carefully try to find hidden variables in each procedure.

Specifically, look for the groups that have not changed the default cages where limbs could reach through and feces could be transferred through the spaces in the cages. This hidden variable would be especially problematic in a room that contains both hepatitis-positive and hepatitis-negative primates. Also, if students move primates to a testing room, play room, or some other central or communal area, make sure that students have accounted for disinfecting the room between uses.

When assigning the results, remind students that today we know that mosquitoes do not transmit hepatitis, so students must think about ways hepatitis could be transferred other than by mosquitoes. In reality, the chance of hepatitis being passed from one primate to another by transfer of feces would probably be very minimal. The results you assign should reflect this fact with only one or two primates being newly infected of the total group of primates tested in the experimental group (usually between 50 and 100) or in the control group.

Students are especially challenged when they get new hepatitis-positive primates in the control group as they are not anticipating these results. The idea here is to get students to look at their procedure in a critical way and try to account for flaws in their experimental design. After assigning results, each group should be able to explain their results and draw conclusions in the space provided on the student answer page and also in the oral presentation.

Day Seven

Each group should begin practicing their oral presentation, with each student presenting the section that they wrote. Again, refer the students to the Oral Presentation Assessment rubric.

After about 20 minutes of practicing and clarifying the oral presentation, you should collect all written lab reports so that students cannot change the procedure once another group has presented and hidden variables are discovered. Students present their experiment to the rest of the class, dividing the presentation between the three assigned jobs.

After presenting, there should be time for other students to ask questions and get clarification on each procedure. You should consider how well the students in each group answered the questions when using the Oral Presentation Assessment.

Acknowledgements

“Historical U.S. Map” from “Hepatitis A Information for Health Professionals.” National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention. Centers for Disease Control and Prevention (CDC), Atlanta, GA.

Vis-à-vis® and EXPO® are registered trademarks of Newell Rubbermaid, Inc.
Can Mosquitoes Transmit Hepatitis?  
Simulating a Laboratory Experience through a Role-Playing Exercise

Your teacher is president of the prestigious Albert Einstein University, and the year is 1997. You are a Ph.D. researcher and part of a team that has been hand-selected by the university president to suggest a solution to a complex real-world problem.

Statistical reports from the Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, are beginning to surface that propose mosquitoes can transmit hepatitis. The reports suggest that mosquitoes may have been responsible for the greater-than-average incidence of hepatitis infection among the people that live in the west and southwest regions of the United States.

Figure 1. Average reported cases of hepatitis A per 100,000 population*, 1987–1997

*Approximately the national average during 1987–1997
Source: National Notifiable Diseases Surveillance System (CDC)
Albert Einstein University has received a federal grant of $3 million from the CDC to study this potential epidemic. The CDC wants the university research team to conduct controlled scientific experiments that will answer the question: Can mosquitoes transmit hepatitis between primates? As a member of a three-person research team, your task is to design a valid experiment that will answer the CDC’s question.

The university president must decide which research team will earn the right to perform the research and receive the $3 million grant. To help make this decision, the president has requested that each team submit its proposed research plan.

Good luck, your competition is tough. Only the best plans will be used and will receive highest grades for this lab.

**Purpose**

In this activity, you will design a valid scientific experiment by applying the steps of the scientific method to suggest a solution to a complex, scientific, historical, and real-world problem.

**Materials**

*Each lab group will need the following:*

- marker, Vis-à-vis®
- overhead transparency
Job Descriptions

Layout Designer

Design an easy-to-read diagram on a teacher-provided overhead transparency that shows the layout of the testing, observation, and storage facilities in your lab. Be sure to include a legend to show how each item is represented in your diagram. A clear and accurate diagram, neatly and correctly labeled, should make your experimental setup easy to understand.

Each person in the room should be able to understand your experiment clearly by looking at your diagram. Also include a close-up diagram of a typical cage with a primate in it. (If your group wants another type of cage instead of the default cage, then you must request it from the university president.) Take great care to show how and where the primates will be housed, and be sure to include both the experimental group as well as the control group.

Procedural Author

Write your group’s hypothesis to answer the question, “Can mosquitoes transmit hepatitis between primates?” in the space provided on your student answer page. After deciding on a plan of action, write your group’s procedural steps down in a logical and legible fashion, labeling each sequential step in order with a number.

Include in your procedure a detailed explanation of how your team will use a control in your experiment. The control must be carefully thought out and planned. The only variable that should be different from the experimental group is the independent variable.

