ABSA INTERNATIONAL
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INTRODUCTION TO BIOSAFETY
LEARNING OBJECTIVES

Biosafety Curriculum for Undergraduate and Graduate Students

Target audience:

- 5-credit course: any interested undergraduate student from any background. This course is intentionally designed without prerequisites. This course could function as an introduction to biosafety for undergraduates who want to minor in biosafety and/or have a career interest in biosafety or occupational safety.
- 1-credit course: undergraduate students entering the laboratory for the first time. This course is designed to be a primary component of the introductory training for the sciences and is intended to improve safety in the teaching and research labs.
- Either the 1-credit or 5-credit courses may be adapted to graduate programs hoping to improve biosafety in their labs. This course is a potential introductory training for those entering research that involves potentially infectious material. It is our hope that it will become a staple in research training much like bioethics.

Expected term: 12-15 five-day weeks

5 credit hours: three 1.5 hour class sessions per week
1 credit hour: one 1 hour class session per week

Whole-course learning objectives:

- Students will be able to list the routes of exposure for a pathogen to a human being
- Students will be able to demonstrate and assess the proper use of PPE, best practices, biological containment, and be prepared to safely conduct research
- Students will be able to identify the role of the Biosafety Professional in Biomedical Research Laboratories

Directions to Instructor

The learning objectives are written to chart a path through the frequently complicated landscape of biomedical research to help develop an understanding of the risks involved, as well as the measures frequently used to mitigate those risks. The instructor is encouraged to determine how best to achieve each learning objective in a way that engages the students and encourages them to take ownership of the knowledge. We suggest the instructor approach the class with a problem solving-based approach, a workbook is included in the package to aid in that teaching method. The workbook contains multiple tools that allow the instructor to measure a student's progress in understanding the course material. It also contains questions that can be used as a final examination as well as several exercises and case studies.

Week 1: Introduction and History

A. History of Biosafety
    1. Students will be able to identify the following as major historical events that contributed to the development of the profession of Biosafety:
        a. The US Bioweapons Program (in the context of the Cold War)
        b. Operation Whitecoats
        c. The first Asilomar Conference
B. Laboratory-Associated Infections
    1. Students will discuss how LAI's were considered an occupational hazard in the past, but have not been considered acceptable since passage of the Occupational Safety and Health Act and the Blood-Borne Pathogens rule
C. Introduction to Biosafety Levels
    1. Students will be able to describe the minimum requirements of a BSL-1, - 2, -3, and -4
D. LAI Case Studies
    1. The exercise will walk students through three famous LAI cases:
        a. Janet Parker - 40 year old medical photographer with office adjoining smallpox lab (via HVAC): fatal smallpox infection
        b. Richard Din - 25 year old unvaccinated laboratory technician working with *Neisseria meningitidis*: fatal meningococcal disease
        c. Malcolm Casadaban - 60 year old PhD research professor studying attenuated *Yersinia pestis* but had the condition hemochromatosis which complemented the mutation and resulted in a fatal case of plague
E. Movie Night: *Outbreak*
    1. Students will watch the movie *Outbreak* and will write down at least three items, practices, or summarized conversations they saw in the movie that may have been inaccurate/interesting representation of safety in the laboratory. The instructor will facilitate a discussion about these same topics in class using the students' notes as a starting point.

Week 2: Basic Microbiology and Epidemiology

A. Basic Microbiology
    1. Students will be able to recognize general microbial characteristics to consider when working with bacteria, viruses, fungi, or parasites
        a. Drug sensitivities and resistances
        b. Route(s) of exposure resulting in fulminant infection and the name of the associated disease
        c. Size of microorganisms
        d. Vulnerability of microorganisms to disinfectants and/or clinical therapeutics
        e. Environmental stability
    2. Students will be able describe the how microorganisms move/spread in the environment
        a. Direct transfer
        b. Fomites
        c. Aerosol generation
        d. Through a liquid medium (diffusion or motility)
    3. Student will be able to define the routes of transmission:
        a. Inhalation
        b. Ingestion
        c. Inoculation
        d. Direct contact
    4. Student will be able to demonstrate proper aseptic technique
    5. Students will be able to list the features associated with each biological risk group
B. Mycology

1. Students will be able to identify the physiological features of a prototypical fungus
2. Students will be able to identify and order the prototypical fungal life stages
3. Students will be able to describe the difficulties of decontaminating fungal spores, being sure to mention that they are more resilient to heat and chemical inactivation than their vegetative counterparts

C. Bacteriology
   1. Students will be able to describe the differences between gram negative and gram positive bacteria
   2. Students will be able to list factors that influence bacterial stability in the environment (i.e. humidity, temperature, bacterial state {vegetative state vs spore})
   3. Students will be able to identify the contributing factors in bacteria developing antibiotic resistance
   4. Students will describe the role of biofilms in the natural life cycle of a prototypical bacterium

