CHAPTER 26

BIOHAZARDS

26-1 INTRODUCTION

In July, 1976, at the height of the nation's bicentennial celebration, members of the American Legion descended on Philadelphia for their national convention; 182 conventioneers staying at one hotel became ill and 29 died. The outbreak, which displayed symptoms similar to pneumonia, led researchers to discover a new pathogenic bacterium: *Legionella pneumophila*. This was the first pathogen identified in more than 25 years. Pursuant investigations found that other outbreaks of Legionnaire's disease had occurred earlier. The bacterium thrives in cooling tower sumps and condenser valves of air conditioning equipment and is also found in water supplies and hot water tanks of buildings.

In April, 1985, *Salmonella* contamination of 1-gal cartons of 2% milk infected more than 6,000 people in five states. Many lawsuits resulted, and the Chicago area dairy that processed the milk closed its doors. The cause may have involved the design and operation of the processing equipment. Raw, contaminated milk somehow got mixed with pasteurized milk during the processing.

In June, 1985, cheese contaminated with *Listeria monocytogenes* produced flu-like symptoms in at least 87 people in the Los Angeles area. The bacterium affected mostly women and children. Some reports linked the deaths of 28 people to the contaminated cheese.

In approximately 1987, American public attention turned to acquired immune deficiency syndrome (AIDS). The virus known as HTLV-III/LAV causes this disease. It attacks the immune system by affecting a type of white blood cell called T lymphocytes and prevents antibody development, which leaves the victims open to infections and diseases that would not otherwise be a threat. People may not be aware that they are carriers of the virus. Nonsexual contact that generally occurs among workers and clients or consumers in the workplace does not pose a major risk for transmission of the AIDS virus. However, workers engaged in emergency treatment of people and those who may come into contact with human blood and other body fluids are at higher risk than the normal population. Although much has been learned about this disease and its treatment, it remains a worldwide health threat.

In June, 1989, investigative reporters discovered a new source of potential contamination. When trucking companies that hauled food from the Midwest to the East Coast traveled in the other direction, they hauled garbage from eastern cities to Midwest landfills. There were few regulations covering these activities and minimizing food contamination.

In the late 1990s, the public became sensitive to exposure to molds that may grow in homes, often inside wall structures, and feared toxic effects of certain types. As a result,

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states have passed home inspection requirements during real estate transactions and other situations, often engaging inspectors of limited expertise.

During 2001, there were a handful of letters delivered to government officials or companies containing anthrax spores. Two or three people died, but postal systems and company mail departments were taxed to change procedures to protect the public and employees from potential exposures. Fortunately, the number of actual cases of contaminated mail were very limited, but the breadth of effects was very large.

These events illustrate the dangers of biohazards. Improvements in sewage systems, sanitation, and sanitary engineering practices contributed to major reductions of dangers from many diseases. Food inspection and handling practices reduced dangers even farther. However, dangers from biohazards remain. There are other current examples, such as bacteria in hot tubs and spas, parasitic infection from sushi (raw fish), and similar popular habits that can lead to illnesses from biohazards. Whether one is a consumer or worker, there are many activities that have biohazards.

There are specialty areas of practice for biological hazards. Groups that deal with dangers, exposures, and toxicity of biohazards typically have a background in biology, especially microbiology, environmental health, or industrial hygiene.

26-2 AGENTS AND SOURCES

Biohazards are biological hazards from plants, animals, or their products that may be infectious, toxic, or allergenic. Agents are bacteria, viruses, fungi, rickettsia, or parasites.

Bacteria

Bacteria are simple, one-celled organisms. They are not visible to the eye and they multiply by simple division. Not all bacteria are harmful; many are useful. Bacteria are characterized by their shape: cylindrical or rod shaped (bacilli), shaped like a string of beads (cocci), and spiral or corkscrew shaped (spirilla).

Viruses

A virus is an organism that depends on a host cell for development and reproduction. Viruses are parasitic and are so small that they are not visible with an optical microscope. Viruses are transmitted in many ways, including contact with infected people, from animals and insects, from contact with equipment and diseased specimen, and other means.