Note: Be sure to write your experimental procedure with enough detail that it can be repeated. Also, state your independent variable, dependent variable, constants (controlled variables), and control in your procedure.

Materials Manager

Determine the complete list of equipment that will be needed to test your hypothesis. Include in your list a labeled diagram of the cage that is used to house your primates. (This diagram should match the cage design drawn by the Layout Designer on the overhead transparency.)

The following list is a starting point for resources, supplies, and organisms that you will be provided. You may not add anything to the list without the permission of the university president; however, the president is usually generous as long as the items are justified as reasonable and necessary.

- Two identical, empty rooms (30 m × 30 m) with air-tight doors and windows, supplied with fresh air and air conditioning
- 100 identical cages with metal bars spaced 10 cm apart on all sides of the cage
- 100 hepatitis tests (capable of instantly detecting hepatitis)
- 100 primates (50 are hepatitis negative, 50 are hepatitis positive)
- 400 female mosquitoes in water, capable of laying viable eggs
- Grade A primate food (“Monkey Chow”), served daily at your cafeteria
- Water and feed bowls
- Fresh water supply
Student Activity – Can Mosquitoes Transmit Hepatitis?

Procedure

Day One
1. Carefully read this entire procedure and complete the Pre-Lab Questions on the student answer page. Each student is to complete the Pre-Lab Questions individually and return them to the teacher the following day.

Day Two
1. Gather the members of your research group and present your completed Pre-Lab Questions. You will have 5 minutes to read each person’s prepared plan. As you read each one, decide which parts of each procedure are best suited to answer the problem question. Be objective in determining the best parts from each procedure, regardless of who wrote it.
2. After brainstorming and discussing which ideas you thought were the best, discuss with team members how your team should proceed with the problem.
3. After all group members have expressed their ideas about the design of the experiment, the group should cooperatively decide the best plan for the group procedure. Overriding questions you should be asking at all times are: Is this procedure valid? Could anyone repeat this experiment and obtain the same results?

Day Three
1. Decide which group member will perform each job in your group. Read each of the job descriptions and decide who will be assigned each job. Write each student’s name on your student answer page in the space provided next to the job title.
2. After you have decided on each person’s job you will have two class days to prepare your final report, which includes the procedure, diagram, and list of materials. Do not forget that you are being graded on your ability to work together cooperatively as a team. Each individual person in the group should begin the tasks that are required for that job.
   Note: You will be graded on how well you work together as a group according to the Cooperative Skills Assessment on your student answer page.

Day Four and Day Five
1. Continue to work on your final product (procedure, floor plan, and list of materials), carefully refining it to be a meticulously thought out and valid scientific procedure.
2. When your group has finished creating your final product (procedure, diagram, and list of materials), your teacher will study your diagrams and procedure and then will assign you some hypothetical results (the number of new hepatitis cases) as if you had really performed your experiment and tested all the primates for hepatitis. Write your teacher-generated results in the results section of your student answer page. Be ready to state these results in your oral presentation.
Procedure (continued)

3. Your next task is to explain your results in a conclusion as a group. Remember that results answer “what” questions and conclusions answer “why” questions. If your teacher states that you have new hepatitis cases, then explain your results. What caused these new cases?

Because we now know that mosquitoes cannot transmit hepatitis, how do you explain your results? Was it a hidden variable? Think about potential flaws in your experiment to address these results. Also, if your teacher states that you have no new cases you must still justify these results in your conclusion. Write your conclusion in the space provided on your student answer page.

Note: You will be graded on how well you design your experimental procedure according to the Experimental Design Assessment on your student answer page.

Day Six

1. After you have finished the written product including your results and conclusion, as a team you will present your procedural design to the class. Work cooperatively to decide how your presentation will occur, and be sure to reference your diagram and list of materials.

2. There will be a brief period of time after your presentation for other research teams to ask questions about your procedure. Everyone in your group should be able to answer any question about any aspect of your procedural design. Part of your oral presentation grade will be based on how well you answer the questions. Prior to the first group’s presentation, you will be required to turn in your entire laboratory report. You may not make changes during the presentations.

3. As you listen to each group present their experimental design, think critically about the validity and logic of their procedure. Keep your attention, intellectual power, and questions focused on how each group has applied the steps of the scientific method. Is the procedure valid? Could the experiment be repeated with the same results?

Do not dwell on questions such as, “What did you feed your primates?” or “How did you keep your mosquitoes alive?” These are questions that do not really address the scientific method or influence the experimental design. Good questions that you can ask a group may include:

a. How did you treat the experimental group differently from the control group?

b. How did you verify that you applied the independent variable?

c. Where is your control group?

d. Why did you not disinfect the testing cage between each use?