D. Virology
   1. Students will be able to differentiate viruses based on: presence or absence of lipid coat, tegument, and genome type (dsDNA, ssDNA, ss(+)RNA, dsRNA, (-)RNA)
   2. Students will be able to describe a general viral infection cycle
      a. (attachment/binding → invasion → genome delivery → genome replication and viral particle replication → packaging/assembly → release)
      b. Students will be able to differentiate between lytic, persistent, and latent viral infection

E. Parasitology
   1. Students will be able to explain that the word "parasite" describes a way of life for an organism and human parasites span several branches of the tree of life; they can be single celled or multicelled that can cause mild to severe disease
   2. Students will be able to differentiate one clinically relevant parasites from each major group of parasites: *Plasmodium falciparum* is a protozoan parasite that causes malaria. *Necator americanus* which is a helminth responsible for hookworm infection. *Fasciola hepatica*, which is a parasitic fluke responsible for Fascioliasis. *Sarcoptes scabiei*, which is an ectoparasite responsible for the disease scabies
   3. Students will be able describe, in general terms the principle of parasitism and the need for both an appropriate host and life cycle stage for effective transmission

F. Toxins
   1. Students will be able to define "toxin" and be able to describe in general terms how they are utilized by microorganism
   2. Students will be able to differentiate between different microbial toxins including: mycotoxin (aflatoxins, ochratoxin, etc.), bacterial toxin (endotoxins and exotoxins) and give examples of each
   3. Students will be able to demonstrate general understanding of the mechanism of action of several key microbial toxins (aflatoxin, LPS, botulinum neurotoxin)

G. Host-Pathogen Interactions
   1. Students will be able to list the different microbial host relationships (commensal/colonization, mutualistic, parasitic)
      a. Students will discuss how, frequently, it is not in the best interest of the microorganism to kill its host
   2. Student will be able to summarize the different stages of infection.
   3. Students will appreciate that each host's response to infection can potentially be unique and that frequently, it is the immune response that causes damage in infection

H. Aerobiology
   1. Students will be able to place, on a scale diagram, a viral particle, a bacterium, a droplet nuclei, and a water droplet

2. Students will be able to compare and contrast between a droplet exposure and an aerosol exposure
3. Students will know the correct definition for "indefinitely buoyant

I. Disease Transmission and Epidemiology
   1. Students will be able to explain the "chain of infection" concept and the value of breaking that chain
   2. Students will be able to describe the process of contact tracing
   3. Students will be able to distinguish between an outbreak and a pandemic
   4. Students will quickly review the routes of transmission

J. Aseptic Technique & Standard Microbiological Practices
   1. Students will be able to define the goal of aseptic technique and how it can benefit research
   2. Students will be able to list the common sources of experimental contamination
   3. Students will be able to demonstrate (orally or practically) procedures to serial dilute and prepare culture
   4. Students will be able to list the standard microbiological practices

*Inclusion of this series of lectures presumes that this course is offered to a broad audience and does not include many (if any) prerequisites. If the school or instructor determines that a course in microbiology is a prerequisite for Introduction to Biosafety, then consider removing the didactic components and keeping the practical components focused primarily on Aseptic technique and Standard Microbiological practices. Regardless, the instructor should tailor the content of this section to the audience; i.e. Parasitology lecture should not be offered in a setting where no parasite work will be done even though multiple categories of microbes will be included in this curriculum package.
‡Chemical and radiation safety should be available to students from chemistry instructors. It is not included in this course as this course is focused on biological safety. Please verify with Chemistry faculty that they are receiving this training and consider assessing their chemical safety curriculum.

Week 3 - Molecular Biology

A. Central Dogma and Common techniques
   1. Students will be able to describe the transition of information from DNA to RNA to protein through the processes of transcription and translation and the perpetuation of information via DNA replication
   2. Students will be able to define Molecular Biology as the study of how biological molecules interact to produce the properties and behavior of cells, tissues, and organisms
   3. Students will be able to list several of the central tools of molecular biology:
      a. Cell culture: that cells can be cultured *in vitro* - either from primary sources or from established cell lines
      b. Recombinant nucleic acids: that DNA can be altered or manipulated and this allows us to test the roles of different genes and gene products in their interactions with each other
   4. Students will be able to recognize that viruses frequently subvert and manipulate the Central Dogma and that they have been developed into tools to deliver engineered nucleic acids into living cells
      a. Students will recall the basics of Adenoviral vector function and the role of Adeno-associated viruses or "helper viruses" and safety features
      b. Students will be able to list and explain the basics of lentiviral vector function and safety features
      c. Students will be able to list and explain the basics of retrovirus vector function and safety features