Fungi

There are many species of fungi. They are parasitic and grow in a living host or on dead plant or animal matter. Fungi may be microscopic in size or large (mushrooms are an example).

Rickettsia

Rickettsia are microorganisms that are rod shaped and smaller than bacteria. They depend on a host for development and reproduction and they must live within a host cell. Fleas, ticks, and lice transmit them, although they are sometimes airborne.

Parasites

A variety of protozoa, helminths, and arthropods are parasites. They are different from other organisms that are parasitic because they live in or on other plants or animals. Some well-known parasites are tapeworms, liver flukes, and hookworms.

Bloodborne Pathogens

Bloodborne pathogens are microorganisms that are present in human blood and can cause disease in humans. Examples are the hepatitis B virus and the human immunodeficiency virus. OSHA established a standard addressing safety and health of workers subject to potential bloodborne pathogen exposures.[1]

Sources of Biohazards

Diseases transmitted from animals to humans, zoonoses, are a major source of biohazards. People who work with animals, animal products, or animal waste have a greater risk of infection from biohazards. Another source of biohazards is work in hospitals, other medical facilities, or medical-related research laboratories. It may include any situation in which someone can contact the blood or body fluids of someone else, such as in an accident, first aid situation, or work with patients or hotel guests, cleaning of waste receptacles or washrooms, and so forth. Exposure can be from equipment and materials contaminated with blood, such as needle sticks, handling of linens during laundry, or waste. Table 26-1 lists examples of biohazards, occupations in which they may occur, and other relevant information. The bibliography at the end of this chapter gives more complete listings.

26-3 HAZARDS

The main danger from biohazards is infection, and there are different symptoms for different infections. There is considerable knowledge about infections from some biohazards. However, it must be assumed that a biohazard exists for work with biological agents or related materials for which disease is not known or not understood. Biohazard agents may enter the body or skin by ingestion, skin contact, puncture wounds, or inhalation of aerosols. Infections from some biohazards can be cured or at least treated. For some infections, there is no treatment or cure.

Classification

Federal agencies developed a classification scheme for biohazards. There are five categories. The first four describe increasing hazard levels. Each of the four classes requires increasing levels of controls. The fifth class includes animal pathogens excluded or restricted from import to the United States. Table 26-2 lists the five categories of biohazards.

26-4 GENERAL CONTROLS

One can prevent many occupational infections with training, procedures, and special equipment and facilities. This is particularly true for laboratories involved with infectious

TABLE 26-1 Examples of Biohazards[a]

Biohazard	Sources and Comments
Bacterial	
Anthrax	Direct contact with infected animals, hides, and wool. Risk is higher for veterinarians, farmers, butchers, leather and wool workers, carpet workers.
Brucellosis	Ingestion, inhalation, contact with infected animals, cuts, and scratches. Those who work with cattle and hogs, meat packing workers.
Salmonellosis	Oral; Food service workers and patrons, meat and poultry workers.
Tetanus	Entrance through breaks in the skin from penetrating or crushing trauma. Persons handing jute or contact with manure.
Tuberculosis	Inhalation, contact with lesions. Silica workers, people exposed to heat and organic dusts, medical personnel, animal caretakers.
Fungal	
Dermatophytoses	Contact; People involved with farm and domestic animals and handlers of hides.
Histoplasmosis	Inhalation and ingestion, Roof demolition workers and workers in barns and chicken houses.
Parasitic	
Creeping eruption	Penetration of skin by infected larvae. People involved with digging in soil (ditch diggers, utility workers, laborers, masons, gardeners, plumbers).
Hookworm	Penetration of skin (particularly bare feet) by larvae. Barefoot farmers and ditch diggers, sewer workers, tunnel workers, recreation (children and adults).
Schistosomiasis	Contact with infected water. Farmers and others who stand and work in flooded areas.
Swimmer's itch	Penetration of wetted skin by snails. Workers in and around fresh water, divers, dock workers, lifeguards, and recreational swimmers.
Rickettsial	
Ornithosis	Inhalation or contact with infected bird droppings. Zoo workers, taxidermists, poultry farmers and processors, pet workers and owners, people in locations where there is an accumulation of bird droppings.
Q fever	Inhalation of contaminated dusts and contact with infected animals (cattle, pigs, or sheep) or contaminated substances. Farmers, veterinarians, slaughter house workers, and hide and wool workers.
Rocky Mountain spotted fever	Tick bites, skin contact with tick tissue or feces. People who work outdoors, such as in lumbering, construction, forestry, ranching.
Viral	
Cat-scratch disease	Break in skin, usually from animal scratch. People who work or play with cats and dogs.
Hepatitis (viral)	Fecal-oral transmission. Health workers, particularly pediatrics, oral surgeons.
Milker's nodules	Breaks in skin. Dairy farmers and workers.
Rabies	Bite of infected animal (dogs, cats, bats, pigs, rats, etc.) People who work and play with animals or come near animals (letter carriers, delivery workers, etc.).

