Infection Prevention & Control Program

Module #2: Microbiology

November 3, 2022

Winnipeg Regional Health Authority
Caring for Health
Office régional de la santé de Winnipeg
À l'écoute de notre santé

TABLE OF CONTENTS

MODULE #2: MICROBIOLOGY

OBJECTIVES

At the completion of this module the ICP will:

1. **Describe** the basic elements of microbiology pertinent to Infection Prevention and Control (IP&C)
2. **Provide** information about specimen collection
3. **Identify and interpret** microbiology laboratory tests which have an impact on IP&C

Number of Hours

- **Key Concepts** ~ **3** hours
- **Methods** ~ **4** hours

Required Readings

- ☐ Information available in Appendix A
- ☐ Microbiology Orientation Module Review
- ☐ Lab Presentation – Micro Overview for IP&C
- ☐ See Infection Control Specific Manual (ISM) under "lab" for additional information

(**NOTE:** Please connect with your WRHA IPC to review together)

Associated Readings

- ☐ Alcamo's Text of Microbiology
- ☐ Diagnostic Services of Manitoba See: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj_wKbV3tP7AhWIpIkEHfVRA_oQFnoECA4QAQ&url=https%3A%2F%2Fsharedhealthmb.ca%2Fservices%2Fdiagnostic%2F&usg=AOvVaw3cfCemqZUNyZqCOjpdSX0c
- ☐ Cadham Provincial Lab at http://www.gov.mb.ca/health/publichealth/cpl/index.html
- ☐ APIC Text of Infection Control & Epidemiology (4th edition) – Volume 1, Section 3 (Microbiology and Risk Factors for Transmission – Chapters 21-26)

OVERVIEW

A basic understanding of microbiological terms and organisms is vital to interpret, apply, and act on laboratory information into the infection prevention and control context.

KEY CONCEPTS

Key Terms: Familiarize yourself with these key terms

TERM	DEFINITION
1. **norma flora**	
2. **bacteria**	
3. **virus**	
4. **colonization**	
5. **infection**	
6. **disease**	
7. **pathogenic**	
8. **non-pathogenic**	
9. **opportunistic pathogens**	
10. **antibiogram**	
11. **aerobic organisms**	
12. **anaerobic organisms**	
13. **bacterial spores (endospores)**	
14. **endotoxins**	
15. **exotoxins**	
16. **antitoxins**	
17. **zoonosis**	

The Body's Response to Infection: Describe these processes

BODY'S RESPONSE	DESCRIPTION
1. **natural barriers**	
2. **Immune system (specific host mechanisms)**	
3. **Immune System (non-specific host mechanisms)**	

Stages of Illness: Match the following stages of illness with corresponding definitions

TERM	DEFINITION
1. **Invasion**	**a.** maximum impact of illness when pathogen is proliferating rapidly – toxic byproducts of microbial metabolism and immune response produce tissue damage
2. **Incubation**	**b.** pathogen replicating, no symptoms
3. **Prodromal**	**c.** pathogen acquires entry into the body mucus membranes inhalation, self-inoculation
4. **Acute Illness**	**d.** pathogen is contained and eliminated from body, damaged tissue is repaired and resolution of symptoms
5. **Recovery**	**e.** initial appearance of symptoms (usually mild and vague)

BACTERIOLOGY

Basic Characteristics of Bacteria

TERM	DEFINITION
Gram stain	
Gram positive	
Gram negative	
Culture & Sensitivity	
Acid fast bacilli	
WBC versus epithelial cells	

TERM	DEFINITION
Aerobic	
Anaerobic	
Shape: • Cocci	
• Diplococci	
• Bacilli or rods	
• Spiral forms	
• Pleomorphism	
Coagulase test – positive or negative	
Motility	

Bacteria of Interest

Learning Objective: Identify the key characteristics and diseases most commonly associated with the following bacteria