B. Common Techniques exercise

1. At the instructor's discretion, students will select a common Molecular Biology technique or technology from the supplemental document "Molecular Biology Tools" and identify any safety concerns raised by the technology

C. Recombinant DNA Guidelines, the Asilomar Conferences, and the Institutional Biosafety Committee
    1. Students will be able to recall that after the first recombinant DNA experiments, scientists recognized the potential dangers, self-imposed a moratorium on recombinant research and convened the first Asilomar conference
    2. Students will be able to recall that the first Asilomar conference set the precedent for performing official risk assessments on proposed research and establishing Biosafety Levels under which the work will be performed. The principles eventually became integrated in the NIH rDNA guidelines
    3. Students will be able to explain how the rDNA and synthetic nucleic acid guidelines apply to any investigator using Department of Health and Human Services (NIH) funds to perform research and why many institutions adopt them as policy even when not required
D. Impacts on Risk Assessment and BSL
    1. Students will be able to describe how genetic engineering can modify the behavior or properties of microorganisms
    2. Students will be able to describe the value of re-assessing the risk of transgenic organisms, taking into account potentially new behaviors or properties of these modified organisms
E. Students will be informed of some of the Current Trends in Molecular Biology relevant to Biosafety
    1. Small RNA technologies. One popular technology is the use of small, synthetic RNA oligos in conjunction with the RISC complex to cleave RNA and this is being used to modulate gene expression, amongst other things
    2. CRISPR/Cas. CRISPR/Cas is an RNA-mediated "homing" mechanism that delivers a DNA endonuclease (Cas9) to a specific sequence and induces a double-strand break in the target DNA strand
    3. DIY Bio Movement (i.e. the intentional use of biohazardous materials outside of formalized institutions)
F. Case Studies
    1. Students will read the following papers and discuss in class how recombinant technology resulting in unexpected changes in a microorganism's behavior and properties should have changed a risk assessment
        a. Jackson, R. J., et al. "Expression of mouse interleukin-4 by a recombinant ectromelia virus suppresses cytolytic lymphocyte responses and overcomes genetic resistance to mousepox." J Virol **75**(3): 1205-1210. PubMed ID: 11152493
        b. Smulian, A. G., et al. "Expression of hygromycin phosphotransferase alters virulence of Histoplasma capsulatum."Eukaryot Cell **6**(11): 2066-2071 PubMed ID: 17873086
        c. Fu, Y., et al. "High-frequency off-target mutagenesis induced by CRISPR-Cas nucleases in human cells." Nat Biotech 31(9): 822- 826. PubMed ID: 23792628
        d. Tumpey, T. M., et al. "Characterization of the reconstructed 1918 Spanish influenza pandemic virus." Science **310**(5745): 77-80. PubMed ID: 16210530
        e. Cello, J., et al. "Chemical synthesis of poliovirus cDNA: generation of infectious virus in the absence of natural template." Science **297**(5583): 1016-1018. PubMed ID: 12114528

†Inclusion of this series of lectures presumes that this course is offered to a broad audience and does not

include many (if any) prerequisites. If the school determines that a course in molecular biology is a prerequisite for Introduction to Biosafety, then consider removing the didactic components and keeping the practical components focused primarily on the impact of molecular biology upon a risk assessment and BSL.

Week 4 - Risk Assessment

A. Student will be able to define the components of a biological risk assessment.
    1. Identify the hazard
        a. A good resource is the Canadian Public Health Agency's Pathogen Safety Data Sheets and other resources for information gathering
    2. Determine the potential negative outcome(s) of a given hazard and the frequency of occurrence (i.e. "risk")
    3. Determine if the risk is acceptable
    4. If the risk is not acceptable, develop a mitigation plan that brings it to an acceptable level
B. Student will be able to differentiate between formal and Informal risk assessment and know when to apply them
    1. Formal: performed by the Institutional Biosafety Committee
    2. Informal: performed by a laboratory worker in real time
C. Student will be able to explain how the laboratory procedures influence a risk assessment
    1. E.g. aerosol exposure vs. ingestion exposure vs. parenteral exposure
D. Students will demonstrate how to correctly perform a risk assessment based on case studies and projects
    1. The projects for the class should all build off of one another and include progressively more difficult situations
        a. Performing basic investigation of a known Risk Group II pathogen
            i. *in vitro* work (i.e. growth in a model system, harvest of DNA, RNA, or protein)
            ii. recombinant *in vitro* work (i.e. testing function of unknown genes)
            iii. identification and verification of a virulence factor (i.e. testing a new gene in an animal model of disease)
        b. Classifying the pathogenesis of an unknown organism
            i. ***in vitro* work (i.e. tissue culture challenge):** initial pathogen characterization
            ii. **in vivo work (working with animals):** studying disease
            iii. progression using animal models
            iv. ***in vivo* recombinant work:** modifying the wild-type organism to better characterize pathogenesis
            v. **Vaccine development**: creating a chimeric organism for the purpose of vaccine protection studies.