[a] Adapted from Feiner, B., "Occupational Biohazards," in *Dangerous Properties of Industrial Materials*, 6th ed., Sax, N. I., ed., Van Nostrand Reinhold, New York, 1984, and other sources.

TABLE 26-2 Classification of Biohazards[a]

Class	Definition
1	Agents of *no hazard or minimal hazard* under ordinary handling conditions that can be handled safely without special apparatus or equipment, using techniques generally acceptable for nonpathogenic materials.
2	Agents of *ordinary potential hazard* that may produce disease of varying degrees of severity through accidental inoculation, injection, or other means of cutaneous penetration, but which can usually be adequately and safely contained by ordinary laboratory techniques.
3	Agents involving *special hazard* that require special conditions for containment or require a USDA permit for importation and are not in a higher class.
4	Agents that are *extremely hazardous to personnel or can cause serious epidemic disease* and require the most stringent conditions for containment. Included are certain types of class 3 agents imported into the United States.
5	Foreign animal pathogens that are excluded from the United States by law or whose entry is restricted by the USDA.

[a] Adapted from *Classification of Etiologic Agents on the Basis of Hazard*, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA, 1974.

agents. The U.S. Department of Health and Human Services, Public Health Service, developed guidelines for preventing laboratory infections.[2] The principles they developed are helpful in assessing risk and preventing infections in other activities.

The overriding principle for preventing laboratory infections is containment, the purpose of which is to reduce exposure of laboratory personnel and other persons to potentially hazardous agents. Containment includes preventing escape of potentially hazardous agents outside the laboratory to such persons as workers laundering laboratory clothing, visitors, and family members of laboratory workers. The three elements of containment include laboratory practice and techniques, safety equipment, and facility design. Primary containment addresses protection of personnel and the immediate laboratory environment from exposure, which is achieved with proper techniques and safety equipment. Vaccines may provide additional protection for personnel. Secondary containment refers to protection of environments outside the immediate laboratory, which requires both proper procedures and facility design.

Warnings that laboratories and containers have biohazards are important. The biohazard symbol (see Figure 26-1) is an essential part of a biohazard warning. Several organizations have biohazard warning requirements and standards.[3]

Laboratory Practice and Technique Laboratory workers must learn what hazards exist for particular agents in a laboratory and must receive training in proper handling and operations of laboratory materials. Workers must periodically update their knowledge and skills to ensure high retention levels. There should be an operations and biosafety manual for each laboratory that identifies hazards that may be encountered and what protection is needed for these hazards. Persons knowledgeable in hazards, safety procedures, and laboratory techniques should direct the work. Knowledgeable people should complete a risk assessment before starting any work to identify dangers and to implement appropriate protection.

Biosafety related to laboratory work extends into criminal laboratories and the investigator and laboratory personnel handling and analyzing criminal evidence. Specialists in

Fiugre 26-1. Biohazard symbol.

this field are becoming more concerned with safety in their work with biological materials from crime scenes.

Safety Equipment Enclosed containers, biological safety cabinets, and personal protection equipment are the main kinds of safety equipment. Safety containers prevent release of unsafe substances during normal activities and operations. An example is a safety centrifuge cup. Biological safety cabinets are partial or full enclosures where the air flow is designed to retain agents within the cabinets. There are three classes of cabinets.