BACTERIA	SHAPE (cocci, diplococci, bacilli)	GRAM+ or GRAM -	SPORE FORMING? YES/NO	COMMON DISEASE
Clostridium difficile	bacilli	gram-	no	
Enteroccoccus faecalis	bacilli	gram-	no	
Enterococcus faecium	bacilli	gram-	no	
Escherichia coli	bacilli	gram-	no	
Group A Streptococci *(Streptococcus pyogenes)*	bacilli	gram-	no	
Haemophilus influenzae	bacilli	gram-	no	
Klebsiella pneumoniae	bacilli	gram-	no	
Listeria monocytogenes	bacilli	gram-	no	
Methicillin resistant *Staphylococcus aureus*	bacilli	gram-	no	
Mycobacterium tuberculosis	bacilli	gram-	no	
Neiserria meningitides	bacilli	gram-	no	
Pseudomonas aeruginosa	bacilli	gram-	no	
Salmonella typhi	bacilli	gram-	no	
Staphylococcus aureus	bacilli	gram-	no	
Treponema pallidum	bacilli	gram-	no	
Vancomycin resistant enterococcus	bacilli	gram-	no	

Testing for Bacteria

Learning Objective: Give explanations for the following questions

	EXPLANATION
1. **What is a colony count?**	
2. **How are antibiotic sensitivities tested?**	
3. **What are the clinical implications of resistance to antibiotics?**	
4. **Why is different growth media needed?**	

VIROLOGY

Basic Characteristics of Viruses

KEY TERM	DEFINITION
1. Obligate intracellular parasites	
2. Size of viruses	
3. Nucleic acid	
4. Enveloped vs. Non-Enveloped Viruses	

Describe the five stages of Virus Replication

VIRAL STAGE	DESCRIPTION
1. Attachment	
2. Penetration	
3. Replication	
4. Maturation	
5. Release	

Viruses of Interest

VIRUS	ENVELOPED vs NON-ENVELOPED	IMPORTANCE TO IP&C
Influenza Virus		
Measles Virus		
Respiratory Syncytial Virus (RSV)		
HIV		
Norovirus		
Viral Hemorrhagic Fever (VHF)		
COVID-19		

Interpret the following results for Hepatitis B virus testing

DISEASE	TESTS	RESULTS	INTERPRETATION
Hepatitis B	HBsAg ☐	Negative ☐	
	Anti-HBc ☐	Negative ☐	
	Anti-HBs ☐	Negative ☐	
Hepatitis B	HBsAg ☐	Negative ☐	
	Anti-HBc ☐	Negative ☐	
	Anti-HBs ☐	Positive with ≥ 10 IU/ml ☐	
Hepatitis B	HBsAg ☐	Positive ☐	
	Anti-HBc ☐	Positive ☐	
	IgM anti-HBC ☐	Positive ☐	
	Anti-HBs ☐	Negative ☐	

Differentiate Between Viruses and Bacteria

CHARACTERISTIC	VIRUSES	BACTERIA
Size and type of microscope to see organism		
Need a living host to multiply		
Has a cell wall and a cell membrane		
Usually tested for susceptibility to antibiotics		
Can there be beneficial types?		
Nucleic acid type		

Other Organisms of Interest

Fungi

Fungi are organisms that derive nutrients from organic matter. Most fungi are aerobes that require a moist environment and grow best at a neutral ph. Their spores and conidia are able to survive in dry conditions for long periods of time. Some fungi are well-adapted human pathogens; however, most are accidental pathogens humans acquire through contact with decaying organic matter or in airborne spores. Typically, fungi are divided into two separate groups: yeasts and moulds. Common pathogenic yeasts include Candida spp. (vaginitis, mucositis) and Cryptococcus neoformans (meningitis, pneumonia in compromised individuals). Common pathogenic moulds are Aspergillus spp. (necrotizing pneumonia) and agents of mucormycosis (Rhizopus and Mucor spp.). Some fungi can grow as either a mould or yeast (dimorphic fungi). Common examples are Pneumocyctis carinii and histoplasma capsulatum which cause pulmonary infections.

FUNGI	IMPORTANCE TO IP&C
NAME	**Describe a disease caused by this fungi and any infection control precautions recommended**
Candida albicans	

Parasites

A parasite is an organism that lives in or on and takes its nourishment from another organism. A parasite cannot live independently. Parasitic diseases include infections caused by protozoa, helminths, and arthropods:

Protozoa – Malaria is caused by plasmodium protozoa, a single-cell organism that can only divide within its host organism

Helminths – Schistosomiasis, another very important parasitic disease, is caused by helminthes (worms) in the Schistoma family

Arthropods– The arthropods include insects and arachnids (spiders, etc.), a number of which can act as vectors (carriers) of parasitic diseases

PARASITES	IMPORTANCE TO IP&C
NAME	**Describe a disease caused by this parasite and any infection control precautions recommended**
Giardia lamblia	

METHODS

As a critical component of this module, you will be allocated time to be spent with a preceptor in the microbiology laboratory. Your preceptor for the orientation will arrange for this clinical experience. In preparation for you time in the laboratory here are some exercises (see pg. 13-20) which you should do. If you need further clarification on the exercises you can bring them to your preceptor in the laboratory.

