CHL5918H – Biological hazards in the workplace and community

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COURSE DESCRIPTION:
This course is intended to familiarize students with a wide range of biological hazards that may be encountered in community- and work environments, including commercial, non-industrial, industrial and health care settings, with emphasis on the methods occupational hygienists use to recognize, evaluate and control microbiological hazards. Course modules include: 1) bioaerosol science & sampling; 2) microbiology of the built environment; 3) investigation, sampling, interpretation & remediation of indoor microbial contamination; 4) laboratory biosafety; 5) health care biosafety; 6) industrial biosafety; and 7) biological weapons. Readings will be taken from multiple sources.

SCHEDULE AND TIMING:
The course will meet weekly M9-12 in Gage Bldg classroom. Sessions will be in lecture format and include two field exercises and one laboratory exercise.

READINGS:
I expect that you will complete each weeks reading prior to the lecture. I will try to provide readings as handouts or pdfs. Readings for this course will be taken from several texts, including:


Course website: http://individual.utoronto.ca/jscott/courses/biohazards/biohazards.html

2016 Lecture schedule:

<table>
<thead>
<tr>
<th>DATE</th>
<th>TOPIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 11, 2016</td>
<td>Introduction to bioaerosols (Scott)</td>
</tr>
<tr>
<td>Jan 18, 2016</td>
<td>Microbes in the built environment (Scott)</td>
</tr>
<tr>
<td>DATE</td>
<td>TOPIC</td>
</tr>
<tr>
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<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>Feb 1, 2016</td>
<td><strong>Laboratory analysis exercise (Scott)</strong></td>
</tr>
<tr>
<td>Feb 15, 2016</td>
<td><strong>READING WEEK - TAKE-HOME MIDTERM</strong></td>
</tr>
<tr>
<td>Mar 28, 2016</td>
<td><strong>Field trip (Scott)</strong></td>
</tr>
<tr>
<td>Apr 11, 2016</td>
<td><strong>FINAL EXAMINATION</strong></td>
</tr>
</tbody>
</table>
Evaluation:

- A small group report based on the field air sampling exercise on Jan 25, and the laboratory analysis on Feb 1 will be due on Friday February 12, and will count for 15 % of your grade in the course.

- A mid-term examination will be assigned over Reading Week and due in class on Monday February 22. All readings will be included on the midterm examination. This examination will be worth 25 % of your final mark.

- Each student will prepare a 10-12 pg executive briefing paper on an assigned topic dealing with a microbial hazard that I will assign. The report must be submitted no later than Friday March 18. Normally, students will be required to submit their course essays to turnitin.com for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the Turnitin.com reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University’s use of the Turnitin.com service are described on the Turnitin.com web site. A topic sign-up list will be posted in the Gage student lounge. The report will account for 25 % of your final mark.

- A process flow diagram will be submitted by each student at the conclusion of the plant visit on March 28. This diagram will be annotated with the a description and prioritization of the points in the process associated with occupational risks, particularly from microbial exposures. This assignment will be worth 5 % of your grade in the course.

- The final examination will take place in the regular class time slot on Monday April 11. This examination will count for 30 % of your final mark. All material covered in the course, including readings, will be tested.
1. Introduction to bioaerosols (Scott)

As we go about our daily lives, we are bathed continuously by a sea of airborne particles that arise from a vast number of sources. Depending on the circumstances, from one third up to one half of all airborne particulate matter derive from living materials. These particles may be simultaneously infectious, allergenic and toxic; but, the hazard profile of airborne biological particulate matter or "bioaerosol" is complex and highly variable in time and space making the detection, measurement and characterization of these contaminants exceedingly challenging. Nevertheless, bioaerosols are increasingly being appreciated as critically important, health-relevant air contaminants. Bioaerosol science embodies a new and exciting frontier in occupational hygiene.

This lecture will serve as an introduction to bioaerosol science, discussing biophysical particle characteristics and stressing the importance of these features on airway penetration, particle deposition and personal exposure. We will examine the chief mechanisms of bioaerosol generation: forcible discharge, mechanical disruption, and droplet nucleus formation; and we will discuss collection and dispersion characteristics relating to terminal settling velocity as well as electrostatic and thermal effects.

Reading:
- Scott JA. 2012. An evolving architecture: the past, present and future of indoor microbiology. Indoor Air Quality Assoc annual meeting, keynote address.