A Class I biological safety cabinet has an open front. Air moves inward across the face at 75 ft/min and exhaust air is filtered through high-efficiency particulate air (HEPA) filters.

A Class II biological safety cabinet also has an open front with a 75 ft/min face velocity. It has vertical laminar flow air movement and the air is both HEPA filtered and recirculated within the cabinet and HEPA filtered and exhausted. The filtered recirculation prevents contamination of agents by air drawn into the cabinet. Class II cabinets must meet the National Sanitation Foundation standard.[4]

Class III biological safety cabinets are totally enclosed. Workers complete activities in the cabinet via rubber gloves built into the cabinet walls. To prevent contamination of the contents, supply air enters the cabinet through HEPA filters. The cabinet operates under at least 0.5 in of water-negative pressure. Exhaust air moves through two stages of HEPA filters. Typically, a Class III cabinet has its own exhaust fan, which is independent of any other ventilation systems. Other equipment, such as refrigerators, dunk tanks, and centrifuges, is a part of the cabinet or is contained in the work area within the cabinet.

One can achieve Class III standards another way. Workers wear one-piece, positive-pressure, full-body protective suits that have a life support system and work inside Class

I or II cabinets. In this case, the work area must have an airlock with airtight doors. Workers must pass through a chemical shower to decontaminate the suit before leaving the work area. Exhaust from the suit must pass through a two-stage HEPA filter.

Facility Design Facilities play an important role in containment. Designs protect both those working in a facility and those outside the laboratory and the surrounding community. There are three classes of facility design, each providing a different level of safety. The three facility classes are basic, containment, and maximum containment laboratories. Design features are based on four levels of biosafety for infectious agents and for work with vertebrate animals. Tables 26-3 and 26-4 summarize the four biosafety levels. Designs include easily cleaned surfaces, special features for furniture, cleaning facilities for workers, and other features.[5]

Basic laboratories are intended for work with agents not associated with disease in healthy adults and work in which standard laboratory practices provide adequate protection. Separate basic laboratories from public and office areas. Containment equipment is not normally required.

A major feature of a containment laboratory is a controlled access zone. Containment laboratories have specialized ventilation systems and may be separate buildings or controlled access modules within a building.

Maximum containment laboratories support work with agents that are extremely hazardous or may cause epidemics. Often these laboratories are separate buildings. A main design feature is highly effective barriers, which may include sealed openings, airlocks or liquid disinfectant barriers, clothing-change and shower rooms, double-door autoclave, biowaste treatment system, separate ventilation system, and treatment system to decontaminate exhaust air.

TABLE 26-3 Summary of Recommend Biosafety Levels for Infectious Agents[a]

Biosafety Level	Practices and Techniques	Safety Equipment	Facilities
1	Standard microbiological practices	None: Primary containment provided by adherence to standard laboratory practices during open bench operations	Basic
2	Level 1 practices plus: laboratory coats; decontamination of all infectious wastes; limited access; protective gloves and biohazard warning signs as indicated	Partial containment equipment (class I or II biological safety cabinets) used to conduct mechanical and manipulative procedures that have high aerosol potential that may increase the risk of exposure to personnel	Basic
3	Level 2 practices plus: special laboratory clothing; controlled access	Partial containment equipment used for all manipulations of infectious material	Containment
4	Level 3 practices plus: entrance through change room where street clothing is removed and laboratory clothing is put on; shower on exit; all wastes are decontaminated on exit from the facility	Maximum containment equipment (class III biological safety cabinet or partial containment equipment in combination with full-body, air-supplied, positive-pressure personnel suit) used for all procedures and activities	Maximum Containment

[a] From *Biosafety in Microbiological and Biomedical Laboratories*, HHS Publication (CDC) 84-8395, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA, March, 1984.

