BIOL215: MICROBIOLOGY FOR HEALTHCARE PROFESSIONALS

Lecture notes for Exam 1

DR. PRYOR

INTRODUCTION:

Microbiology – the study of microbes/ microorganisms

Microbes – living organisms too small to see without magnification

Microscope – invented by **Leeuwenhoek** (1600s)

Before we begin discussing microbial species:

Binomial Nomenclature -- naming of organisms as ***Genus species***
-- developed by **Linnaeus** (1700s)

Ex. ***Escherichia coli*** (*E. coli*) – bacterium in GI tract
- named in honor of **Escherich** (guy who discovered it)

MICROBES INCLUDE:

BACTERIA
- prokaryotes (no nucleus)
- unicellular
- ex. ***E. coli***, ***Staphylococcus aureus*** (MRSA: Methicillin-resistant Staphylococcus aureus)

PROTISTS
-eukaryotes (nucleus)
- unicellular
- ex. ***Naegleria fowleri*** (brain-eating amoeba) – in warm freshwater, enters nose/sinuses

HELMINTHS
- eukaryotes
- multicellular 'worms'
- ex. ***Dracunculus medinensis*** (Guinea worm) – in freshwater in Africa, nearly eradicated
- basis for medical logo, the **Rod of Asclepias**

FUNGI - eukaryotes
- unicellular or multicellular
- ex. ***Candida albicans*** (yeast infection)

VIRUSES - not prokaryote or eukaryote; not alive!
- protein coat surrounding DNA or RNA
- ex. **Influenza** (the flu) – note: no Genus or species name

PRIONS - not prokaryote or eukaryote; not alive!
- infectious proteins
- ex. **Mad Cow Disease** (**BSE – Bovine Spongiform Encephalopathy**) in cows
- ex. **CJD** - **Creutzfeldt-Jakob Disease** in people, also called 'KURU" in New Guinea
- ex. **CWD – Chronic Wasting Disease** in deer, elk
- ex. **scrapie** in sheep, goats

Back to the textbook definition of microbiology:

* some microbes are **not alive** (ex. viruses, prions)

* some microbes **can be seen** with naked eye (ex. helminths)

BENEFICIAL MICROBES:

Most microbes are not **pathogenic** (disease-causing)

Many microbes are helpful, for example:

1. Vaginal Bacteria

- "**MICROBIOME**" - naturally-occurring bacteria in and on the body
- ex. ***Lactobacillus*** spp. (such as ***L. acidophilus*** and other species)
- acid-producing (**lactic acid**)
- acid-loving (**acidophilic**)
- pH of normal vagina = 4
- inhibit the growth of pathogenic microbes by **competitive exclusion**/**microbial antagonism**
- ***Candida albicans*** (fungus that causes yeast infection) growth is inhibited at pH < 4
- **Gardnerella vaginalis** (bacteria that cause **BV**, **bacterial vaginitis**) is inhibited at pH < 4

- when *Lactobacillus* is absent (after antibiotics, for example), vaginitis is thus more likely

2. Fecal Transplantation

- use of a donor's healthy feces (with its **microbiome**) to treat a patient with **CDIFF**
- CDIFF is ***Clostridium difficile*** (bacteria) that cause gastrointestinal infection
- causes almost 30,000 deaths per year in USA
- most common in hospitalized patients and in nursing homes
- success rate with fecal transplant is 94% (three times better than with antibiotics)

3. Food Production

- bread, wine, beer made with live yeast (fungus) ***Saccharomyces cerevisiae***
- yogurt made with live bacteria ***Lactobacillus bulgaricus*** and other bacteria
- cheese made with live bacteria (many different species)
- etc…

4. Probiotics

- live microbes eaten for better health (<u>not</u> scientifically proven, however)
- for GI problems,including **irritable bowel syndrome (IBS)**, **inflammatory bowel disease (IBD)**

* The rest of the semester will cover pathogenic microbes

HISTORICAL FIGURES:

Leeuwenhoek (1600s) – first microscope

Jenner (1700s) – first **vaccine** (immunization, inoculation)
- inoculated people with **cowpox** virus to prevent **smallpox** virus
- cowpox is mild and not lethal, causes skin rash (milkmaid's hands, from milking cows)
- smallpox is virulent and lethal
- term "vaccine" derived from "**vacca**" = cow in Latin

Pasteur (1800s) – developed **pasteurization** (use of heat to reduce bacteria in food/drink)
- pasteurization prolongs shelf life and makes safer foods/drinks
- originally used to prevent **wine** from turning sour
- **Acetobacter** bacteria convert **alcohol** into **acetic acid** (**vinegar**; vin aigre…sour wine)

- also disproved **spontaneous generation** –idea that organisms can arise from nothing
- used gooseneck flasks and broth

- also demonstrated **biogenesis** – idea that live cells only come from live cells

- also developed **aseptic techniques** – sterile equipment used in research and healthcare

Semmelweis (1800s)
- implemented handwashing in hospitals to reduce spread of infection
- doctors washed hands with a chlorine solution (similar to bleach)
- infection rates dropped from 10% to 1%
- still today, **hospital-acquired** (**healthcare-associated**, **nosocomial**) infections
- 30% of ICU patients have nosocomial infections!

Lister (1800s) - first use of an antimicrobial chemical (**phenol**) during surgery to prevent infection

Koch (1800s) - first to prove a species of microbe can cause a specific disease
- **anthrax** (caused by **Bacillus anthracis** bacteria), respiratory disease, in mice
- **Koch's Postulates**:
    - isolate in culture the suspected microbe from diseased host
    - administer the microbe to healthy new subject
    - observe disease progression
    - isolate same microbe from new host, now with same disease

Fleming (1900s) - discovered first **antibiotic** (chemical taken internally that kills bacteria)
- **penicillin**, derived from fungus **Penicillium notatum**
- the fungus was exhibiting **competitive exclusion** to fight bacteria

Marshall (1980s) - first to prove **peptic ulcers** can be caused by bacteria
- peptic ulcers are **lesions** (open sores) in stomach
- ***Helicobacter pylori*** (acid-tolerant bacteria in stomach)
- he used Koch's Postulates on himself!
- he gave himself the bacteria, developed ulcers, then treated with antibiotics

Peptic ulcer diagnosis:

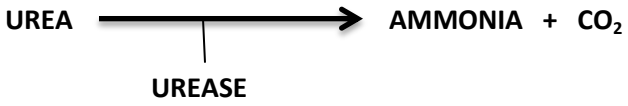
1. **symptoms** (subjective; reported by patient)
and **signs** (objective; can be observed or measured)

- dull pain in the stomach, heartburn in chest **- symptom**
- weight loss (not wanting to eat because of pain) **- sign**
- nausea or vomiting (vomit looks like coffee grounds or is bloody) **- sign**
- anemia (low blood cell count; tired, short of breath, pale skin) **– signs and symptoms**
- dark, tarry stool **– sign**

2. **EGD** - **esophagogastroduodenoscopy** (endoscopy)
- examine stomach lining for **ulcers** (open sores)

3. **Urea Breath Test**

- patient swallows isotope-labelled **urea**
- urea = **$(NH_2)_2CO$**
- labelled urea has either **^{13}C** or **^{14}C** (normal is **^{12}C**)
- isotopes have different numbers of **neutrons**
- ***H. pylori*** bacteria convert urea into **ammonia** and **CO_2**, via enzyme **urease**



- exhaled breath is analyzed for **^{13}C** or **^{14}C** (in **CO_2**)
- positive result if the isotope is present in breath

Peptic ulcer treatment (all of the following)**:**

Antibiotics	- two antibiotics taken - ex. **Metronidazole** ("Flagyl") - ex. **Clarithromycin** ("Biaxin")
Acid secretion inhibitor	- reduces acid production - ex. **Omeprazole** ("Prilosec")
Antacid	- buffers acidity - ex. **Bismuth subsalicylate** ("Pepto-Bismol")

MICROBES IN THE LAB:

How small are microbes?