2. Microbes in the built environment (Scott)

Fungi are the most common and health relevant contaminants of indoor home and work environments. Fungi are the most complex and diverse of all microorganisms. However, because they are infrequent agents of human infection, their study within the field of microbiology has traditionally been eclipsed by that of bacteria and viruses. The study of fungi, known as “mycology”, was consigned historically to the disciplinary suburbs of the science of botany, where it languished nearly to the point of extinction. Consequently, it is no surprise that fungi receive little attention in the curricula of mainstream biology courses where their scant coverage is often fortunate given its very poor quality. This lecture endeavors to redress this gap by providing a basic background on fungal biology as a basis for later discussions on health and the built environment.

First we will discuss the different ecological growth forms of fungi: filamentous or hyphal forms and yeast forms. We will then discuss the nutritional requirements and features of fungi, their reproductive characteristics and their dispersal mechanisms. The four main phyla of “true fungi” will be described and placed in context relative to their importance as indoor contaminants. Fungi are the chief agents of biodeterioration of structures and the main agents of decomposition of wood. We will learn about the biochemical and physiological differences between the various forms of wood rot and how these relate to structural problems in buildings. Finally, we will address the relationship of the fungi commonly known as “moulds” (or "molds") to the rest of the fungi, discuss their biology, classification and ecology.

In the second part of the session, we will shift to discussing bacteria, emphasizing those that are important contaminants of the built environment. One species, Legionella pneumophila, is an environmentally common bacterium that are intracellular parasites of animals. This species was newly recognized in the 1970s as the causative agent of an outbreak of pneumonia associated with a Philadelphia hotel during a convention of Legionnaires. The disease, accordingly, was named
Legionnaire's Disease. In the intervening years, a number of additional species have been described in the genus *Legionella*, but still none are as important as *L. pneumophila* in the etiology of environmentally associated pneumonia. Several additional clinical syndromes have been linked to *Legionella* infection as well. It is now well-recognized that *Legionella* is a frequent contaminant of warm standing water, becoming airborne when the water is disrupted or aspirated. This lecture will review the current state of knowledge on the ecology, clinical presentations, environmental risk factors, sampling strategies and mitigation of pathogenic *Legionella* species.

**Reading:**

3. **Bioaerosol field sampling exercise (Scott)**

A number of methods are available for the measurement and characterization of microbial contaminants in air and bulk materials. This lecture will introduce the concepts and sampling methodologies commonly used in the practice of occupational hygiene.

Air sampling for fungi and bacteria is normally undertaken to evaluate the likelihood of indoor microbial growth sources rather than to assess human exposure. This is so for several reasons. Firstly, the techniques that are commonly applied to microbial air sampling are able to detect only a subset of microbes, depending on the particular collection and analytical techniques used. Secondly, the measurement units that result from standard methods, such as colony forming units or spores per cubic metre of air, are not relevant to the evaluation of human exposure which instead are usually expressed in milligrams of defined contaminant per cubic metre of air, or parts per million. Lastly, bioaerosol is a complex mixture of biochemical contaminants the relative composition of which is spatially and temporally variable.

Air sampling for microbes usually involves the collection of bioaerosol by impaction or filtration, and the analysis of the "catch" using direct microscopy or culture. Each method has advantages and disadvantages that need to be considered fully in the selection of the most appropriate approach for a given situation. We will learn the proper techniques for the most frequently used methods of culturable air sampling with jet-to-agar impactors, such as the Andersen N6, and centrifugal samplers such as the RCS standard and high-flow. We will also consider spore trap sampling using slit samplers such as the Air-O-Cell/ Allergenco-D, and filtration samplers such as mixed cellulose ester membrane filters. Finally, we will survey the proper techniques for sampling bulk materials, including the use of contact slides, tape lifts and surface swabs.

**Reading:**

4. **Laboratory analysis exercise (Scott)**

Interpretation of results of fungal sampling is one of the greatest challenges in all of occupational hygiene data analysis. This is primarily due to the absence of referred standards. Much of the interpretation of fungal sampling results rests of the subjective assessment of these data by the occupational hygienist, based on their individual experience and knowledge. Despite the lack of objective standards, there are several helpful jurisdictional guidelines, such as those give by Health Canada for the occupational non-industrial workplace, and more recently, an amendment to the Canadian Environmental Protection Act addressing mould contamination in residential housing. At
their core, these documents present three fundamental principles: 1) moulds should not grow indoors; 2) hazard level varies directly with mould-affected area; and 3) all cases of mould growth result from failures to control moisture.

Armed with these basic principles and a sound knowledge of building mycology and indoor fungal ecology, a practicing hygienist can learn to evaluate the analytical results of environmental samples in consideration of site observations to produce a meaningful assessment of a building interior. This session will present a series of case studies including both analytical data and relevant observations to guide students to make informed decisions on interpretation. We will conclude with a discussion how sampling data and site observations can be integrated into a professional synopsis, providing clear and accurate recommendations to guide hazard mitigation and prevention in consideration of relevant guidelines and legislation.