Week 5 - Biosafety Levels

A. Students will describe that one way to mitigate risk is to perform proposed work at a higher Biosafety Level and what that means.
B. Biosafety Level 1
    1. Students will be able to describe facility features and special practices of a BSL-1 laboratory including Standard Microbiological Practices and aseptic technique
    2. Students will be able to identify or list PPE that is appropriate for BSL-1 laboratory
    3. Students will use risk assessment to describe research that would be conducted at BSL-1
C. Biosafety Level 2
    1. Students will be able to describe facility features and special practices of a BSL-2 laboratory and how BSL-1 features contribute to it
    2. Students will be able to identify or list PPE that is appropriate for BSL-2 laboratory

3. Students will use risk assessment to describe research that would be conducted at BSL-2
    a. Particularly, they will focus on the properties of the organism, the procedures or types of experiments being performed, and if any genetic modification
4. Students will be able to understand what goes into biosafety 2 laboratory with 3 practices

D. Biosafety Level 3 (Briefly)
1. Students will be able to describe facility features and special practices of a BSL-3 laboratory and how BSL-2 features contribute to it
2. Students will be able to identify or list PPE that is appropriate for BSL-3 laboratory
3. Students will use risk assessment to describe research that would be conducted at BSL-3

E. Biosafety Level 4 (Briefly)
1. Students will be able to describe facility features and special practices of a BSL-4 laboratory and how BSL-3 features contribute to it
2. Students will be able to identify or list PPE that is appropriate for BSL-4 laboratory
3. Students will perform a risk assessment to describe research that would be conducted at BSL-4

F. Students will be able to recognize that some research projects involving infectious agents are performed in nonstandard models and require specialized features to work safely in containment (Briefly)
1. Students will be able to identify two of the following specialized types of containment research facility:
    a. Agricultural BSL-3 (BSL-3 Ag)
    b. Greenhouse
    c. Arthropod Containment Laboratory
    d. Aquatics containment facility

Week 6 - Personal Protective Equipment (PPE)

A. Students will be able to explain how different pieces of PPE protect the different routes of exposure from infection

B. Types of PPE
1. Students will describe when it is appropriate to use the following types of PPE:
    a. Gloves - protect hands
    b. Bite scratch resistant glove
    c. Chemical resistant glove
    d. Nitrile or Latex
        i. double gloving
        ii. taping gloves
        iii. working with 2 colors
    e. Lab coats, gowns, and scrubs - protect skin on body, legs, and arms
        i. Reusable lab cloth coat
            (a) cotton vs. polyester vs. blend
        ii. Closed front gowns disposable gowns
        iii. Water impermeable closed front gowns
        iv. Tyvek
    f. Close-toed shoes - protect feet
        i. Leather-top shoes
        ii. Fabric-top shoes
    g. Eye protection - protect eyes
        i. Face shields
        ii. Safety glasses
        iii. Safety Goggle
    h. Respiratory protection - protect upper and lower respiratory tract
        i. Surgical mask is not respiratory protection

ii. N95
iii. PAPR
iv. Positive pressure suit

i. Appropriate laboratory attire
i. Street clothes
ii. Washable scrubs
iii. Paper disposable scrubs

C. Students will be able to demonstrate how and when to use respirators in the laboratory and will be made aware of the requirement for medical evaluation and fit-testing
D. Students will demonstrate risk assessment based PPE selections by recommending appropriate PPE for several case studies. Examples below:
1. A laboratory that uses botulinum neurotoxin in tissue cultures assays to study cytotoxicity
2. A laboratory that uses *mycobacterium tuberculosis* in aerosol challenges of guinea pigs
3. A laboratory that studies innate immune response to West Nile Virus using a primary cell line
4. A laboratory doing a necropsy on a mouse infected with *streptococcus pneumoniae*
E. Students will be able to demonstrate how to properly select, don, and doff different types of PPE (exercise)
F. Students will be able to demonstrate proper doffing procedure with a functional assessment using Glo Germ or equivalent. The exercise will focus on cross- contamination, proper doffing, and disposal of PPE exercise
G. Poor combinations of PPE (more =/= better)
H. Students will consider at least one scenario in which a researcher or technician is encumbered or impeded by too much PPE. They should focus on redundant PPE and participate in a discussion about acceptable risk and choosing the appropriate solution for a given hazard. Examples below:
1. Wearing 3 pairs of gloves
2. Wearing a PAPR over a surgical mask
3. Face shield and goggles