CONTACT INFORMATION

Local Laboratory – Site Specific (Diagnostic Services – Shared Health)

KEY CONTACTS	Work Hours	After Hours Contacts
Name:		
Location:		
Phone:		
Email Address:		
Required Contacts:		

Cadham Provincial Laboratory (CPL)

KEY CONTACTS – MICROBIOLOGY	Work Hours	After Hours Contacts
Name:		
Location:		
Phone:		
Email Address:		
Required Contacts:		

KEY CONTACTS – VIROLOGY/VIRUS DETECTION	Work Hours	After Hours Contacts
Name:		
Location:		
Phone:		
Email Address:		
Required Contacts:		

Manitoba Health - Clinical Notification of Reportable Diseases

KEY CONTACTS – MICROBIOLOGY	Work Hours	After Hours Contacts
Name:		
Location:		
Phone:		
Email Address:		
Required Contacts:		

Communicable Disease Coordinators – Public Health Nurses

KEY CONTACTS – MICROBIOLOGY	Work Hours	After Hours Contacts
Name:		
Location:		
Phone:		
Email Address:		
Required Contacts:		

MICROBIOLOGY

Specimen Collection and Transportation

Learning objective: Describe the appropriate method for the collection, storage and transportation of specimens to the bacteriology lab. See DSM Manual at Reference Material - Diagnostic Services - Health Providers (sharedhealthmb.ca)

Cadham lab: Guide to Services 2020 (gov.mb.ca)

Specimen collection and transport to the lab is an essential part of the culture process. In general, all specimens should be collected aseptically and placed in a sterile container; in some cases, specimens may be placed directly into culture media (e.g., blood cultures, genital cultures). Special handling techniques may be necessary for some specimens such as those for anaerobic culture. Prompt delivery to the laboratory is essential to prevent the death of pathogenic organisms or the overgrowth of commensal organisms. If transport is delayed, some specimens may be refrigerated

(e.g., urine, stool, sputum) while others should be maintained at room temperature (e.g., genital, eye, or spinal fluid).

Specific procedures for specimen collection and transport are lab dependent. Please refer to the appropriate laboratory manual for specific procedures and protocols.

TEST	USUAL TRANSPORT MEDIA	IMPORTANT POINTS ON COLLECTION OF SPECIMEN	COMMON PROBLEMS WITH SPECIMEN COLLECTION AND TRANSPORTATION TO LAB	USUAL TEST RESULT TIME
Blood culture				
Wound culture				
Urine culture				
Stool for C&S				
Stool for C. *diff*				
MRSA screen				
VRE screen				
Throat culture				
Eye culture				
Sputum culture				
AFB smear/culture				

Interpretation of Microbiology Laboratory Results

Review 2 or 3 microbiology requisitions with your preceptor and determine the laboratory significance:

CRITERIA	LABORATORY SIGNIFICANCE
Demographics	
Date collected	
Time Collected	
Diagnosis	
Gender	
Person ordering the test	
Date received in lab	
Time received in lab	
Date reported	
Gram stain	
Mixed count	
Amount of growth	
Specimen number	
Cell count	
Organism	
Sensitivity	
Intermediate sensitivity	
Beta lactamase positive	
Resistance	
Source of the specimen (e.g., leg, vagina, etc.)	
Type of test required (i.e. not viral studies by HSV)	

Why is a full work up on stool not sufficient to guide the lab staff? Is it for C. *diff*, *salmonella*, ova and parasites, etc.?

Common Microbiology Requisition Problems

Discuss with your preceptor if there are requisition problems commonly experienced in the microbiology lab and how they affect the testing methods and possibly the results.

