

Hazardous Materials and Safety

Instructors' Guide

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About these materials:

The educational philosophy of this course is that properly educated technical students will have the skills and mindset to be trained in specific safety skills by their future employers. Therefore, much of the emphasis of this course focuses on:

- Introducing the common tools students will need to work safely in the laboratory.
- Developing the mindset that students will use to plan and carry out their work safely.

This teachers' guide has been provided to help instructors choose the material that will best meet their own needs, and to illustrate how we use these materials in the classroom and laboratory to help students learn to take responsibility for their own safe work environment.

The lecture material in course is based on:

Basic Laboratory Methods for Biotechnology (3rd ed.) (Lisa A. Seidman, Cynthia J. Moore, and Jeanette Mowery) ISBN: 9780429282799

The labs come from:

Laboratory Manual for Biotechnology and Laboratory Science: The Basics (Lisa A. Seidman, Mary Ellen Kraus, Diana L. Brandner and Jeanette Mowery) (2nd ed.) ISBN: 9781032419916

Module 1: Introduction to Workplace Safety

Objectives:

- Introduce the safety mindset.
- Perform a simple risk assessment.
- Provide a personal safety hygiene contract.
- Provide an overview of safety in the workplace.
- Summarize the purview of both OSHA and the CDC.

Block 1:

[45 minutes] Activity 1: Risk Assessment in-class group activity

Performing a risk assessment (in Seidman, Kraus, Brandner and Mowery)

Structure: I always perform this activity in small groups (no bigger than 4 students). This gives the students time to meet their peers and begin to think about how to anticipate things that can go wrong in the workplace. This activity can easily be modified to fit your class schedule, although I usually give about 45 minutes for this activity.

Comments: It is important to stress that the safety mindset remains the same regardless of situation. Working safely in a fast-food restaurant, for instance, is very similar to working safely in a laboratory environment in many ways: awareness of co-workers' presence and location, cleanliness in the work environment, clear labeling and handling of hazards, proper training, etc. During this course we will stress the development of a conscious safety mindset while also providing instruction on handling hazards unique to a laboratory environment. I try to stress the concept of the safety mindset, and draw parallels to actual laboratory experiences during the Part Three discussion of this activity. I then encourage the students to draw relatively broad conclusions about safety, rather than conclusions specific to a given hazardous situation.

[30 minutes]

Laboratory Exercise 1: *Tracking the spread of chemical contamination (in Seidman, Kraus, Brandner and Mowery)*

[Homework] Optional reading assignment: Chapter 8 in Seidman, Moore, and Mowery

[Homework] **Safety contract.** I have students read and complete the Safety Contract in the laboratory manual.

Block 2:

[30 minutes] Lecture: *Introduction to Workplace Safety (provided as a PowerPoint document)*

[30 minutes] Video: “Can’t take no more” OSHA, 1980. (**Currently available as a YouTube video; <https://www.youtube.com/watch?v=13gzGkQtVzg>**)

Structure: Depending upon the amount of time available, this video is easily cropped.

Comments: This video is a historical documentary telling the story of the safety movement in the industrialized United States from 1900 to 1980. While it is dated, it dramatically describes the need for OSHA.

[60 minutes] In-class Activity: Classroom Activity 2: *Exploring safety-related government websites (in Seidman, Kraus, Brandner and Mowery)*

Structure: I usually assign this for work, at least partially, outside the classroom.

If you do not have good internet access, you may want to assign this entire exercise to be done outside the classroom.

Comments: The major purpose for this exercise is to introduce the students to the vast amount of information that is available to them as laboratory employees. The more comfort and familiarity the students have with these websites, the more effective they will be in taking responsibility for maintaining a safe workplace. If this assignment is not done in class, it is useful to discuss the students' findings, especially as regards the differences in scope and mission between these two important agencies.