Week 7 - Laboratory Facilities and Safety Equipment

A. B Principles of engineering control, e.g. mechanical pipetters, sharps safety
1. Students will be able to define an engineering control as the removal of a hazard at its source by design of equipment or facility
2. Students will be able to identify the following as examples of engineering controls:
a. A mechanical pipetter that replaces mouth pipetting
b. Safer sharps that minimize the chance of a needlestick
c. A facility design that avoids moving contaminated material through the same space that uncontaminated material moves through
3. Biosafety cabinets
a. Students will be able to explain how a biosafety cabinet provides, user, product, and environmental protection.
b. Students will observe a smoke demonstration (in-person or on video) and discuss:
i. how fragile the directional airflow in a BSC is
ii. how air is partitioned as it moves from the top of the cabinet to the grilles.
c. Students will be able to demonstrate
i. how to enter and exit the BSC with minimal airflow disruption
ii. how blocking the grilles compromises BSC function
iii. how walking near a functioning BSC or leaving nearby doors open disrupts BSC function
iv. how even small movements and clutter in the cabinet can cause turbulence and

compromise the effectiveness of the BSC
v. how to plan the cabinet setup in advance and prepare the cabinet to accommodate a clean to dirty workflow and avoid moving arms from inside the cabinet to outside unnecessarily
vi. how to decontaminate pipette tips or other disposables while working in the BSC
d. Students will demonstrate how to verify function and certification of a BSC
e. Students will demonstrate how to set up their cabinet from clean to dirty and establish a workflow in the same direction

4. Directional airflow
   a. Students will be able to explain how directional airflow in laboratories provides protection from contaminated aerosols
   b. Students will be able to identify the support space housing the mechanical components providing directional airflow as large, expensive, and managed by engineers
5. Building Automation Systems
   a. Students will be able to recall that HVAC, doors, fire, and other alarms and statuses are frequently monitored by building engineers via a Building Automation System
6. Fire Detection and Control Systems
   a. Students will be able to recall that laboratories are rated by the estimated volume of flammable materials present and designed accordingly with sprinkler systems, fire extinguishers, and emergency exits
7. Effluent Decontamination Systems (optional)
   a. Students will be able to recall that liquid waste (effluent) from some labs is treated by effluent decontamination systems
   b. Students will be able to recall that EDSs can use heat inactivation or chemical inactivation, but either must be validated
8. Design a Facility Assignment
   a. Students will receive an assignment to design a high containment laboratory which will be assessed from both a safety and a function perspective

Week 8 - Disinfection, Decontamination, and Sterilization

A. Students will be able to define:
   1. Disinfection as "the elimination of nearly all recognized pathogenic microorganisms but not necessarily all microbial forms on inanimate objects"
   2. Decontamination as "the reduction in quantity of a target hazard to an acceptable level"
   3. Sterilization as "the destruction of all life"

B. Spill Cleanup
   1. Students will be able to demonstrate the appropriate response to a spill is:
      a. to surround a spill with absorbent material
      b. flood it with fresh disinfectant
      c. allow contact time
      d. dispose of properly
      e. contact their supervisor and occupational medicine professional
   2. Students will be able to identify the following as best practices that prevent avoid cross-contamination:
      a. Flood and wipe, don't spray
      b. Communicate
      c. Move slowly and deliberately
      d. allow contact time of disinfectant
      e. Think through what is contaminated very carefully - your gloves and clothes are likely

dirtier than you think

C. Waste Disposal
    1. Students will be able to identify waste disposal as a complicated topic, with regulations specific to each location, and if done improperly, can result in large fines, negative environmental impacts, or other negative consequences
        a. Students will discuss each state, and potentially each municipality has different rules for waste disposal. It is at the instructor's discretion to enumerate these rules for their specific location
    2. Students will be able to identify the appropriate Safety professional to contact for help in disposing of waste

D. Selection of Disinfectants
    1. Students will be able to recall that the EPA and FDA maintain lists of approved disinfectant
    2. Students will be able to explain why there is no perfect disinfectant; it is always a trade-off between efficacy, volatility, toxicity, and materials compatibility
        a. Students will be able to explain why different organisms (and sometimes, growth phase of organism) have different susceptibilities to different disinfectants (i.e. mechanisms of action vary per disinfectant and targets vary by organism and, sometimes, growth phase)
        b. Students will be able to explain why different toxins have different sensitivities to heat or chemical action (e.g. proteinaceous or non-)
    3. Students will be able to explain that different disinfectants have different chemical properties and therefore different interactions with different surfaces or matrix components (e.g. high organic load) - i.e. materials compatibility varies between disinfectants and applications
    4. Students will be able to explain why they need to verify the activity of their disinfectant on their target organism in their planned application