PROBLEMS	IP&C SIGNIFICANCE
Information not filled in correctly	

VIROLOGY

Specimen Collection and Transport

See: **DSM Manual** at [Reference Material - Diagnostic Services - Health Providers (sharedhealthmb.ca)]

TEST	USUAL TRANSPORT MEDIA	IMPORTANT POINTS ON COLLECTION OF SPECIMEN	COMMON PROBLEMS WITH SPECIMEN COLLECTION AND TRANSPORTATION TO LAB	USUAL TEST RESULT TIME
Stool for parasites				
CSF for viral studies				
Nasopharyngeal swab for RSV				
Nasopharyngeal swab for influenza				
Varicella zoster swab from vesicle				
Herpes simplex 1 & 2				
Buccal swab for mumps				
Stool for norovirus				
Stool for rotovirus				

Testing for Viruses

Direct examination methods for antigen detection:

Unlike most bacteria, viruses are not complete cells that can function on their own. They cannot convert carbohydrates to energy, the way bacteria and other living cells do. Viruses depend on other organisms for energy. And viruses cannot reproduce unless they get inside a living cell.

Serology methods for antibody detection:

Serology forms the mainstay of viral diagnosis. Following exposure, the first antibody to appear is IgM, which is followed by a much higher titre of IgG. Detection of rising titres of antibody between acute and convalescent stages of infection, or the detection of IgM in primary infection is often used for diagnosis of viral infections.

Interpretation of Virology Laboratory Results

Review 2 or 3 virology requisitions with your preceptor and determine the laboratory significance:

	SIGNIFICANCE ON REPORT
Date reported	
PCR report	
IgM	
IgG	
IgE	
IgA	

NOTE: IF SIGNIFICANCE OF RESULT IS UNCLEAR - **CONTACT THE APPROPRIATE LAB** (e.g., Diagnostic Services - Shared Health, CPL) **FOR FURTHER CLARIFICATION****

Common Viral Requisition Problems

Discuss with your preceptor the different requisitions required for virology testing. Review different virology requisitions for CPL and DSM.

Public Health Laboratory

Cadham Provincial Laboratory

Find answers to the following questions:	
1. What tests are referred to CPL?	
2. Is there a different protocol for sending samples to CPL on week-days versus week-ends?	
3. Is there a specific protocol for sending samples to CPL during an outbreak?	
4. Is there a requirement for specific collection methods for samples which must be transported to CPL?	
5. How long does it take to get a report from CPL?	
6. Does CPL do a panel of virus on some respiratory samples? Is there a criterion around this procedure? E.g. is it done only on patients less than 5 years and over 75 years?	
7. Are samples for MRSA, VRSA, VRE, ESBLs, carbapenem resistance sent to the CPL routinely?	
8. Are any samples referred to the National Microbiology Laboratory?	

Clinical Microbiology Laboratory Experience

Follow a specimen from the time it is received in the laboratory until the report is finalized and sent to the ordering professionals.

NOTE: video to support learning provided

Discuss with laboratory preceptor or refer to reading for answers:

ITEM	NOTES
1. Get an understanding of how lab work is divided	
2. How long different tests take and why	
3. The differences in the type of media for different tests	
4. How the media are selected	
5. How contamination of the specimens is avoided	
6. Tests for identifying organisms	
7. Review antibiotic sensitivity testing	
8. See a Gram stain done	
9. How are reports generated and where are the reports sent to	

Observation of procedures if available:

PROCEDURES	NOTES
Blood culture	
Gram stain	
Sensitivity method	
Specimen for AFB	
Urine culture	
Wound culture	

Documentation and Reporting

Laboratory reporting mechanism to IP&C **–** discuss with your preceptor.

CRITERIA	DESCRIPTION
1. Determine the lab reports which are sent to IP&C on a daily basis	
2. How are routine reports sent to IP&C?	
3. Is there a process for stat reports to IP&C for TB, GAS, MRSA, VRE, ESBL, **4.** Carbapenemase producing organism?	
5. How long does the lab keep specific samples such as MRSA, VRSA, VRE, ESBL?	

Responsibility of IP&C for laboratory reports - Discuss with preceptor:

1. Is there a designated surveillance program for certain microorganisms such as MRSA?
2. How are the reports stored (i.e., database)?
3. Who is responsible for entering the data?
4. Who is responsible for analyzing the laboratory data collected?
5. Are there reports generated from the data and to whom are these reports sent?