Module 2: Working with Hazardous Chemicals

Objectives:

- Identify the safety equipment available in the laboratory.
- Complete Laboratory Exercise: Tracking the spread of chemical contamination.
- Practice using Safety Data Sheets to safely plan laboratory exercises.
- Introduce the concept of chemical incompatibility with regard to equipment and supplies.
- Provide an overview of proper fume hood usage.

Block 1:

[20 minutes]

Classroom Activity 3: *Responding to Emergencies (in Seidman, Kraus, Brandner and Mowery)*

Structure: Because it is so important to know the location of emergency equipment and to make evacuation routes clear, if time is short, it is useful to provide students with a pre-sketched floor plan, rather than have them create their own.

Comments: It is a useful addition to this activity to do a dry run of an evacuation, or run several, if you have multiple evacuation routes in response to different mock scenarios.

[90 minutes]

Laboratory Exercise 1: *Tracking the spread of chemical contamination (in Seidman, Kraus, Brandner and Mowery)*

Structure: Usually, the students will get all their dilutions prepared and their workplace surveyed by eye and with UV light by the end of this lab period.

Preparation of the filters will generally occur in the second lab period of the module. Their laboratory notebook documentation should be complete prior to leaving the laboratory.

Comments: How much time you allot to this exercise is flexible. Generally, I will give a lot of time for the students to make their solutions. Before they begin, I give them ample time to use classroom resources, such as Safety Data Sheets, to research their chemicals. I also discuss proper glove use and various other personal hygiene rules before beginning the laboratory. This information can be found in Classroom Activity 5: *Personal protection (available in Seidman, Kraus, Brandner and Mowery)*. Just discussing glove use alone can take quite a bit of time.

[At home] Classroom Activity 4: *Understanding the Chemicals with Which You Work (in Seidman, Kraus, Brandner and Mowery)*

Structure: Students can complete this activity as written. It is important to emphasize to the students that the correct documents to use in the future when planning lab work are the GHS Safety Data Sheets for chemicals in their workplace.

Comments: The most important point is that the students have the ability and the responsibility to use the information available to them to research the hazards associated with their work and to plan the safest procedure possible.

[At home] Video: *Fume hood airflow and operation* Labconco. (**currently available at <https://www.labconco.com/video-labconco-fume-hood-airflow-demonstration>**)

Structure: This is a short video that may be better shown and discussed in class.

Comments: Visualizing how the hood controls airflow will help students understand the importance of learning to use the hood correctly, and to understand the consequences of improper hood usage.

[At home] Optional reading assignment: Chapter 9 in Seidman, Moore, and Mowery.

Block 2:

[45 minutes] Lectures: *Working with Hazardous Chemicals, PPE and Various Hazards in Lab* (**both provided as PowerPoint PDF documents**)

[75 minutes] Complete Laboratory: *Tracking the spread of chemical contamination* (**in Seidman, Kraus, Brandner and Mowery**)

Structure: Students will complete the preparation and viewing of filter papers, and check their workspaces for contamination.

Comments: Additionally, as time permits, I emphasize the importance of chemical compatibility of chemicals and equipment. One way to do this is to put chloroform or ethyl acetate into polyethylene, polystyrene and glass test tubes. Be sure all tubes are sitting in glass beakers. Depending upon the chemical used, different degradation of the tube materials will be observed. It is not a good idea to have students do this exercise as injury may occur. Instead, do this, or have this set up ahead of time (it can take 15 minutes or more for the chemicals to completely eat through the plastic) as a teacher demonstration. I usually just invite students over to the hood to see the rather dramatic effects observed. One sample exercise is Laboratory Exercise 29A: Check your tubes to see if they are resistant to ethyl acetate (**in Seidman, Kraus, Brandner, and Mowery**).

Module 3: Handling and Storage of Hazardous Chemicals

Format: Two blocks

Objectives:

- Discuss the proper handling and storage of hazardous chemicals.
- Introduce the NFPA Hazard Diamond System of labeling.
- Emphasize the process of risk reduction when planning laboratory work.
- Practice researching hazards and reducing risk in a laboratory procedure.