TABLE 26-4 Summary of Recommended Biosafety Levels for Activities in Which Experimentally or Naturally Infected Vertebrate Animals Are Used[a]

Biosafety Level	Practices and Techniques	Safety Equipment	Facilities
1	Standard animal care and management practices	None	Basic
2	Laboratory coats; decontamination of all wastes and of animal cages before washing; limited access; protective gloves and hazard warning signs as indicated	Partial containment equipment and/or personal protective devices used for activities and manipulations of agents or infected animals that produce aerosols	Basic
3	Level 2 practices plus: special laboratory clothing; controlled access	Partial containment equipment and/or personal protective devices used for all activities and manipulations of agents or infected animals	Containment
4	Level 3 practices plus: entrance through clothes change room where street clothing is put; shower on exit; all wastes are decontaminated before removal from the facility	Maximum containment equipment (class III biological safety cabinet or partial containment equipment in combination with full-body, air-supplied positive, pressure personnel suit) used for all procedures and activities	Maximum containment

[a] From *Biosafety in Microbiological and Biomedical Laboratories*, HHS Publication (CDC) 84-8395, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA, March, 1984.

Robotics Another control to reduce the dangers of contact with biohazards is the use of robotics for analysis and processing of biological samples. A robot placed in an enclosure can perform many functions, thereby reducing human handling and potential contacts. Automatic or manual controls operated from outside the enclosure direct the actions of the robot. There are companies that produce robots for processing biohazards.

26-5 SICK BUILDING SYNDROME AND INDOOR AIR QUALITY

Sick building syndrome is a term from the 1980s. It stems from a number of incidents where many occupants of an entire building or a certain portion of a building exhibited a rash of physical complaints, including headaches, muscle pains, chest tightness, nausea, fever, cough, allergic asthma, allergic rhinitis, pneumonitis, and pneumonia. Often the symptoms diminished over weekends. Some individuals became sensitized or exhibited allergic reactions to conditions. ASHRAE defines the term *sick building* as a building in which a significant number (more than 20%) of building occupants report illnesses perceived as building related.[6]

Researchers began looking into these problems, and there appear to be a number of causes, including contaminants entering air conditioning units from birds. Investigations found development of microbial slimes in air-handling units. Condensate pans, humidifiers, and tanks of coolant from machining can form places for organisms to grow. Hot water supplies that are not hot enough can incubate bacteria. Beside biological contaminants, there are often chemical contaminants from smoking, off-gassing of new furniture

and carpet, asbestos particles from insulation, and other applications and release of polychlorinated biphenols from exploding or burning electrical transformers. Poor lighting and acoustics also have been implicated as contributors to sick building syndrome, as has tight building construction, where there is little infiltration of outdoor air. Other factors may be the release of formaldehyde from certain foam insulations and the release of contaminants from heating, cooking, and power machinery. Emissions from powered vehicles can contribute. Researchers continue in their efforts to identify the complexities of this problem and its corrections.

Controls vary with the problem. Chlorination and other chemical treatments for water-based problems in heating, ventilating, and air conditioning (HVAC) equipment have not always been effective. Segmented smoking areas have not always removed contaminants from the general office environment. When contaminants build up as a result of an inadequate supply of outdoor air, attention should be directed to the HVAC system. Specific causes, when located, should be removed at the source.

ASHRAE's ventilation standard[7] may be helpful. The Environmental Protection Agency (EPA) offers a number of publications on indoor air quality and radon. Table 26-5 lists some actions for preventing and controlling sick building syndrome.

TABLE 26-5 Some Actions for Preventing and Controlling Sick Building Syndrome[a]

Contamination clean up
Remove harmful chemical sources when they exceed recognized limits
Remove dirty air filters in HVAC systems
Empty all condensate drainage trays
Use hot water to clean microbial growth from condenser coils, tubing, etc.
Swab down suspected ductwork with antimicrobial solution
Remove materials in locations found infested with microbial growth where cleaning is not possible
Clean carpeting and furniture that has microbial growth
Make sure drains in HVAC equipment are working
Preventive maintenance
Keep hot water supply temperatures higher than 120°F
Provide drains for air handling packages to prevent stagnant water
Limit relative humidity to less than 70%
Abandon air washers that use recirculating water systems
Use steam from fresh water for humidifiers, not recirculated water
Abandon spray coil systems
Keep coils, pans, drainage systems, and duct work clean
Check air filters regularly and replace
Prevent stagnant water
Preventive design
Locate intake vents where they receive fresh air and not contaminated air
Use only steam humidifiers, not recirculating ones
Use prefilters to clean air upstream of high efficiency filters
Design HVAC systems to handle varying resistance to air flow in buildings
Locate HVAC system components where it is easy to inspect and service them

[a] Adapted from Bishop, V. L., Custer, D. E., and Vogel, R. H., "The Sick Building Syndrome: What It Is and How to Prevent It," *National Safety and Health News*, Vol. 132, No. 6:31–38 (1985).