OTHER ISSUES

Ethics

Discuss with your preceptor the steps which have been taken at your facility and regionally to ensure the confidentiality of reports e.g., shredding of confidential documents, PHIA, Privacy policies, site specific process.

APPENDIX A: TERMINOLOGY

aerobic organisms – grows in the presence of oxygen

anaerobic organisms – will not grow in the presence of oxygen

antibiogram – antibiotic sensitivity patterns of the organisms being tested

antitoxins – chemicals produced to bind to the exotoxins to inactivate them

bacterial spores (endospores) – produced by some Gram-positive bacilli –difficult to kill (used for sterilization testing)

colonization – multiplication of an organism in or on a body surface without causing tissue invasion or cellular injury or immune response. The person is "asymptomatic".

disease – a pathological condition of the body that presents a group of symptoms particular to it and that sets the condition apart as an abnormal entity differing from other normal or pathological body states (e.g. CDI)

endotoxins –harmful substances released when bacterium dies which are toxic to host – primarily associated with Gram negative bacilli

exotoxins – harmful substances released into environment by living bacterium (i.e.) botulism, tetanus, diphtheria, some forms of food poisoning; exotoxin may be released from a small infected area into the bloodstream or absorbed from the gut

facultative organisms – will grow with or without oxygen

infection – multiplication of an organism in a host causing tissue invasion or cellular injury accompanied by an immune response – occurs with (e.g. pneumonia) or without clinical illness (e.g. HCV infection)

non-pathogenic – microorganisms that do not cause illness

opportunistic pathogens – microorganisms that do not usually cause infection except when a person's immune system has been compromised

pathogenic – microorganisms that can cause disease and illness

virulence – invasiveness, toxin production, ability to survive within the cell and cause illness

zoonosis – from animals or animal products

KEY INFORMATION FROM READING

Normal Flora

Microorganisms are found everywhere in nature and are also naturally present in and on humans. The term used for those microorganisms that can establish populations in a host, such as the human body, without causing disease is “normal flora”. The normal flora that establish permanent populations are called “resident flora” and the microorganisms with temporary or semi-permanent populations are called “transient flora”.

The Body’s Response to Infection

Natural Barriers

- Skin and mucous membranes provide mechanical barriers
- Cilia of respiratory tract entrap organisms and cough mechanism expels them
- Gastric acid of stomach helps destroy some ingested pathogens, peristaltic waves prevent them from attaching and multiplying
- Mechanical flushing protects urinary tract
- Tears flush the eyes

Immune System

- Specific host defense mechanisms
    - Humoral (produces an antibody for each antigen recognized)
    - Cell mediated (macrophages and lymphocytes)
    - B lymphocytes and T-lymphocytes (4 types)
- Regulatory, killer and suppressor and memory
- Non-specific host defense mechanisms
    - Can distinguish between self and non-self but do not differentiate between antigens
    - Complement system: destroys pathogens by enabling the body to produce inflammation and facilitate localization of the infectious agent
    - Cytokines: influence other inflammatory cells, including macrophages, neutrophils and lymphocytes
    - Phagocytosis: injured cells and foreign substances (including microorganisms) are ingested by phagocytic cells (e.g. neutrophils, monocytes)
    - Fever is produced to augment the immune system, inhibit microbial growth, increase the rate of chemical reactions, raise the temperature above the organism’s optimal growth temperature and decrease the individual’s activity.

Stages of Illness

1. **Invasion** – pathogen acquires entry into the body (mucous membranes, inhalation, self-inoculation)
2. **Incubation** – pathogen replicating, no symptoms
3. **Prodromal** – initial appearance of symptoms (usually mild and vague)
4. **Acute Illness** – maximum impact of illness when pathogen is proliferating rapidly – toxic by-products of microbial metabolism and immune response produce tissue damage
5. **Recovery** – pathogen is contained and eliminated from body, damaged tissue is repaired and resolution of symptoms