Block 1:

[60 minutes] Lecture: *Handling and Storage of Hazardous Chemicals* (**provided as a PowerPoint PDF document**)

Supplemental material: NFPA/OSHA Quick Card (**provided as a PDF, NFPA card**)

Comments: A large part of this lecture focuses on attention to labeling of hazards. A second system of labeling (the first was the GHS system described previously) is the NFPA Hazard Diamond System. Two systems of labeling can seem confusing, but students should be familiar with both. I have provided an NFPA/OSHA Quick Card that was prepared by these two organizations to quickly compare the two systems.

[30 minutes] Video: *The Chem Lab: Safety in Every Step* A Films for the Humanities and Sciences Production.

Comments: I like to show some video that depicts the process of working safely in a laboratory setting. An example is *The Chem Lab: Safety in Every Step*, which is a Films for the Humanities and Sciences Production. It is available through Films on Demand, if your institution has a subscription. It is also available as an eVideo through a number of libraries. However, any safety video that shows lab work and discusses risk management will work.

[At home] Optional reading assignment: Continue Chapter 9 in Seidman, Moore, and Mowery.

Block 2:

[Up to 2 hours] Classroom Activity 6: *Analyzing Safety Issues in a Laboratory Procedure (in Seidman, Kraus, Brandner and Mowery)*

Comments: I have students complete this as their quiz for this course. They are given access to all of the materials that they will need to complete this exercise. The goal is to model the practice of analyzing a procedure and looking at risk assessment. Here is an example of the prompt I would give the students:

Complete Classroom Activity 6 in your lab manual. Please document all of your work and your thought processes. The most important thing is that I see, from your written document, that you understand how to identify hazards in a procedure and understand the processes you should follow to analyze and plan for a new procedure. Please provide enough text in your document that you walk me through your analysis. (Do not just provide a three-word answer to the questions; tell me HOW you arrived at your conclusions and what you have learned about planning to work safely in the laboratory. I'd expect about a two-page typed document for this activity.) This grade will count as a quiz grade, so please do your best work on this activity.

Module 4: Emergency Response and Chemical Classification

Format: Two blocks

Objectives:

- Discuss proper response to emergency situations.

- Discuss the proper use of fire extinguishers.
- Use safety information resources to learn about the hazards of chemicals.
- Use laboratory tests to help identify chemicals.
- Use safety information to determine proper disposal methods for hazardous chemicals.

Block 1:

[40 minutes] Lecture: *Emergency response plans (provided as a PowerPoint PDF document)*

[15 minutes] Video: *Fire extinguisher training video. (currently available as a YouTube video: <https://www.youtube.com/watch?v=ONUIMSbrog>)*

Any similar video will do.

Comments: If the opportunity arises to provide actual, hands-on training with fire extinguishers, this is something to seriously consider.

Block 2:

[Up to 60 minutes] Laboratory **Preparation:** *Classification of mystery substances (provided as PDF document)*

Supplemental material: This laboratory activity is based on the Flinn Scientific activity *Mystery Substance Identification: The Identification of Unlabeled Laboratory Chemicals Found on School Premises* available at:

<http://www.flinnsci.com/media/755029/mystery.pdf>

Structure: You can make this lab fit into the time you have simply by increasing or decreasing the number of chemicals provided to the students. Please note that Flinn Scientific has many resources supporting safety and it is worth spending a fair amount of time just introducing the students to these materials.

Comments: This laboratory is primarily about the use of safety information to learn about hazards, handling, and disposal methods for hazardous chemicals. It also stresses good laboratory notebook documentation. I focus on the process for identifying

chemicals, rather than memorization of particular tests and test results. When employed, no one would want workers to “work from memory” for a task as crucial as proper disposal of hazardous chemicals!

[At home] Optional reading assignment: Chapter 10 in Seidman, Moore, and Mowery.

