What Do Nursing Students Need to Know About Microbiology?

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• Stress - these are just suggestions based on experience in nursing career and as micro instructor

• Struggled with approaches for how to get info across in 45 min!
  • decided to share topics I cover in MY class, and give as much rationale as I can fit in

• My focus is on what R.N.s will use in practice, and secondarily on topics that they may see on boards
  • NOTE - I do cover info in my course that they probably aren’t going to use in practice, for various reasons

• Great idea: go to Borders, etc. and look at the NCLEX review manuals to get ideas of test questions re: micro. They are almost always critical thinking questions. Could also ask nursing school faculty if they have review books you could borrow.
Pervasive themes, a.k.a. the topics we beat to death throughout the quarter

• **Nosocomial infection**
  - importance to both them and their patients, prevalence, their role in controlling

• **Hand washing** - goes hand in hand with controlling nosocomial infection. They ARE going to get insanely busy on the floor. MUST stop and take time to wash hands (when super busy is probably most important time!)

• **Enzymes**
  - central to metabolism as well as understanding why microbes behave the way they do. Joke - “Magic answer” to “why” questions on exams

• **Virulence factors & pathogenicity**
  - Big emphasis on pathogenic microbes, especially opportunistics
  - students have a lot of interest in what makes one bug “worse” than another

• **Microbial antagonism**
  - After lab experience, the tendency is to think about microbes in isolation from one another. Must realize that in nature (incl. human body) that’s not reality.
  - Also important to understand role of normal flora in health
Pervasive themes, a.k.a. the topics we beat to death throughout the quarter

**Immune system - BIG TOPIC**

- Importance of supporting own and patient’s immune health (some start getting paranoid when learn about microbes so good opportunity to emphasize)
- MUST automatically register the 3 populations who are at an immunological disadvantage: very young, very old, & immunocompromised
- BEAT into them :) emphasizing applicability to patient care ie. Most realize that these three groups are susceptible on a microbiology exam, but often don’t translate this into practice
  
  - e.g. can’t put a pt with a communicable disease in the same room with an elderly patient on steroids!

**Aseptic technique:** 1° goal of lab: gain understanding of/ability to execute properly

- Stress their personal role in prevention of nosocomial infection
- Avoid getting yelled at by a doctor

**Scientific Method:** important to be able to problem-solve in logical, systematic way

**Labeling:** teach not only to label plates, etc. in class but also how to label patient specimens

**Saved most important for last: CRITICAL THINKING,**

- No matter which topics you teach, important to get them to think critically about them
- Teaching them to try to apply what they learn in actual practice - they learn lots of facts but it doesn’t immediately occur to them to apply them. I help them to learn to do this (i.e. I often don’t make the connections straight out to them, rather, I lead them through. Helps build confidence in thinking ability.
Encouraging Ownership of the Information:

Applicability

- Helping them understand how learning X will help them in their job
- PLEASE don’t think of this as justifying your curriculum choices!
- My own experience is that students make more effort to understand and retain the info if they know it will be of use to them (either career or life)
- Anytime you can provide an example of how they might use a particular piece of info in practice, go for it!
- I also encourage my guys to watch shows like House, ER or CSI - they get very excited when they understand something from the show
The Hook: Why Do We Care?

- Disease
- Agriculture
- Food and beverages
- Chemicals
- Basic research and biotechnology

- primary focus of course is role of microbes in disease, so easy to get them interested in the disease applications
- other topics not covered in depth, but briefly mentioned to point out importance of microbes in their everyday lives, help them understand why microbiology is important to them personally

- Do R.N.s need to know? No (except biotech). I just want them to try to form a personal connection with the subject matter
Providing Perspective

• Animalcules
• Miasma
• Semmelweis
• Germ Theory of Disease*
• Koch’s Postulates*
• Golden Age of Microbiology

Providing Perspective
• brief history of microbiology from healthcare perspective
  • emphasize people didn’t always know microbes existed, and that they caused disease
• Perspective to get them interested, engaged before they start hating me and the class, but not essential to know non-starred items
• Koch’s postulates still used today - student heard “SARS” researcher interviewed on NPR and got very excited when KP mentioned
• Semmelweis esp useful learning opportunity
  • Not every crazy idea actually is (most are, though)
  • Careful consideration before dismissing new ideas
Laying the Groundwork: Eukaryotes vs. Bacteria

- Membrane-bound organelles
- Cell walls
  - Gram positive
  - Gram negative
    - O antigen
    - Lipid A
  - Acid fast