Note: You will be graded on your oral presentation according to the Oral Presentation Assessment on your student answer page.
# Table 1: Experimental Design Assessment

<table>
<thead>
<tr>
<th>Category</th>
<th>Super</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Omit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental Design</strong></td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>– Design shows students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>have analyzed the problem,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>designed and conducted a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>thoughtful experiment,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>carefully applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>independent variables,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and controlled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>obvious and hidden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>variables.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scientific Concepts</strong></td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>– Report/presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>illustrates an accurate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and thorough understanding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of scientific concepts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>underlying this activity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diagram/Drawing</strong></td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>– Clear, accurate diagram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>is included and makes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the experiment easier to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>understand. Diagrams are</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>labeled neatly and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>accurately.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Use of Control</strong></td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>– Control was carefully</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>thought out and planned.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The only variable that</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>was different from the</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>experimental group was</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the independent variable.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2: Cooperative Skills Assessment

<table>
<thead>
<tr>
<th></th>
<th>Super</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Omit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Helping</strong> – The teacher observed the students offering assistance to each other.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Listening</strong> – The teacher observed students working from each other’s ideas</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Persuading</strong> – The teacher observed the students exchanging, defending, and rethinking ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Questioning</strong> – The teacher observed the students interacting, discussing, and posing questions to all members of the team.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Respecting</strong> – The teacher observed the students encouraging and supporting the ideas and efforts of others.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sharing</strong> – The teacher observed the students offering ideas and reporting their findings to each other.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3: Oral Presentation Assessment

<table>
<thead>
<tr>
<th></th>
<th>Super</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Omit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparedness</strong> – Ability to speak without reading, knowledge and understanding of information, fielding of questions, and organization.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Content</strong> – Accuracy and clarity.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Thoroughness</strong> – All required information included, amount of research, and length of speech.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Overall Presentation</strong> – Volume, use of language, stance, and eye contact.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pre-Lab Questions

1. What is the problem question presented in the lab?

2. What is your hypothesis?

3. What is the independent variable in this experiment?

4. What is the dependent variable in this experiment?

5. What are three controlled variables that you held constant in this experiment?

6. Explain how you would design a control group in this experiment.

7. On a separate sheet of paper, write a procedure that would test your hypothesis using the equipment provided under the Materials Manager section of the job descriptions and any other equipment that you think that you might need. The procedure may have as many numbered steps in sequential order as necessary to clearly explain your process.

8. On a separate sheet of paper, include a labeled diagram of your laboratory floor plan with storage rooms, testing rooms, cages, animals, and equipment.
Student Activity – Can Mosquitoes Transmit Hepatitis?

Group Members

Layout Designer ______________________________________

Procedural Author ______________________________________

Materials Manager ______________________________________

Hypothesis

Procedural Design Steps
Student Activity – Can Mosquitoes Transmit Hepatitis?

Materials List

Results

Conclusion
Introduction to Laying the Foundation through Experimental Design

Acknowledgements

Advanced Placement® and AP® are registered trademarks of the College Entrance Examination Board. The College Board was not involved in the production of this product.

All references to Barbie imply the Barbie® doll or action figure. BARBIE is a registered trademark used with permission from Mattel, Inc. © 2008 Mattel, Inc. All Rights Reserved.

Graphical Analysis®, LabPro®, LabQuest™, and Logger Pro 3® used with permission, Vernier Software & Technology.

“Historical U.S. Map” from “Hepatitis A Information for Health Professionals.” National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention. Centers for Disease Control and Prevention (CDC), Atlanta, GA.

Vis-à-vis® and EXPO® are registered trademarks of Newell Rubbermaid, Inc.

Online content referenced or linked in this publication remains the property of the respective content providers. All website and webpage links included herein were verified correct and current as of the date of this printing. For changes, corrections, or to report a broken or invalid link, please contact the publisher directly.
## Process Skills Progression Chart