Common Normal Flora

BODY SITE	COMMON ORGANISMS
Mouth	*Staphylococci, S. viridans, Enterococci, S. pneumoniae, Neisseriae, Corynebacteria, Haemophilus*, *Enterobacteriaceae, Actinomyces, Lactobacilli, Bifidobacteria, Fusobacteria, anaerobic* Gram neg*. cocci,* anaerobic Gram neg. cocci
Upper Respiratory Tract	*Staphylococci, S. viridans, S. pneumoniae, Corynebacteria, Haemophilus, Propionibacteria, Actinomyces, Bacteroides, Fusobacteria,* anaerobic Gram neg. *cocci,* anaerobic Gram neg. *cocci*
Skin	*Staphylococci, Corynebacteria, Propionibacteria*, anaerobic Gram neg. *cocci*
Conjunctiva	*Staphylococci, Corynebacteria*, anaerobic Gram neg. *cocci*
Lower Intestine	*S. viridans*, *Enterococci, Corynebacteria, Enterobacteriaceae, Clostridia, Lactobacilli, Bifidobacteria, Fusobacteria*, anaerobic Gram neg. *cocci*
External Genitalia	*Staphylococci, S. viridans, Enterococci, Corynebacteria, Enterobacteriaceae, Bacteroides, Fusobacteria,* anaerobic Gram neg. *cocci*
Anterior Urethra	*Staphylococci, Enterococci, Neisseriae, Corynebacteria, Bacteroides, Fusobacteria,* anaerobic Gram neg*. cocci*
Vagina	*Staphylococci, S. viridans, Enterococci, Neisseriae, Corynebacteria, Lactobacilli, Bifidobacteria, Bacteroides,* anaerobic Gram neg. *cocci*

Bacteria

Bacteria are very small, relatively simple, single celled organisms. They contain a single long circular molecule of double strand DNA. This "bacterial chromosome" is not surrounded by a nuclear envelope and is attached to the plasma membrane.
The cell wall of bacteria is a rigid structure that maintains the shape of the cell and prevents bursting of the cell from the high osmotic pressure inside it. There are several different types of cell wall structures in bacteria, which have traditionally been categorized according to their staining characteristics. The 2 major types of cell walls are Gram positive and Gram-negative. In addition, some mycobacteria have an acid-fast wall (e.g., *M. tuberculosis*) and mycoplasms have no cell wall.

A Gram-positive cell wall is composed of a very thick protective peptidoglycan layer. Because this layer is the principle component of the Gram-positive cell wall, many antibiotics effective against Gram-positive organisms act by preventing synthesis of peptidoglycan.

The cell wall of the Gram-negative microbe is composed of two layers. The inner peptidoglycan layer is much thinner than in Gram-positive cell walls. Outside this peptidoglycan layer is another outer membrane unique to the Gram-negative cell wall.

The outer membrane contains proteins, phospholipids and lipopolysaccharide. This outer membrane:

- Acts as a barrier to hydrophobic compounds and harmful substances
- Acts as a sieve, allowing water-soluble molecules to enter through protein-lined channels called porins
- Provides attachment sites that enhance attachment to host cells

Because of these cell wall structure differences, Gram-negative bacteria are less affected by antibiotics.

Shapes of Bacteria (Morphology)

Bacteria vary in size from 0.4-2 um. They occur in four basic shapes:

1. **Cocci** (spherical) – usually round but may sometimes be irregularly shaped. Cocci that remain in pairs are after dividing are called diplococci and those that remain attached in a chain are called streptococci, while those that remain attached in clusters or broad sheets are called staphylococci.
2. **Bacilli** (rod shaped) – most appear as single rods and are fairly uniform in shape although some are oval and look so much like cocci that they are called coccobacilli
3. **Spirochetes** (spiral shaped) – vary in length and in number of turns
4. **Pleomorphic** lack a distinct shape (like jello)

Mycobacteria

Are weakly Gram-positive but stain better with an acid-fast stain. This group includes organisms that cause tuberculosis and leprosy.

Mycoplasma

Mycoplasmas are extremely small bacteria that lack cell walls and are surrounded only by an outer plasma membrane. Because they lack a rigid cell wall they are resistant to cell wall-active antibiotics (penicillins). Mycoplasms associated with human infections are *mycoplasma pneumoniae* (atypical pneumonia), *ureaplasma urealyticum* (UTIs) and *mycoplasma hominis* (urogenital infections).

Other Cell Attributes

Surface polymers: some pathogenic bacteria produce a covering called a "capsule" which acts as virulence factors in helping the pathogen evade phagocytosis. Slime layers are similar to capsules but are more diffuse layers surrounding the cell. They also serve to inhibit phagocytosis or in some cases to aid in adherence to host tissue or synthetic implants.