- As get deeper into content & material gets more challenging, I focus on big picture & I try to elim details they won’t actually use (again if you have one you’re wondering about you can contact me)

- Must understand fundamental differences & similarities in order to understand basis of control, antibiotics, selective toxicity, immune response

- Gm stain: WILL get lab reports back that say, “Gram negative coccus,” etc. so need to know what this means (don’t HAVE to know how to Gram stain but I teach)

- For Gm neg focus on OM, esp:
  - O-antigen (r/t O157:H7)
  - Lipid A & role in endotoxic shock - if they have pt with systemic Gm neg infx beware

- For AF wall, introduce Mycobacterium tuberculosis
  - need to understand role of wall in virulence
  - need to know that if Dr orders AF stain it’s b/c suspect TB
  - talk about basics of TB infection, why CXR is needed and what Dr is looking for

- Fair amount of detail but not TOO much minutae
  - E.g. presence of teichoic acids in Gram positive cell walls interesting but not essential info, runs, tumbles, flagellar structure nonessential
• This is a good place for me to add a disclosure (maybe should have done it earlier)… I don’t do a “Bug Parade.” I.e. I don’t make them memorize a laundry list of bacteria and diseases.
  • They will be covering specific diseases in pathophysiology class
  • They will need to know completely different organisms/diseases depending on the specialty area they end up in
• My goal is to give them a solid foundation of underlying knowledge that they will be able to apply to any microbe they come across in the future
• I DO introduce many, many specific microbes throughout the course. However, I present them as appropriate to main discussion topics, not as topics in an of themselves. E.g. when talk about acid fast cell wall, we discuss *Mycobacterium tuberculosis*, and basic overview of TB. When talk about spores, we discuss *Clostridium difficile* and *B. anthracis*, etc..
• DO talk about capsules, spores, fimbriae and biofilms as **virulence factors**

• **capsules** - (introduce *Strep pneumoniae*) and how capsule used to evade immune syx

• **fimbriae** - talk about *N. gonorrhoeae* using to attach to UT cells (and why pee after sex)

• talk about how BOTH may be used to form **biofilms**
  
  • BF play a role in huge amount of **human disease**, e.g. gum disease, infections in CF patients
  
  • talk about BF forming on all sorts of **medical catheters** & indwelling tubes e.g. urinary catheters, IV catheters, central lines, respiratory tubes (important to monitor for s/s infx visually and via labs)
  
  •MAKE the connection for them… another example of a topic they can tell you all about on paper, but in practice they forget to monitor catheters for signs of infection

• **spores** - introduce **Bacillus & Clostridium**
  
  • do ask them to remember that these two genera are spore formers
  
  • spores everywhere, emphasize importance of proper disinfection, aseptic technique
    
    • Introduce *C. difficile* - prevalent in hospitals, many drug resistant strains
• Fundamental importance of enzymes and enzyme function in governing cell activity
  
  • **lock and key**
  
  • **enzyme regulation** - groundwork for understanding metabolic disorders in their pts

• cellular respiration - SO many students have NO idea why it’s important! Focus on **BIG PICTURE**

• Focus on what goes in, what comes out, and what the whole point is (converting food energy into form cells can use)

• Admittedly, no one is going to quiz them at the hospital about what the final product of glycolysis is, for example. Some faculty may choose to omit cellular metabolism and it probably isn’t going to kill anyone. Personal teaching decision. I think it’s fundamentally important.

• Important to understand role of O₂ - they’re going to spend hours interpreting blood gas levels and monitoring their pt’s O₂ sats & I think they should have a clue why

  • to help understand I use examples they can relate to
  
  • E.g. why can’t they survive long if bag placed over their head?
  
  • Why cyanide (blocker) and 2,4-dinitrophenol (uncoupler) are poisonous

• Brief overview of anaerobic resp & ferm b/s

  • many pathogens with this metabolism (facultative anaerobes, etc.)
  
  • when collecting pt specimens important to put specimen in proper environment e.g. aerobic blood culture bottles vs. anaerobic cx bottles (don’t want Dr to yell at you) :)
Basic Genetics

- **DNA**
  - Structure
  - Chromosomal
  - Plasmids

- **OVERVIEW**
  - Replication

- **OVERVIEW gene expression**
  - Transcription
  - Translation

**Applicability**: role of genetics as basis for life

- understanding of genetics re: role in disease and disease treatment - future of medicine!
- e.g. role in antibiotic resistance
- e.g. role in biotechnology

**DNA**

- **Structure** noting points of similarity and differences between bacterial and eukaryotic DNA
- Role of **Chromosomal** DNA
- Role of **Plasmid** DNA; intro resistance & virulence plasmids

**OVERVIEW (These are fair game for standardized tests)**

- **Replication** - WHY does the cell do this? Enzyme?
- Gene expression - errors in expression lead to disease - I give basic intro to promoters
  - **Transcription** - WHY? Basics of how.