<table>
<thead>
<tr>
<th>Acquire Data by Experimentation and Observation</th>
<th>Factual Knowledge</th>
<th>Conceptual Understanding</th>
<th>Reasoning and Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify scientific equipment, instruments, and technology</td>
<td>Choose appropriate equipment and technology</td>
<td>Work collaboratively to obtain scientific data</td>
<td></td>
</tr>
<tr>
<td>Know and observe safety precautions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow a procedure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Record and Manipulate Data</th>
<th>Measure and record data in SI units</th>
<th>Determine variables to be measured</th>
<th>Design a data table or chart as appropriate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make and record observations</td>
<td>Estimate and approximate quantities</td>
<td>Solve mathematical equations using data</td>
<td>Create appropriate graphical representations of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Analyze error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Apply statistical analysis such as standard deviation, percent error, and chi square</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Graph and Analyze Data</th>
<th>Plot data points</th>
<th>Translate graph into words</th>
<th>Evaluate line of best fit, curve fit, and regression equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label the axes</td>
<td>Scale axes</td>
<td>Calculate slope, area, and intercepts</td>
<td>Detect patterns in data</td>
</tr>
<tr>
<td>Title the graph</td>
<td></td>
<td>Construct line of best fit, curve fits, regression equations</td>
<td>Interpret physical meaning of slope, area, and intercepts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interpolate, extrapolate and predict from a graph</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Transform data into linear form</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recognize cause and effect relationships</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Draw appropriate conclusions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Apply conclusions to new situations and further investigations</td>
</tr>
</tbody>
</table>
## Science Process Skills Progression Chart (continued)

<table>
<thead>
<tr>
<th></th>
<th>Factual Knowledge</th>
<th>Conceptual Understanding</th>
<th>Reasoning and Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communicate and Share</strong></td>
<td></td>
<td></td>
<td>Defend results and conclusions in both written and oral format</td>
</tr>
<tr>
<td><strong>Results</strong></td>
<td></td>
<td></td>
<td>Relate concepts to unifying themes</td>
</tr>
<tr>
<td></td>
<td><strong>Translate data into words</strong></td>
<td><strong>Read and understand scientific articles</strong></td>
<td><strong>Defend results and conclusions in both written and oral format</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Read and understand</strong></td>
<td><strong>scientific articles</strong></td>
<td><strong>Relate concepts to unifying themes</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Defend results and conclusions in both written and oral format</strong></td>
<td><strong>Relate concepts to unifying themes</strong></td>
<td><strong>Defend results and conclusions in both written and oral format</strong></td>
</tr>
<tr>
<td><strong>Design Experiments</strong></td>
<td><strong>State the purpose</strong></td>
<td><strong>Design and use models to explain scientific concepts</strong></td>
<td><strong>Formulate testable questions and hypotheses</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Practice identifying</strong></td>
<td><strong>Understand the importance of controls</strong></td>
<td><strong>Critique experimental designs</strong></td>
</tr>
<tr>
<td></td>
<td><strong>variables</strong></td>
<td><strong>Apply steps of scientific method to solve a problem</strong></td>
<td><strong>Predict outcomes</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Formulate a feasible and practical procedure</strong></td>
<td><strong>Make environmentally friendly choices when designing experiments</strong></td>
</tr>
<tr>
<td><strong>Demonstrate</strong></td>
<td><strong>Identify relevant given</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mathematical Problem-Solving</strong></td>
<td><strong>information</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Skills</strong></td>
<td><strong>Substitute values into</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>an equation and solve</strong></td>
<td><strong>Use dimensional analysis</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Use dimensional analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Estimate reasonable answers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Use Technology</strong></td>
<td><strong>Recognize useful data tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>such as graphing calculators, probes, data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>collection device and</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>computers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Use data collection tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>such as graphing calculators,</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>probes, data collection device and</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>computers</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Module Descriptions

Biology

Module 1 – Introduction to Laying the Foundation through Experimental Design
This is the first module of any science training series. It is presented to a mixed audience of middle school and high school teachers and explores the resources available through LTF and emphasizes the philosophies and strategies we employ. Participants develop the concept of experimental design by performing selected activities from the middle grades, biology, chemistry and physics courses.

Module 2 – Chemistry of Life and Cells I
Participants explore introductory activities from biology that involve the chemistry of life. Over the course of the training sequence, these topics are revisited and explored in depth each year. This module investigates the four major classes of biomolecules along with enzyme structure and function. An introduction to cellular structure and surface area-to-volume relationships is also explored and discussed.

Module 3 – DNA, Genetics, and Animals
Participants explore introductory activities from units on DNA, Mendelian genetics, and animal systems. Over the course of the training sequence, these topics are revisited and explored in depth each year. This first group of activities explores Mendelian inheritance principles in maize, extracting DNA from plants, and using graphing calculators to simulate Mendelian inheritance patterns. The final activity explores the nervous system and senses.

Module 4 – Plants, Ecology, and Evolution I
Participants explore introductory activities from units on plants, ecology, and evolution. Over the course of the training sequence, these topics are revisited and further developed. This first group of activities compares monocots and dicots with respect to stem and stomate structure and function, simulates natural selection, and identifies the photosynthetic component of plants.