The second part of this session will be a hands-on workshop to familiarize students with the air sampling devices that are used commonly in occupational hygiene practice.

Reading:

5. Building science and indoor microbial investigation (Scott)

This lecture will begin with an overview of the history of housing and an introduction to the discipline of building science, the area of engineering concerned with the functionality of the structure and performance of the building and the building envelope (i.e., the "skin" of the building which is attached to its skeleton, called the "framing", that consist of sheathing materials, membranes the provide a barrier to moisture and wind, covered by cladding materials such as sliding). The building envelope helps to hold up the building, to keep out rainwater, groundwater, drafts, water vapor and soil gas, while allowing escape of water and water vapor should they become accidentally trapped or released inside. The building envelope is also responsible to keep in heat during the winter, and to facilitate the cooling of the interior space during the summer. We will next discuss the house as a system, in which the occupants, the building and the environment all interact through various mechanisms, exchanging moisture, air and heat. In this triad, people exhibit hereditary and adaptive characteristics that define sensitivities to environmental exposures. People also modify the functionality of the house system by means of operational or lifestyle choices. The building consists of the envelope, the building subsystems, and the finishes and contents of the building, all of which respond to the conditions presented by the occupant and the environment. Lastly, the environment is characterized by dynamic differences in temperature, pressure and moisture, all of which impose stresses on the building system. A basic understanding of the house as a system provides a helpful paradigm for the recognition, evaluation and control of microbial contaminants.

Following this introduction to building science, we will discuss the investigation of the indoor environment for mould growth. Investigation begins with a review of the "presenting problem" and the formulation of an investigation plan centered around a walk-through.

Reading:
6. Mould remediation (Zitnik, Atrash)

This session will deal with the approaches to the removal of indoor materials that have become contaminated by microbes and the restoration of the interior to the pre-contamination condition. We will discuss the processes that are normally undertaken in mould remediation, and review the standards of practice and relevant guidance documents that apply. A number of case examples will be given.

Reading:

7. Biosafety principles (Scott)

Biosafety is a highly specialized sub-domain of laboratory safety that deals specifically with the protection of workers against unintentional exposure to microbiological agents, and the prevention of release of agents into the environment. With the explosive growth of biotechnology in the past few decades, and the plummeting cost of many commonly used laboratory methods for gene sequence analysis and genetic manipulation, laboratory research on biotechnology is no longer restricted to traditional university and pharmaceutical research laboratories. Today, biosafety is one of the fastest growing sub-disciplines of occupational hygiene.

This lecture will first review the scope of biosafety, including microorganisms themselves, toxic substances of microbial origin, nucleic acids and proteins. We will then discuss the approach used to evaluate hazards. The concept of “risk group” is important in biosafety, and it is widely misunderstood and jurisdictionally variable. Currently in Canada, a 4-point scale is used to describe the innate risk posed by an agent. Placement on this scale is done in consideration of an agent’s pathogenicity or virulence, the severity of disease produced, the mode of transmission and host range, the availability of preventive or prophylactic treatment and the status of the agent to Canada. Risk group level is used as a basis to recommend containment level, which may be adjusted upward or downward according to the hazard circumscription (extent to which the hazard is well- or poorly defined) and the intended manipulation of the agent. We will discuss how these characteristics are used to undertake a risk assessment to set containment needs. Through a series of case studies, we will then consider the biosafety consequences of use and misuse of a range of common laboratory equipment, including autoclaves, biological safety cabinets, as well as techniques of liquid measurement, centrifugation and microbial cultivation.

Reading(s):

8. Microbes in research (Scott)

The research laboratory is the prototypical workplace one associates with the handling of biohazardous materials. A number of elements of the research environment set it apart as a challenging setting to ensure adequacy of biosafety and biosecurity. As discovery is a core tenet of the research laboratory, the processes and agents that are used in these workplaces are often new and poorly characterized warranting stringent approaches to risk assessment and hazard mitigation.

Reading(s):
9. Industrial biosafety (Scott)

For centuries microbes have been employed in the manufacture of a plethora of food and beverage products. Beginning with the development in the early 20th century of citric acid manufacture using vat fermentation with the mould *Aspergillus niger*, the use of microbial processes has blossomed into an integral technology for producing multitudes of biochemicals with diverse end-uses. Fundamentally, the discussion of occupational hazards in industrial microbiological processes is a discussion of biosafety, in which agents are cultivated, deliberately or inadvertently on a much larger scale than they might be in the traditional research or diagnostic laboratory. Still, the principles remain essentially the same.