Cell Appendages: flagellum is an organ of locomotion. They are exterior protein filaments that rotate and cause bacteria to be motile. Flagella that extend from one end of the bacterium are called "polar". Flagella that occur on all sides of the bacterium are called peritirichous. Pili (also known as fimbriae) are hair like protein structures that aid in attachment to surfaces. Some (known as sex pili) are involved in bacterial conjugation and gene exchange. Proteins exist within the pili that aid in attachment and are called adhesins.

Endospores are formed by 2 genera of bacteria *Bacillus* and *Clostridium.* Endospores are dormant forms of bacteria that are resistant to heat, cold, drying and chemical agents. Spores form when there is a shortage of needed nutrients and can lie dormant for years. When the spore is exposed to a favourable nutrient rich environment, it becomes active again.

Environmental Factors Influencing Growth

Three factors influence the growth rate of bacteria: pH, temperature and gaseous composition of the atmosphere.

- Most bacteria of concern grow best at a neutral pH
- Bacteria that have adapted to humans grow best near body temperature
- Some require oxygen (obligate aerobes), some cannot grow in the presence of oxygen (obligate anaerobes) and some can grow either with or without oxygen (facultative anaerobes).

They also need a source of:

- Carbon
- Nitrogen
- Energy (ATP)

Smaller amounts of elements such as phosphates and a variety of metals and ions must also be present.

All bacteria that inhabit the body are heterotrophic: require more complex substances for growth such as an organic source of carbon and they obtain energy by oxidizing or fermenting organic substances. Often the same substance (e.g., glucose) is used as both a carbon source and energy source.

Fungi

Fungi are organisms that derive nutrients from organic matter. Most fungi are aerobes that require a moist environment and grow best at a neutral pH. Their spores and conidia are able to survive in dry conditions for long periods of time. Some fungi are well-adapted human pathogens however most are accidental pathogens that humans acquire through contact with decaying organic matter or in airborne spores. Typically, fungi are divided into two separate groups: yeasts and moulds. Common pathogenic yeasts include *Candida spp.* (vaginitis, mucositis) and *Cryptococcus neoformans* (meningitis, pneumonia in compromised individuals). Common pathogenic moulds are *Aspergillus spp.* (necrotizing pneumonia) and agents of mucormycosis (*Rhizopus* and *Mucor spp.*). Some fungi can grow as either a mould or yeast (dimorphic fungi). Common pathogenic ones are *Pneumocyctis carinii* and *Histoplasma capsulatum* both which cause pulmonary infections.

Viruses

Viruses were originally classified according to the diseases they caused or where they were found. Now they are classified by the type and structure of their nucleic acids, chemical and physical characteristics, size, type of replication and host. They are ultramicroscopic particles that contain nucleic acid (either RNA or DNA) surrounded by protein and in some cases a membrane-like envelope.

Viruses that contain only the viron are called “naked” or “non-enveloped” viruses and are relatively stable to temperature, pH and chemicals. Viruses that wrapped in a membrane are called enveloped viruses and are more fragile because anything that disrupts their envelope inactivates them.

Outside the host cell the virus is known as a viron. A viron is metabolically inert and does not grow or multiply. All viruses replicate in a similar fashion: (APEC)

- **Attachment:** the viron attaches to a receptor site on the host cell

- **Penetration:** the viron enters the host cell
- **Replication:** viral DNA or RNA directs the host cell to begin synthesis of viral components Replication uses host cell energy sources and amino acids to produce these components
- **Maturation:** the viral components spontaneously assemble into a viral particle: new virons are formed
- **Release:** the host cell breaks open or the virus buds through the cell wall and new virons are released. Some viruses lie dormant in the host cell for months or years; after this latent period new virons form and cause damage to host cells

Common Infections and the Usual Organisms That Cause Them: Reviewing and Interpreting Culture Results