Measured in **micrometers** (**microns**) - μm

1000 μm / 1 mm (millimeter)

Sometimes measured in **nanometers** - nm

1000 nm / 1 μm

FUNGI and PROTISTS	>	BACTERIA	>	VIRUSES
4 – 40 μm		0.1 – 10 μm		0.03 – 0.3 μm

Q. How many μm long is a helminth that is 10.5 mm long?

$$\frac{10.5 \text{ mm}}{1} \times \frac{1000 \text{ μm}}{1 \text{ mm}} = 10{,}500 \text{ μm}$$

Q. How many nm long is a virus that is 0.05 μm long?

$$\frac{0.05 \text{ μm}}{1} \times \frac{1000 \text{ nm}}{1 \text{ μm}} = 50 \text{ nm}$$

Staining Microbes:

Staining is necessary to see microbes under the microscope (otherwise are colorless)

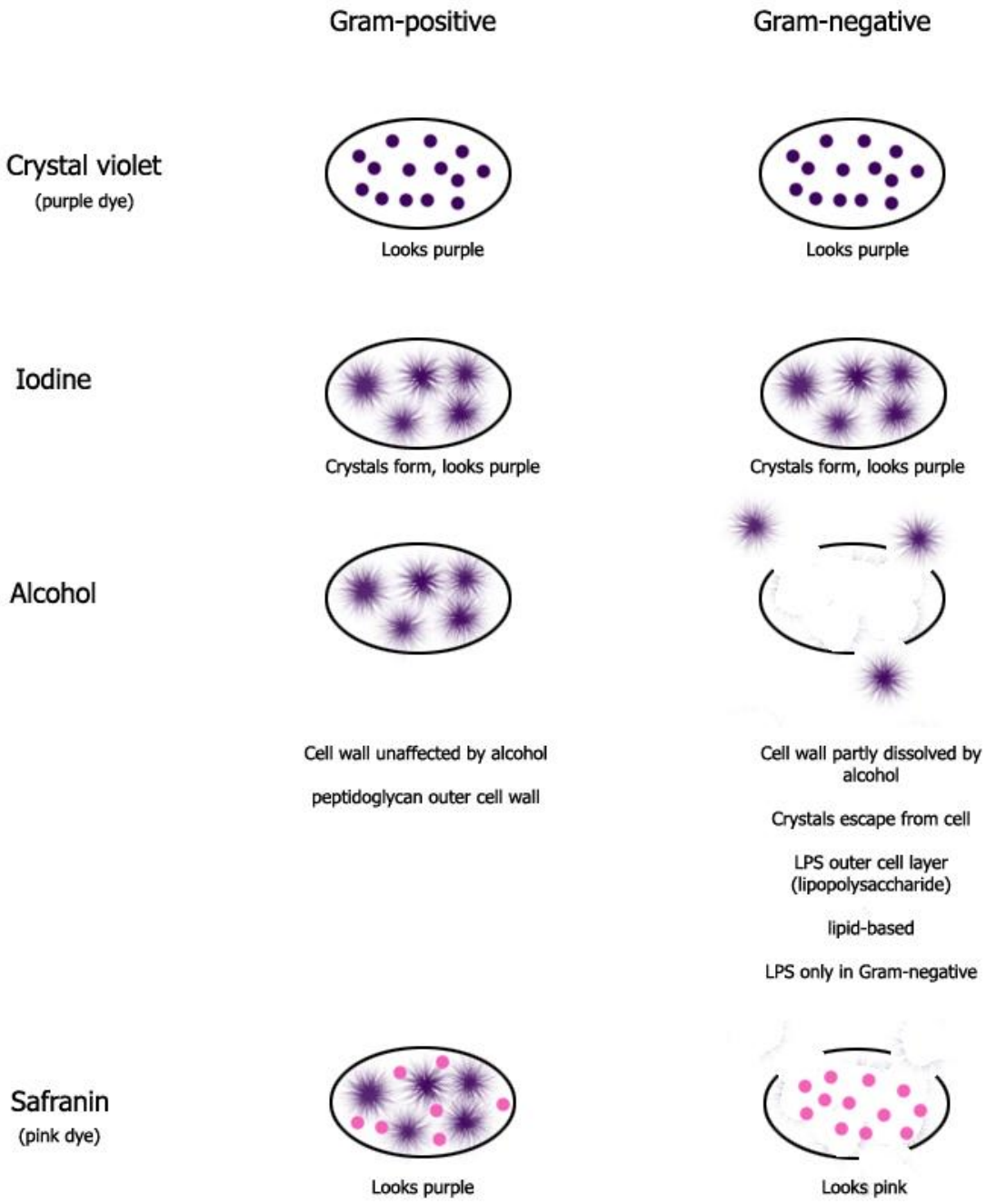
1. **Simple stain** - a single dye is used