Module 5 – Measurement and Statistics
Participants discuss and develop student skills related to measurements and statistics in the biology classroom. Lessons are explored that incorporate microscopes and graphing calculators. Data analysis and its inclusion in laboratory reports is also addressed.

Module 6 – Chemistry of Life and Cells II
Participants investigate the laws of thermodynamics and kinetics as they relate to the biology classrooms. In addition to traditional wet labs, LTF lessons incorporate probeware and modeling techniques as they explore enzyme catalysis and membrane structure.
Module Descriptions
Biology (continued)

Module 7 – Cellular Processes and Animal Adaptations
In this second look at DNA, genetics, and animals, participants explore lessons related to endo-
therms and ectotherms and other animal adaptations. Participants perform an introductory gel
electrophoresis lab and discuss the implications of DNA fingerprinting.

Module 8 – Plants, Ecology, and Evolution II
The plant lessons for this module investigate plant transpiration and pigment chromatography.
Participants also discuss and explore the response and interactions of organisms with their envi-
ronment as well as population studies.

Module 9 – Mitosis, Passive Transport, and Genetics
Participants discuss and develop student skills related to mitosis and karyotypes using class-
room manipulatives. Passive transport is explored in two labs using microscopes and graphing
calculators.

Module 10 – Bacteria, Viruses, and Paramecia
This module conducts a discussion over common misconceptions in the biology classroom. Par-
ticipants also investigate bacterial transformation, viral transmission, and the trp operon using
modeling strategies. Participants use microscopes to observe a Paramecium feeding process in a
traditional wet lab.

Module 11 – Plants, Ecology, and Evolution III
In this look at plants, ecology, and evolution, participants explore lessons related to adapta-
tions and alternation of generations in plants. Participants demonstrate evolution in the animal
kingdom with an in-depth look at the different forms of body cavities and symmetries.

Module 12 – Enzymes and Body Systems
Participants explore strategies for teaching lessons about enzymes and conduct a lab designed to
illustrate enzyme-substrate specificity using technology. The body system activities here include
the endocrine system, the respiratory system, and the excretory system.
Module Descriptions
Chemistry

Module 1 – Introduction to Laying the Foundation through Experimental Design
This is the first module of any science training series. It is presented to a mixed audience of middle school and high school teachers and explores the resources available through LTF and emphasizes the philosophies and strategies we employ. Participants develop the concept of experimental design by performing selected activities from the middle grades, biology, chemistry and physics courses.

Module 2 – Graphing Calculators and Data Collection Devices
Participants explore the use of graphing calculators and data collection devices in the chemistry classroom. A step-by-step guide to using the calculator and data collection device is examined, and practice activities are performed.

Module 3 – Atomic Structure
Participants explore topics from chemistry that develop the concepts of matter and atomic structure. The discussion portion of the day develops student-friendly methods for teaching electron configurations, orbital notation, and quantum numbers. Participants perform two simple activities that integrate algebra and graphing skills into this unit of study.

Module 4 – Bonding and Nomenclature
Participants explore lessons from chemistry that focus on bonding and nomenclature topics. The discussion portion of the day addresses teaching students to draw Lewis structures, determine molecular geometries, and write correct chemical formulas. Two activities are performed that investigate the importance of intermolecular forces and the geometry of molecules.

Module 5 – Mathematics and the Periodic Table
Participants discuss mathematical problem-solving strategies in chemistry and investigate relationships between elements on the periodic table. Both traditional wet and dry labs are explored with the intention of solidifying student understanding of periodic trends and their role in chemical behavior. An examination of AP style questions and common student misconceptions further develops the strategies that can be implemented to facilitate student success.

Module 6 – Intermolecular Forces and Condensed States of Matter
Participants use a variety of techniques to explore intermolecular forces and the solid and liquid states. Computer simulations, probeware, and traditional lab activities are all utilized to this end. A discussion of common student misconceptions and strategies to overcome those obstacles is also developed. Examining Pre-AP assessments serves to assist participants in better preparing their students for the expectations of AP science.
Module Descriptions
Chemistry (continued)

Module 7 – Thermodynamics
Participants review concepts in thermodynamics and apply these to problem-solving and laboratory experiments. Investigations using probeware and traditional laboratory equipment are explored with an emphasis on developing the conceptual framework necessary for successful problem-solving.