INFECTION/SITE	COMMON ORGANISMS
Bronchitis	*S. pneumoniae*, *H. influenzae*, respiratory viruses
Device-related	Coagulase-negative *staphylococci*, *Corynebacteria sp.*
Endocarditis	*S. viridans*, *S. aureus*, *Enterococci*
Gastroenteritis	*Salmonella sp.*, *Shigella sp.*, *Campylobacter sp.*, *E. coli 0157:H7*, viruses
Meningitis	*H. influenzae*, *N. meningitides*, *S. pneumoniae*
Pelvic Inflammatory Infection	*C. trachomatis*, *N. gonorrhoeae*, *Bacteroides sp. Enterobacteriaceae*
Pharyngitis	*S. pyogenes*, respiratory viruses
Pneumonia (community)	*S. pneumoniae*, *H. influenzae*, *M. pneumoniae*, *C. pneumoniae*, *M. tuberculosis*
Pneumonia (healthcare)	*Pseudomonas sp. S. aureus*, *Enterobacteriaceae*
Septicemia	*S. aureus*, *S. pneumoniae*, *E. coli*, *Klebsiella sp.*, *Salmonella sp.*
Sinusitis	*S. pneumoniae*, *H. influenzae*, *S. pyogenes*, *S. aureus*
Skin	*S. aureus*, *S. pyogenes*, *Candida sp.*, dermatophytes
Urinary Tract	*E. coli, Enterococci, Candida sp., Klebsiella sp., Proteus sp.*

Reviewing and Interpreting Culture Results

Specimens and Culture Results

1. Gather as much information as possible!!
2. Know what “normal flora” is and what potential “pathogens” are
3. Some specimen types such as sputum and feces will always contain organisms as “normal flora” and potential pathogens must be separated from them (coughing up sputum will always be contaminated with saliva and potentially non-pathogenic organisms)
4. Other specimens such as blood and CSF are normally sterile so any growth needs to be evaluated
5. Is it clinically significant (is the person sick with symptoms)?
6. Is it a contaminant (skin contamination with blood collection)?
7. Is it a transient loss of sterility (transient bacteremia after brushing teeth)?
8. Quantitative values – the quantity of organisms is expressed as colony forming units per litre (CFU/L) helps in identifying contamination from infection – used for urine testing (counts > 100,000 usually considered a potential UTI)
9. Number of positive cultures important (the same organism isolated from blood and another site suggests bacteraemia arising from infection at that site)
10. Clinical findings important in interpreting cultures (e.g., signs and symptoms of dysuria and frequency of urination as important as urine culture in diagnosing UTI)
11. Person’s history important (e.g., the presence of a prosthetic heart valve increases the likelihood of coagulase negative staphylococcus [CNS] in a blood culture representing endocarditis than when the person has no history of heart surgery).
12. Keep in mind that some heavily colonized wounds will heal spontaneously, and conversely, some organisms are able to cause serious infection at much lower levels of colonization. Infection depends on the pathogenicity of the organism, the type of wound, and the patient’s response
13. Persons who are immunosuppressed, on steroids or neutropenic have a greater chance of infection with “opportunistic pathogens” (e.g., *aspergillus* in the sputum of a neutropenic person has more serious implications than in a normal host)

Specimen Collection

See **DSM Manual at** Reference Material - Diagnostic Services - Health Providers (sharedhealthmb.ca)

Cadham lab Manual at Guide to Services 2020 (gov.mb.ca)

Review the specimen collection process for:

- Wound cultures
- Blood cultures
- Urine cultures
- Sputum cultures

The WRHA would like to thank the Provincial Infection Control Network of British Columbia (PICNET) for allowing the use of their ICP Orientation Manual.

IP&C ORIENTATION MODULE EVALUATION - MICROBIOLOGY

These modules have been developed in order to make your IP&C orientation to the WRHA Infection Prevention & Control Program a good experience. Please complete the below evaluation for each module so any necessary changes can be made to improve the manual for future use. Your thoughts and comments are greatly appreciated, thank you.

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. The material was presented in a clear and organized way.	☐	☐	☐	☐
2. The information in the module was consistent with the objectives stated.	☐	☐	☐	☐
3. The required readings were useful.	☐	☐	☐	☐
4. The instructions with in the module were clear.	☐	☐	☐	☐
5. The amount of time given for the module was adequate.	☐	☐	☐	☐
6. The module provided information that I needed in order to do my job.	☐	☐	☐	☐
7. The module helped me to develop my critical thinking by using examples of IP&C situations.	☐	☐	☐	☐

COMMENTS

1. Do you now feel better prepared to begin your job, recognizing that this is an orientation manual and not meant to replace an accredited infection control course?

2. Do you have any suggestions on how this module can be improved?

3. Are there any additional topics that should be included in this module?

4. Any further comments?