E. Mechanisms of action and categories of disinfectants
    1. Students will be able to recognize the following categories of disinfectants: quaternary ammonium compounds, oxidizers (bleach, chlorine dioxide, hydrogen peroxide), phenolics, reducers (sodium hydroxide), alcohols, and formaldehyde
    2. Students will be able to discuss the following mechanisms of action:
        a. quaternary ammonium compounds have several mechanisms of action including membrane and protein disruption
        b. oxidizers chemically modify lipids, proteins, and nucleic acids to render them non-functional
        c. phenolics are membrane and protein disruptors
        d. alcohols are protein and membrane disruptors formaldehyde is a protein and membrane disruptor

F. Mixed waste
    1. Students will be able to recognize that mixed waste is a combination of two or more of these three types of waste: radioactive and biohazardous or chemically hazardous materials
    2. Students will be able to recall that mixed waste is either disposed of at great expense directly or treated to remove one or more of the hazards before being disposed of as only one kind of waste

G. Sterilization
    1. Students will be able to differentiate between sterilization (the total destruction of all life) and decontamination (the reduction of a target contaminant to an acceptable level)
    2. Students will be able to identify autoclaving (heat and steam exposure) as a process frequently used to achieve sterilization for waste and heat- stable objects
    3. Students will be able to describe how gas decontamination with formaldehyde,

vaporized hydrogen peroxide, or chlorine dioxide are commonly used methods to effectively sterilize large areas such as laboratories

Week 9 - Regulatory Compliance/Best Practices/ Process Validation

A. Procedure and process validation
    1. Students will demonstrate how to design experiments to test/ validate disinfection and sterility procedures
        a. What are the proper controls?
        b. How do you decide what to use as a readout or indicator? (i.e. turbidity in growth media, plaque assay, CFUs on an agar plate
B. If you didn't write it down, it didn't happen
    1. Students will be able to explain why, from a regulatory perspective, if an action or activity was not written down AS IT HAPPENED then it DID NOT happen
    2. Students will appreciate that this mindset extends to all aspects of a research program that the regulatory body is interested in
    3. Students will be able to describe general rules and practices dealing with record keeping (inventory, autoclave logs, waste manifest)
C. The inspection process
    1. Students will be able to identify that there are announced and unannounced inspections
    2. Students will be able to describe a typical inspection process: an opening meeting, a program review, worker interviews, a facility review, and an exit meeting or briefing
    3. Students will be able to recognize that inspectors perform their assessment by comparing what they observe to relevant regulations, laws, or best practices and will cite the relevant document when noting a variation/finding
    4. Students will be able to paraphrase that, in most contexts, an institution will receive a formal report listing findings or deficiencies and have a specific time frame in which to either correct findings or design a Corrective Action Plan
    5. Students will be able to describe the contents of a Corrective Action Plan must address findings, outline the intended response, identify a timeline for the response, and identify an individual responsible for the response
D. Potential consequences of non-compliance
    1. Students will be able to discuss that monetary fines, loss of funding, or even jail time can be an official consequence of non-compliance
    2. Students will be able to discuss how the impact to an institution's reputation can be equally powerful and can result in difficult relations with the community, funding sources, potential collaborators or prospective faculty in the future
E. Select Agents - DSAT, APHIS
    1. Students will be able to define the term "select agent" and list characteristics that go into their selection
    2. Students will describe the mission of APHIS and DSAT and be made aware of the corresponding CFRs
    3. Students will be able to recognize that Select Agents infractions can lead to a delay or stoppage of research. They will also recognize that it can result in jail time
F. APHIS (permits)
    1. Students will be able to recognize that USDA APHIS issues permits for the import, transit and release of regulated animals, animal products, veterinary biologics, plants, plant products, pests, organisms, soil, and genetically modified organisms
    2. Students will be able to identify a permit as a highly specific, non- transferable permission from USDA APHIS to do specific work, and comes with an expiration date
G. AAALAC/OLAW/IACUC
    1. Students will be able to define AAALAC/OLAW's/IACUC mission

2. Students will be able to identify how different governing bodies affect their research and where they fit in biological research

H. NIH OBA
   1. Students will be able to describe the role of NIH OBA and how they affect their research
   2. Students will be given a brief overview of the NIH rDNA guidelines, institutional biosafety committees, and oversight for human gene transfer studies
   3. Students will be able to define dual use research and the considerations when evaluating your own research