Module 8 – Assessment and Kinetics
Participants spend time examining specific assessment strategies that can be implemented in the Pre-AP classroom to prepare students for AP exams. Reading of actual student samples from the 2008 LTF Chemistry End of Course (EOC) exam help participants identify student misconceptions and emphasize the finer points of assessment development. In addition to developing participants’ assessment skills, instruction in chemical kinetics and a traditional clock reaction experiment are also included.

Module 9 – Reactions and Equations
Participants discuss types of reactions and the equations that accompany them. Both traditional wet and dry labs are explored with the intention of solidifying student understanding of chemical reactions. An examination of AP style net ionic questions and common student misconceptions further develop the strategies that can be implemented to facilitate student success.

Module 10 – Solutions
Participants use a variety of techniques to explore the properties and nature of solutions. Multiple wet labs are performed, and colorimeters and data collection devices are used to analyze solutions. A discussion of common student misconceptions and strategies to overcome those obstacles is also developed. Examining Pre-AP assessments serves to assist participants in better preparing their students for the expectations of AP science.

Module 11 – Equilibrium
Participants review concepts in equilibrium and apply these to problem-solving and laboratory experiments. Investigations using probeware and traditional laboratory equipment are explored with an emphasis on developing the conceptual framework necessary for successful problem-solving.

Module 12 – Gases
Participants explore lessons and activities relating to gas laws in the chemistry classroom. In addition, time is spent analyzing and evaluating the components of a rigorous chemistry lesson, and participants have the opportunity to apply those components to an activity they can take back to their classroom.
Module Descriptions
Middle Grades Science

Module 1 – Introduction to Laying the Foundation through Experimental Design
This is the first module of any science training series. It is presented to a mixed audience of middle school and high school teachers and explores the resources available through LTF and emphasizes the philosophies and strategies we employ. Participants develop the concept of experimental design by performing selected activities from the middle grades, biology, chemistry and physics courses.

Module 2 – Numbers in Science
This module explores activities from Middle Grades Life Science, Earth Science, and Physical Science that demonstrate the many ways students are asked to deal with numbers in the science classroom. Concepts such as measurement, error, significant digits, and numerical relationships are discussed and demonstrated.

Module 3 – Meaningful Graphs
This module explores activities from Middle Grades Life Science, Earth Science, and Physical Science that emphasize students’ abilities to create and interpret meaning from graphical representations of data. A look at the graphing skills required by AP students and a discussion of proper graphing techniques is presented. Participants have the opportunity to perform some activities that incorporate graphing skills into the middle school classroom.

Module 4 – Rate
This module explores activities from Middle Grades Life Science, Earth Science, and Physical Science that emphasize the variety of instances where rate can be explored in the middle school classroom. Rate is a common theme among all AP science exams, and its introduction and development in the middle school classroom can help lay a strong conceptual foundation.

Module 5 – Patterns
This module explores activities from Middle Grades Life Science, Earth Science, and Physical Science that emphasize patterns in science. The topics addressed include taxonomy, genetics, periodic trends, and lunar phases. Participants perform activities to better visualize and apply these topics in the middle grades classroom.

Module 6 – Properties of Matter and Density
This module explores activities from Middle Grades Physical Science that apply to all middle grades classes. As matter and density are explored, the topics are related to life and Earth science topics as well as AP Biology, Chemistry, and Physics classes.
Module Descriptions
Middle Grades Science (continued)

Module 7 – Evolution and Energy
This module explores activities from Middle Grades Life Science, Earth Science, and Physical Science, focusing the first part of the day on predator/prey relationships and genetics and the second part of the day on work, power, and energy. Participants spend the day completing hands-on activities that explore real-life extensions of these topics.

Module 8 – Environmental Human Impact
This module explores activities from Middle Grades Life Science and Earth Science that emphasize the impact humans have on our environment. Current topics such as climate change and pollution are discussed and studied. Participants see how simple changes can affect the impact they have on the world around them.

Module 9 – Models and Reactions
This module explores activities from Middle Grades Life Science and Earth Science as well as related topics from chemistry and physics that include the use of models or address different types of reactions in science. The topics addressed include photosynthesis, the solar system, thermodynamics, and waves. Participants perform activities to better visualize and apply these topics in the middle grades classroom.

Module 10 – Misconceptions and Magnets
This module explores activities from Middle Grades Life Science and Earth Science as well as related topics from chemistry and physics that are often misunderstood by students. Misconceptions are addressed each in life science, Earth science, chemistry, and physics units. Magnets and magnetic fields are also addressed with a direct tie to the planets.