26-6 GENETIC ENGINEERING

In the 1950s, researchers discovered the double helix of deoxyribonucleic acid (DNA), the building block of life. Since then, research has mapped the complete DNA molecule and many companies work with modified DNA molecules. Genetic engineering, cloning, and gene splicing are becoming common and in some cases commercialized. In 1980, the U.S. Supreme Court decided that a live, laboratory-made microorganism is patentable. This decision let stand a lower court decision for the first patent on genetically engineered materials. The patent recognized a General Electric product—an oil-eating organism.

Genetic engineering, gene splicing, and cloning led to public fears about modifying DNA. Modified organisms, plant, and animal species produced in error or for destructive purposes made some people fear incidents similar to the black plague of the Middle Ages and the worldwide influenza epidemic of 1918 that killed 20 million people. The National Institutes of Heath (NIH) developed guidelines for recombinant DNA research[8] and a review committee assesses potential hazards of proposed research. Genetic engineering has produced biological growth of insulin, interferon, and bacteria capable of digesting 2,4,5-T, the key chemical component in Agent Orange. Other useful products have also emerged from biotechnology research.

A major control to prevent dangerous releases of new organisms is careful review by government agencies, such as the EPA. There are few methods for evaluating the safety of genetically engineered products. Risk analysis techniques are useful.

26-7 OTHER BIOHAZARDS AND CONTROLS

There are many other ways biohazards can threaten people in daily living and in special environments. Biohazards in the food chain threaten many people. Biohazards in hospitals require careful control to prevent transfer in infections and disease.

Food

Biohazards enter the food chain at many points. For example, a natural bacterial growth in corn stored in grain bins and elevators can produce a toxic substance called aflatoxin. Farmers, grain elevators, and grain companies must monitor corn for this toxin. Some seasons have a greater problem than others. The U.S. Department of Agriculture has numerous standards for and conducts inspections on grain and other food materials. These standards and other controls ensure that plant and animal foods pose little risk of biohazards for consumers.[9] The Department of Commerce has standards for fish and seafood products.[10] The Food and Drug Administration sets standards on food for human consumption[11] and food for animals intended for human consumption.[12]

Restaurants and Food Establishments

State and local governments have public health inspectors who regularly inspect restaurants and related food establishments. Regulations require workers to handle, refrigerate, and process food properly for customers. They also prevent spread of biological agents by insects and rodents through sanitary practices. Establishments that do not meet inspection standards must resolve deficiencies or face temporary or permanent closure. A major problem in food preparation and service at restaurants and hotels is ensuring that employees wash their hands and adhere to other basic sanitation practices.

Hospitals and Other Health Care Facilities

Federal regulations for construction of medical facilities[13] include features that help minimize hazards of biological agents. State regulations and certification programs for medical facilities also help establish controls to minimize dangers of biological agents. The American Hospital Association and other healthcare organizations have their own guidelines to assist operators of facilities to minimize biohazards and any resulting infections. Refer also to Chapter 30.

Swimming Pools, Spas, Saunas, Therapy Pools, and Tanning Booths

A variety of public facilities create opportunities for transfer of biohazards; proper design, operation, cleaning, and maintenance are important in controlling biohazards. Each recreational facility may have other safety and health hazards requiring additional controls.

Water in swimming pools becomes contaminated by microorganisms from swimmers' skin, mucus, feces, and urine and from dirt, plant material, and other sources. The water must be cleaned and disinfected. Recirculation systems pump water through filters to remove hair, lint, and other large particulates. Filters are backwashed to clean them and the collected materials are flushed down sewer lines. Chlorine and other chemicals are used to disinfect the water. The rate of filtration and disinfecting is based on swimmer load and tests of water samples. There are state and local codes for operation of public swimming pools, and there are many sources of criteria for design of large pools.