Module 5: Introduction to Radioisotopes (Part one)

Format: Two blocks

Objectives:

- Discuss types of ionizing radiation.
- Discuss hazards posed by working with radioactivity in the laboratory.
- Practice half-life calculations.
- Introduce the biological effects of radiation exposure.
- Illustrate how radiation doses are measured.
- “Visualize” radioactive particle emission using the cloud chamber.
- Learn how time, distance and shielding are employed to protective radiation workers.
- Practice half-life calculations.

Block 1:

[40 minutes] Lecture: *Introduction to Radioisotopes: Measurements and Biological Effects (provided as a PowerPoint PDF document)*

Comments: This unit is based on materials available from the University of Wisconsin-Madison radiation safety program. Their manual, *Radiation Safety for Radiation Workers* is available as a PDF online at the UW-Madison Environmental Health and Safety website. Any institution’s radiation safety manual should work, however. This first lecture introduces the concept of ionizing radiation, identifies the major types and discusses which are internal and which are external hazards. It also introduces the concept of half-life. The math involved is practiced in class, later. The lecture concludes with a discussion of the measurement of radiation dose received by workers,

and the potential biological effects.

[20 minutes] Activity: Radiation safety case study assessments (***provided as Word document***)

Comments: These two scenarios may be best addressed in pairs or small groups.

Discussion afterward also helps students realize how easy it is to track radiation around the laboratory and how important it is to always monitor where the radiation is.

[40 minutes] Laboratory: Cloud chamber

Materials:

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Cloud Chamber (***Carolina Biological Supply: #759240***)

Video: *Cloud chamber to observe radioactivity* (***available as a YouTube video; for example: <https://www.youtube.com/watch?v=7VH9l4hgblI>***)

Comments: This laboratory allows students to indirectly visually radioactive particles by observed vapor trails left by ionization in an alcohol cloud. Students really enjoy this lab, the level of radioactivity used is low but real, and makes an impression – one that is later enforced in the Time, Distance, Shielding laboratory. Once the cloud chamber lab has been completed, the concept of shielding as protection is much easier to understand (and remember!) The Cloud Chamber laboratory is available from Carolina Biological Supply Company. I show the above listed very brief video to help the students understand the Cloud Chamber.

[At home] Optional reading assignment: At home you may wish to assign pages out of whatever radiation safety manual you choose. However, these manuals are often dense. Additionally, your students will be required to receive additional training in the event that they ever work with radioisotopes, so it is likely that simply reviewing lecture notes at home will be sufficient for student understanding and success.

Block 2:

[60 minutes] Lecture: *Working with Radioisotopes: Reducing the Risk (provided as a PowerPoint PDF document)*

Comments: This lecture is also based on materials from the UW-Madison radiation safety training manual. Their manual, “Radiation Safety for Radiation Workers” is available as a PDF online at the UW-Madison Environmental Health and Safety website. Brief notes are provided.

[60 minutes] Activity: *Radiation safety half-life calculations and Radiation safety half-life calculations answer key (PDF document)*

Comments: A key is provided. I have the students graph by hand or Excel both in standard and semi-log formats and work with the half-life equation presented. This can take much less than an hour if you only want the students to plug numbers into the equation. Many online resources can introduce half-life calculations in-depth if you need more material than was presented in the first lecture.

Module 6: Introduction to Radioisotopes (Part two)

Objectives:

- Examine the effects of time, distance and shielding on radiation exposure
- Discuss the inverse square law
- Complete assessment

[Up to 2 hours] Laboratory: *The effects of time, distance and shielding on radiation exposure (provided PDF document)*

Supplemental material:

Comments: This lab is a very visual representation of the effects of time, distance and shielding on radiation exposure, and how these three parameters can be manipulated to reduce risk to workers. I generally let the students submit the worksheet provided as

their documentation for this laboratory. Sources can be purchased without a license from companies such as Images SI, Inc. (Staten Island, NY).