2. **Differential stain** - uses two or more dyes
   - can discern between types of bacteria

Ex. **Gram stain**

- Gram-positive bacteria = purple
- Gram-negative bacteria = pink/red

How does the Gram stain work?



3. Negative stain

- colors background dark, bacteria appear colorless/white
- used for bacteria that **repel** stains
- also allows visualization of **capsules** = protective 'shell' around some bacteria that resist the immune system and antibacterial drugs
- ex. ***Streptococcus pneumoniae*** is pathogenic when it has capsules, but not pathogenic when it lacks capsules (immune system can fight off nonencapsulated strains)

* **strains** are different varieties of one species of bacteria, ex. encapsulated and nonencapsulated strains of ***S. pneumoniae***

4. Flagellar stain

- allows visualization of **flagella** = whip-like structures used for motility
- **motility** = ability of some bacteria to move in fluids

- **atrichous** = no flagella
- **monotrichous** = one flagellum
- **amphitrichous** = two flagella; one at each end of cell
- **lophotrichous** = tuft of flagella at one end
- **peritrichous** = covered in flagella

5. Acid-fast stain

- rapid diagnostic stain to test for **tuberculosis** and **leprosy**
- **positive result** (red bacteria) will only be either:

- **Mycobacterium tuberculosis** = bacteria that causes **tuberculosis** (**TB**)
  - respiratory disease
  - highly contagious
  - many strains are resistant to antibiotics,
    ex. MDR TB (multidrug resistant TB)
    XDR TB (extensively drug resistant TB)

- **Mycobacterium leprae** = bacteria that causes **leprosy ("Hansen's disease"**)
  - skin disease, open sores (**lesions**) on cool extremities
  - extremities = face, fingers, toes

-contagious
- can be treated with antibiotics
- grown on armadillos for research (low body temp)

* side note: what is the TB test?

TST = tuberculin skin test
- tuberculosis bacterial protein (**tuberculin**) injected into the skin
- 48-72 hours later, the **induration** (welt) is measured
- 6-10 mm OK, but more than that means the person is vulnerable to TB

6. Endospore stain
- allows visualization of bacterial **endospores**
- **endospores** = highly resistant to chemicals, heat, radiation, etc…
- seed-like, dormant stage of some bacteria
- ***Bacillus*** species and ***Clostridium*** species, including:

- ex. ***Bacillus anthracis*** (causes anthrax; respiratory disease -- mentioned earlier)

- ex. ***Clostridium difficile*** (causes Cdiff -- mentioned earlier)

- ex. ***Clostridium botulinum*** -- causes **botulism** = muscle paralysis
  - type of food poisoning
  - can cause **Infant hypotonia** (**floppy baby syndrome**) – when babies eat *C. botulinum*- contaminated honey

- ex. ***Clostridium tetani*** – causes **tetanus** = uncontrolled muscle contraction
  - endospores enter body via puncture wound (step on rusty nail)