I. OSHA
   1. Students will be able to define the jurisdiction of OSHA as all activities affecting commerce and thus applicable to laboratory activities
   2. Students will be able to clarify that some states can have their own OSHA if and only if the state OSHA meets or exceeds the baseline set by Federal OSHA
   3. Students will be able to restate that OSHA says that all workers have the right to work in an environment free from hazards; if those hazards are integral to the work, they have the right to be protected from them
      a. Specifically, that anyone working with human blood or other potentially infectious material is to be knowledgeable of Blood- Borne Pathogens

J. DOT/IATA
   1. Students will be able to summarize that the transport of biological or chemical hazards is regulated by the Department of Transportation (when shipped domestically or via ground only) or IATA (when shipped internationally or via air)
   2. Students will be able to recognize that the liability for shipment of materials lies on the INDIVIDUAL who shipped it, NOT the institution and that fines can be substantial
   3. Students will be able to cite the fact that a person must be specifically trained to ship biological materials and certified by their institution to be able to do so

K. Other
   1. Students will be able to clarify that the listed agencies are not the only regulatory bodies one might encounter
      a. Local government i.e. state and city regulation and others

Week 10 - Laboratory Security & Emergency Response

A. Personnel suitability programs
   1. Students will be able to list the components of a personnel suitability program
      a. pre-access suitability
      b. Students will be able to list all of the components of pre- access suitability
      c. Students will be able to explain when/ how pre-access suitability should be used
         i. background investigation, interviews, mental health screen, financial records, international travel history, etc.…
      d. Personnel reliability
         i. Students will be able to list all of the components of the personnel reliability program
         ii. peer reporting, counseling, whistleblower protection
         iii. Students will be able to recognize the value of a peer reporting through the use of case studies and exercises
      e. Personal security
         i. Students will be able to demonstrate their understanding of physical security and the 3 major components
            (a) Personnel security (guards, cameras), Information security (IT security passwords), access control (locks, key cards, biometrics)
         ii. Students will also be able to summarize key components of situational

awareness and be coached in how to respond to suspicious package, and suspicious people

B. Targeted violence process
    1. Students will be able to diagram the components of the targeted violence process
        a. Students will be able to describe how "Intent, Ability, and Opportunity" fit into the targeted violence process and be able to define the associated terms
        b. Intent
            i. Grievance
            ii. Ideation
        c. Ability
            i. Planning
            ii. Preparation
        d. Opportunity
            i. implementation
C. Mental health awareness and available resources
    1. Students will be able to recall that, according to the research, poor mental health does not always equate with violence, but that certain personality types more frequently correlate with violent behavior
    2. Students will be able to recognize that stress and fatigue contribute to accidents in the lab and weaknesses in security
    3. Students will be able to conclude that supporting worker wellness is a valuable investment in laboratory safety and productivity; this support can include a number of different programs or resources made available to the worker
D. Emergency response, disaster response, and continuity of operations
    1. Students will be able to describe the phrase "life safety supersedes biosafety" and understand when this is applicable
    2. Students will be able to describe some key features of a successful emergency response
    3. Students will be able to describe a healthy relationship between a research institution and their supporting emergency response services - be it in the surrounding community or within the institution
    4. Students will be able to describe a successful Continuity of Operations plan
E. Students will be able to describe several ways that the "Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism Act" (USA Patriot Act) strengthen regulation on biological materials

Week 11 - Administrative Controls

A. Administrative controls
    1. Students will be able to define administrative controls as the reduction of risk by institutional policy or workplace practices
    2. Students will be able to describe how effective that administrative controls rely on the dutiful compliance to rules by those performing work
B. Replacement/substitution with lower hazard
    1. Students will be able to conclude that one way to reduce risk is by using an organism of lower risk in a study rather than a fully virulent organism
C. Standard Operating Procedures
    1. Students will be able to identify one way to ensure compliance with institutional (or laboratory) policy is to write and enact a Standard Operating Procedure for a specific task
    2. Students will be able to write a good SOP which describes the proper place, circumstances, and way to perform a specific task, is sufficiently specific but not overly wordy, includes pictures when helpful, and can (ideally) fit on a single page
D. Institutional Policies

1. Students will be able to describe the typical regulatory balance between the Institutional Biosafety Committee, Institutional Animal Care and Use Committee, and the Institutional Review Board
2. Students will be able to paraphrase how an institution reviews regulatory requirements from multiple levels and locations, industry standards, best practices, and institutional goals and risk tolerance to set institutional policy