Module 11 – Adaptations and Changes
This module explores activities from Middle Grades Life Science and Earth Science as well as related topics from chemistry and physics exploring adaptations, black holes, acceleration, and chemical reactions. Participants spend the day completing hands-on activities, taking advantage of data collection devices and probeware.

Module 12 – Effects and Effectiveness
This module explores activities from Middle Grades Life Science and Earth Science as well as current related topics from chemistry and physics such as the greenhouse effect and global commons, which are discussed and studied. Participants also study heating curves and the effectiveness of levers.
Module Descriptions

Physics

Module 1 – Introduction to Laying the Foundation through Experimental Design

This is the first module of any science training series. It is presented to a mixed audience of middle school and high school teachers and explores the resources available through LTF and emphasizes the philosophies and strategies we employ. Participants develop the concept of experimental design by performing selected activities from the middle grades, biology, chemistry and physics courses.

Module 2 – Pre-AP Physics and Kinematics

Participants explore physics lessons that focus on constant and changing motion. Emphasis is placed on developing a curriculum system to accomplish the goals for teaching the Pre-AP Physics course. Example calendars, scopes and sequences, and objectives are discussed. Problem-solving is demonstrated and practiced using both AP and Pre-AP problems. Probes and data collection devices are used to collect and analyze data.

Module 3 – Developing Skills and Mechanical Waves

Participants explore student lessons that focus on both longitudinal and transverse wave motion. Participants investigate waves in a string, a spring, and a ripple tank as well as determine the speed of sound in air. This session also emphasizes graphing calculators, graphing skills, problem-solving skills, and ways to administer and evaluate labs.

Module 4 – Using the Tools—Electricity and Magnetism

Participants explore student lessons that introduce electrostatics and electric circuits. Participants map an electric field and examine equipotential and electric field lines as well as build and investigate various types of circuits involving light bulbs and resistors in both series and parallel circuits. Methods for resolving circuits and for the formulation of Ohm’s law are discussed and practiced. Emphasis is also placed on data collection and display devices.

Module 5 – Kinematics—Two Dimensional Motion—Impulse and Momentum

Participants investigate kinematics, two-dimensional motion, momentum, and impulse. Experiments exploring acceleration in one and two dimensions emphasize graphing and vector activities to enhance understanding and development of concepts. Exercises that strengthen problem-solving and analysis of motion are examined and practiced. Additional problem-solving activities and assessments are provided to show the expected levels for Pre-AP and the relationship to AP Physics.

Module 6 – Dynamics—Work, Power, and Energy

Participants explore dynamics, Newton’s laws, free body diagrams, work, power, and energy. Participants perform experiments using carts and ramps and use technology to investigate Newton’s second law and the effects of friction. A roller coaster lab is used to develop the concepts of work, power, and energy. This module includes practice with free body diagrams and their importance in problem-solving.
Module Descriptions
Physics (continued)

Module 7 – Waves and Sound—Light and Optics
Participants examine the concepts of waves, sound, light, and optics. Labs are performed to determine the speed of sound and to investigate the properties of reflection, refraction, and diffraction of waves and light. These activities involve optics experiments using lenses, mirrors, light, and water. Practice with ray diagrams and computer simulations for lenses and mirrors are included in the activities. A discussion of assessments is provided as well as the relation of these activities to Pre-AP and AP Physics.

Module 8 – Electricity, Magnetism, and Modern Physics
Participants investigate electricity, magnetism, and modern physics topics. Labs include building a capacitor and measuring its capacitance, constructing a circuit involving resistors and capacitors, and the effects of current on magnetic fields. Exercises on right-hand rules and a discussion of magnetic fields and their effect on moving charges are included. A discussion of assessments is provided as well as the relation of these activities to Pre-AP and AP Physics.

Module 9 – Relationships
Participants discuss methods for data analysis and practice determining relationships from data. Labs are included that not only develop skills and concepts applicable to Pre-AP Physics but also increase analysis of data strategies that can be implemented to facilitate student success. Further study of kinematics, two-dimensional motion, dynamics, and the concept of physical and mathematical constants are included in the laboratory activities.

Module 10 – Gathering and Manipulating Data
Participants engage in a discussion of misconceptions and discrepant events that impede students’ ability to understand physics concepts. Teachers investigate aspects of work, power, energy, impulse, and momentum through laboratory exercises and discussions. Included are a further emphasis on data analysis and the use of curve fitting, data smoothing, and additional techniques.

Module 11 – Data Analysis
Participants continue the theme of gathering and analyzing data using technology and traditional methods. Ways to ensure that all students are given instruction in terms of their needs and individual requirements are discussed along with ways to build physics and other science programs to include a larger and more diverse group of students. Lab activities include an emphasis on thermodynamics and fluids.