Spas, therapy pools, hot tubs, and similar water containers that have multiple uses require treatments similar to swimming pools. Simply draining the containers, flushing out solids, and scrubbing them regularly with disinfecting detergents will prevent transfer of biohazards.

Other recreational facilities that many people use require care in preventing transfer of biohazards. Cleaning, disinfecting, and other means can be effective.

Plumbing, Sanitary Sewer Systems, and Water Supplies

The implementation of sanitary sewer systems removed many kinds of biohazards. State and local governments have plumbing codes, codes for sanitary sewer systems, and codes for water supply systems. In many locations, plumbing and sanitary lines must be inspected when they are initially installed or modified. Strict code enforcement prevents potential disease transfer. Careful separation of potable water from untreated water supplies and sewer lines prevents any cross-contamination or back flow to the potable water.

Ventilation and dehumidification in closed spaces can help prevent the growth of molds. Treatment of standing water in air conditioning equipment also can minimize the opportunity for molds to grow.

EXERCISES

1. Visit a water treatment facility, biological laboratory, or other facility to find out how biohazards are controlled.
2. Find out how hospital biosafety hazards are controlled.
3. Research the events surrounding a major biohazard incident.
4. Research the scope of biohazard problems in the world, particularly developing countries that have poor water supplies, limited sanitary sewers and treatment plants, and practices that lead to biohazard infections and illnesses.

5. Visit a food processing plant and find what measures are in place to control biohazards.
6. Investigate state and local regulations governing food handling and service in restaurants and eating establishments. Determine how public health and sanitary inspection ratings are completed and scored. Obtain records of inspection scores for a group of local restaurants for the last 6 to 12 months.
7. Investigate various types of molds and identify the hazards each presents. Review methods for removal or treatment and the safety and effectiveness of each.

REVIEW QUESTIONS

1. What are the five kinds of biohazard agents?
2. What are zoonoses?
3. What is the main danger from biohazards?
4. What are the four classes of biohazards in order of hazard severity?
5. What are the three major types of controls for biohazards in laboratory work?
6. Characterize class I, class II, and class III biological safety cabinets.
7. Define sick building syndrome. What symptoms do people typically exhibit with sick building syndrome? What agents are commonly involved?
8. What are potential hazards for genetic engineering? What controls are there?

NOTES

1 29 CFR 1910.1030, Boodborne Pathogens.

2 *Biosafety in Microbiological and Biomedical Laboratories*, HHS Publication (CDC) 84-8395, Public Health Service, Centers for Disease Control, U.S. Department of Health and Human Services, Atlanta, GA, March, 1984.

3 Examples are 29 CFR 1910.145, 49 CFR 172.444, 49 CFR 173.388, and ANSI 35.2, *Specifications for Accident Prevention Tags.*

4 *Class II (Laminar Flow) Biosafety Cabinetry*, NSF/ANSI 49-04a, National Sanitation Foundation International, Ann Arbor, MI, 2004.

5 See details for each class of facility in *Biosafety in Microbiological and Biomedical Laboratories*, HHS Publication (CDC) 84-8395, Public Health Service, Centers for Disease Control, U.S. Department of Health and Human Services, Atlanta, GA, March, 1984.

6 *Indoor Air Quality—Position Paper*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, approved by the ASHRAE Board of Directors, August 11, 1987.

7 ANSI/ASHRAE Standard 62.1-2004, *Ventilation for Acceptable Indoor Air Quality*; and ANSI/ASHRAE Standard 62.2-2004, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

8 "Recombinant DNA Research. Proposed Revised Guidelines," National Institutes of Health, U.S. Department of Health, Education and Welfare, *Federal Register*, Vol. 42, No. 187 (1977).

9 7 CFR and 9 CFR contain regulations on food safety.

10 50 CFR 260.

11 21 CFR 100.

12 21 CFR 500.

13 42 CFR 124.

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