E. Signs, placards, and other mass media
   1. Students will be able to identify signs, placards, and other mass media can serve as a vehicle for communicating institutional policy, or reminding workers of said policy
F. Administrative systems and programs in place to support laboratory safety
   1. Students will be able to list several programs are typically in place to support laboratory safety, they can include (but are not limited to):
      a. Protocol review and approval by IBC, IACUC, or other safety committee
      b. Occupational medicine
      c. Respiratory protection program (respirator medical clearance and fit test)
      d. Laboratory Safety Surveys (or inspections)
      e. Select Agents program
      f. Preventative Maintenance programs
      g. Hazardous Waste and Radiation safety programs
      h. HazMat or other emergency response teams
      i. Biosurety or other suitability assessments including background screening
      j. Mental health counseling or other resources (ombudsman, placement service, etc.)
G. Hierarchy of Controls
   1. Students will be able to rank the types of hazard controls according to their place in the Hierarchy of Controls:
      a. Elimination or substitution (most effective)
      b. Facility or equipment design - Engineering controls
      c. Awareness tools - administrative controls
      d. Training and procedures - administrative controls
      e. Personal Protective Equipment (least effective)

Optional Course Content - Current topics in Biosafety

A. Achieving Compliance - working with recalcitrant elements and imperfect channels of communication
   1. Students will be able to discuss scenarios in which not all stakeholders in a laboratory environment wish to cooperate with all safety initiatives
   2. Students will be able to explain why that imperfect communication hinders the implementation of safety programs
   3. Students will be able to describe at least two strategies for dealing with recalcitrant elements
      a. Negotiation
      b. Recruit them to the IBC or IACUC (or other safety committee)
B. Limited Resources - one constant in a dynamic landscape
   1. Students will be able to identify that there is never enough money or labor to implement all the best safety measures
   2. Students will be able to describe at least two strategies for obtaining funding
      a. Demonstrated need
      b. Demonstrated liability
C. Laboratory Definitions - or the lack thereof
   1. Students will be able to report that there is no formal definition of a BSL-1, or -2 and very rarely are they commissioned to a rigorous standard
   2. Students will be able to cite that only Select Agent laboratories are held to a definition and that

the definition was written as a guidance document

D. International Biosafety
    1. Students will be informed that there is a strong and growing need for biosafety professionals in other countries and in international settings
    2. Students will be able to name the World Health Organization Biosafety Manual and the CEN Workshop Agreement (CWA) 15793 as resources frequently used by biosafety professionals in international settings
E. Leading Edge Metrics - how do you gather them?
    1. Students will be able to recall that most safety programs measure trailing edge metrics
    2. Students will be able to explain why it is difficult to gather prospective measurements for safety programs
F. How Important is Vocabulary? - The difference between an aerosol and a droplet exposure
    1. Students will develop a discussion over the difference between droplet and aerosol exposures drawing from popular news, popular media and scientific publications (good and bad information exists in both)
G. Public Perception - Movie Night 2: *Contagion*
    1. Students will watch the movie *Contagion* using the same exercise guidelines as the first movie night and a class discussion will be held to discuss what the students have learned in the course
H. Practicum - Site inspection with the students' reports
I. As a small group, students and instructor will visit a functional laboratory including the support space and perform a safety assessment

Resources for Instructor:

- Biosafety in Microbiological and Biomedical Laboratories, 5th ed.
    - link: http://www.cdc.gov/biosafety/publications/bmbl5/
- Biological Safety, Principles and Practices, 4th ed. (Fleming & Hunt)
    - ISBN: 978-1-55581-339-0
- Guide For The Care and Use of Laboratory Animals, 8th ed. (National Research Council)
    - link: http://www.nap.edu/catalog/12910/guide-for-the-care-and-use-of-laboratory-animals-eighth
- Control of Communicable Diseases Manual, 20th Ed. (Heymann)
    - ISBN: 978-0-87553-018-5
- Institutional Animal Care and Use Committee Guidebook, 2nd ed.
    - link: http://grants.nih.gov/grants/olaw/guidebook.pdf
- NIH Guidelines For Research Involving Recombinant or Synthetic Nucleic Acid Molecules (2013)
    - link: http://osp.od.nih.gov/office-biotechnology-activities/biosafety/nih-guidelines
- Laboratory Biosafety Manual, 3rd ed. (WHO)
    - link: http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_CSR_LYO_2004_11/en/
- EPA registered disinfectants
    - link: http://www.epa.gov/pesticides/antimicrobials/chemregindex.htm
- FDA registered disinfectants
    - link: http://www.fda.gov/medicaldevices/deviceregulationandguidance/reprocessingofreusablemedicaldevices/ucm437347.htm
- Canadian Public Health Agency's Pathogen Safety Data Sheets
    - link:http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/index-eng.php
- BIOS Instant Notes in Molecular Biology, 4th ed. (2012) ISBN: 9780415684163