Module 12 – Extending Physics to Modern Topics
Participants explore lessons and activities relating to electricity and magnetism such as Faraday and Coulomb’s laws. Also, concepts in modern physics and particle physics are discussed and investigated in laboratory experiences. In addition, time is spent analyzing and evaluating the components of a rigorous Pre-AP Physics lesson or lab activity, and participants have the opportunity to apply those components to an activity that they can take back to their classroom.
Teachers receive an initial user name and password to access the LTF website, based on attendance at training. Teachers are asked to complete an online profile to ensure data integrity and provide easy access to all online training records and certificates. Once the required elements of the profile are complete, teachers gain access to all of the materials for their discipline. Teachers also use the website to access evaluations and print-ready certificates for each day of training.

The LTF website contains a wealth of password-protected resources tied to training and is frequently updated with new materials, including:

- Lessons, projects, lab exercises, and other classroom activities
- Teacher overviews containing Common Core State Standards alignments
- Alignments to other national and state standards
- Embedded, formative, and summative assessments with answer keys, scoring guides, and student samples
- Planning documents and sample syllabi
- SAT preparatory materials for vocabulary
- Gender-equity strategies and resources
- Vertical Team Materials
- Links to other online resources
- Additional resources

FOR REFERENCE

My login: _____________
My password: _____________
LTF Online Forum for All Educators

The LTF Online Forum is a powerful community-based application on the LTF website that provides additional support for all teachers in English Language Arts, Mathematics, and Science courses. The LTF Online Forum has been created for the purposes of sharing ideas and providing a nurturing environment for improving education. Although many users will come to the forum after attending LTF training, many others around the country will join the academic conversation out of a desire to exchange teaching ideas and best practices with colleagues—and perhaps learn more about LTF teacher training at the same time.

The objectives of the forum are to foster collaboration among teachers, provide a set of tools and resources to support integration of LTF strategies and materials into your classroom, and stimulate an awareness and appreciation of education that promotes college readiness for all students.

The LTF Online Forum can be accessed from the LTF webpage at www.ltftraining.org beneath the Math, Science, and English drop-down menus. Anyone accessing the LTF website can view forum content but only those possessing an LTF login will be able to post or comment on topics. If a user does not have an LTF login, they may create one by clicking on the “Register” link at the top of any forum page.

The English, Mathematics, and Science forums are each moderated by outstanding LTF trainers and successful classroom teachers in each of the three discipline areas. Our moderators are dedicated to sustaining a lively, productive, and useful discussion among like-minded professionals through the forum. We welcome you and your fellow teachers to the new LTF Online Forum, and we hope you will join us soon!
Consent and Release Agreement

On occasion, Laying the Foundation (LTF) asks trainers, teachers and students to share their original work and images, such as photos and videos, with other teachers involved in training. This agreement form indicates that you grant permission for LTF to use your original work and/or images in LTF materials and postings on the LTF website.

AGREEMENT

Trainer, Teacher, Student, or Parent/Guardian agree to release their work and/or images to Laying the Foundation (LTF).

LTF agrees that the work and/or images shall be used only for educational purposes including, but not limited to, teacher/student training materials, print publications and videos, and postings on the LTF website and the LTF Online Forum.

Trainer, Teacher, Student or Parent/Guardian understand and agree that:

- No monetary consideration shall be paid.
- The consent to release has been given without coercion or duress.
- This agreement is binding upon heirs and/or future legal representatives.
- The student work may be used in subsequent years.
- Editorial changes may be made to the work for the purposes of publication.

A rescindment of this agreement may be enacted at any time with written notice, provided LTF is granted permission to distribute any remaining inventory of material containing the work or images without the need for revision.

Effective Date of Agreement: __________________________________________

Name:  ____________________________________________________________

Signature:  _________________________________________________________

Parent/Guardian if student is not 18 years old:  ____________________________

Parent/Guardian if student is not 18 years old:  ____________________________
With your registered account, you gain access to these useful classroom resources:

- Updated lessons with teacher and student pages that can be downloaded and printed
- New lessons that are not included in the printed modules
- Content Skills Charts that aid in planning curriculum
- Information showing the connections between LTF skills/content and state standards
- Connections that correlate AP objectives to LTF lessons
- Assessments that train students for AP testing
- End-of-course free response questions that provide opportunities for cumulative assessment of student achievement and authentic student samples
- ...And much more!

Please visit us online at www.ltftraining.org