The main health hazards associated with occupational exposures to industrial microbes involve airway hypersensitivity disorders, such as the hypersensitivity pneumonitides many of which are named eponymously for their associated industry, and secondarily infectious diseases. Other occupational diseases such as dermatitis and systemic toxic syndromes have been reported, but are comparatively uncommon or highly industry-specific.

We first distinguish between clean processes and dirty processes: the former describes procedures that involve well-characterized, known microbes generally handled using well-described containment procedures, such as vitamin production and biochemical manufacture; by contrast, the latter refers to processes that often inadvertently become contaminated by extraneous unknown or poorly-characterized microbes, such as composts, paper recycling and sewage treatment. With respect to clean processes, we will use a series of case studies to review the containment guidelines and the characteristics of the microbes, the environment, and the production practices that are used to inform the selection of appropriate containment. Using a second series of case studies, we will then investigate some of the common industries where workers may encounter microbiological hazards in dirty processes, such as metal machining, recycling, wastewater treatment, composting and agriculture. Throughout, we will discuss the opportunities for monitoring, the relevant occupational exposure limits, and the options for hazard mitigation.

**Reading(s):**

10. Health care biosafety (Mubareka)

We will review the history of infection control and the miasma and germ theories of disease. We will also look at interventions such as Listerian antisepsis, aseptic technique, and later, antibiosis, collectively intended as means to reduce the burden of infection from nosocomial agents. We will discuss the profound effect of the development of antibiotics on infection control practices, both positive and negative, and the emergence of drug-resistance in common nosocomial agents.

Biological hazards will be reviewed with an emphasis on the health care workplace. From the standpoint of care recipients, we will discuss nosocomial infections relating to indwelling devices such as intravascular and urinary tract catheters, as well as infections of surgical sites, the respiratory tract and the GI tract. Patient health status is a principal determinant of susceptibility to nosocomial infection. We will discuss some particularly at-risk patient populations such as those with immune depletion resulting HIV & AIDS, or chemotherapeutic immunosuppression in organ and bone marrow transplant recipients, in anticancer treatment, and the special issue of burn patients. Recognition of pseudoinfections may arise from the reactivation of latent infections. We will cover the characteristics of pseudoinfections and how these may be properly distinguished from bona fide nosocomial infections. Nosocomial infections related to construction are increasingly frequent, and we will discuss the common agents of these infections and examine the current Canadian best practice guidelines for construction in health care facilities.
From the standpoint of health care providers, we will review aerosol-, blood-borne- and enteric hazards. Aerosol hazards have long been separated into distinct categories of "airborne" versus "droplet" transmitted agents. We will discuss the historical rationale for this and talk about some of the current controversy around this distinction in consideration of diseases such as tuberculosis and influenza, the procedures that are high risk for aerosol generation and the strategies for hazard mitigation such as the use of personal protective equipment and ventilation.

The bloodborne pathogens we will consider include HIV, Hepatitis B and Hepatitis C. We will cover the use of universal precautions by health care workers, and where available, vaccination, as risk mitigation strategies. Finally we will examine the role of hand hygiene, PPE and decontamination, and the importance of patient sources versus environmental reservoirs for enteric pathogens include bacteria such as *Salmonella*, *Shigella*, *Clostridium*, and viruses such as norovirus, rotavirus, Hepatitis A and enteroviruses.

Reading(s):

11. Field trip (TBA)

12. Dual use agents (Scott)

Beginning with the 2002 anthrax attacks in the US, and fuelled in parallel by political and media-hyped allegations of active biological weapons programs in Iraq and North Korea, fears of impending foreign and domestic biological threats that had been muted during the years following the conclusion of the cold war have reawakened in the US, Canada and elsewhere in the developed world. Though much of the public fear is disproportionate to the actual risk, weaponized microbes can indeed pose a legitimate threat in the workplace and community.

This lecture will provide a historical perspective on biological weapons, and an overview of current threats related to bioterrorism and biological weapons. Emphasis will be given to the occupational hazards to military personnel during deployment and in training, as well as the hazards to the community arising from domestic bioterrorism. The recent and current threats relating to weaponized microbes will be presented in context with evolving biological defense programs in Canada and the USA. We will review the methods used covertly in the weaponization of microbes, and discuss the economies of manufacture and cost that underpin the emerging threat posed by biological weapons. We will investigate the methods used for the surveillance of weaponized agents, and study the various approaches to decontamination of materials and personnel following exposure to weaponized agents. The agents we will consider include anthrax, plague, smallpox, viral encephalitides, viral haemorrhagic fevers, as well as toxin weapons such as ricin, abrin and botulinum toxin.

Reading(s):