- give OVERVIEW, not nitty gritty. Need to understand basics, and overall purpose of these processes
Role of genetics in disease

• Mutations
• Cancer

Role of genetics in disease

• Mutations

  • Basic types (point, frameshift)
  • Talk about significance of spontaneous error during replication, use UV radiation as Model Mechanism mutagen
  • role of oncogenes - on surface level and how a mutagen can be a carcinogen - very basic level
Transfer of genetic information

- Transformation
- Transduction
- Conjugation
- Recombination
- Basic cloning

**Flu pandemic**  **Insulin production**  
**Antibiotic resistance**  **Gene therapy**  **Vaccine production**

- Laying this groundwork helps them understand basics of some of the up and coming treatments in medicine, as well as importance in spread of disease
- **BASICS** of each process, not nitty gritty details like role of Rec A protein, etc.
- **BASIC cloning** only
  - Do talk about restriction enzymes & how important their discovery was, & that they come from bacteria
- use examples shown on slide
• BASIC structure, highlighting **acellularity**, unique **genomes**, **intracellular parasites**, size difference bet. viruses and cells
  - basic **classification** based on genome, shape
  - **helical** - e.g. measles, rabies
  - **polyhedral** - e.g. Herpes simplex
  - **complex** - e.g. pox virus
• Basic **replication & metabolism** using T4 bacteriophage, generic DS DNA virus e.g. chickenpox and retrovirus (HIV) as models
  - talk relatively quite a while about HIV (e.g. 15-20 minutes)
  - mention possibility of using phage in lieu of antibiotics, think about advantages, risks
• Also discuss **prions**
• Need to be able to recognize that the illnesses listed are viral in origin (but will get pathooohys in nursing school)
• Chemical control

• **Membranes**

• **Denaturation** of proteins and nucleic acids

• They are going to come into contact with many of these in healthcare setting so I ask them to remember:

  • in general **how** each class works,
  
  • special **precautions** (e.g. aldehydes)
  
  • specific **example** for each category

• Great opportunity to discuss pros and cons of antibacterial soaps, etc.

• Factors that affect control also important (time, population composition, presence of organic material, etc.) I don’t make them memorize parameters for use of each agent, but I do stress that they ALWAYS need to **READ the DIRECTIONS**

• talk about why H₂O₂ is terrible on open wounds but is a great disinfectant
Controlling Microbial Growth: Other Means

- Heat, cold, dessication
- Filtration
- Radiation
- Osmotic pressure
- How to choose?

- Again, going to come in contact with supplies that have been treated with most of these in healthcare setting (except maybe osmotic)
  - e.g. lyophilized drugs or irradiated instruments
- I ask them to understand how each works and what their limitations are
- Heat, cold, dessication
  - introduce Listeria & discuss cold resistance, foods that should be avoided by pregnant women & immunocompromised individuals
- Filtration
- Radiation - great opportunity to discuss use on foods
- Osmotic pressure
  - Discuss how to choose… (Critical thinking!)
• Sources of antibiotics - reminder of microbial antagonism

• **Selective Toxicity**

• Therapeutic index (toxic dose:therapeutic dose)

• ideal characteristics - critical thinking

• **General mechanisms** - overview of how each works, give 1-2 examples of each (don’t make memorize list of drugs b/c they’re going to do that in pharm); CT - selective toxicity of each?
  - Cell wall synthesis inhibitors
  - Membrane disruption
  - Protein synthesis inhibitors
  - Antimetabolites
  - Nucleic acid synthesis inhibition

• Ask them to think about using these for **viral infections**

• BRIEF discussion of **mechanisms** of **antiviral agents** -
  - focus on NAS inhibitors
  - want to expand (incl. antimetabolites, etc.)

• emphasize importance of using correct drug (R.N. can be sued just like Dr. although not as likely - we don’t have as much $$$)
Control of Microbial Growth: Antibiotics

- **Spectrum of activity**
  - discuss when broad vs. narrow preferred (CritThinking)

- **Superinfection** - e.g. *C. difficile*, *Candida* infections in pts on abx

- **Antibiotic resistance**
  - need to understand practices that have led to increase in **development & spread** of resistance, and how they can help **SLOW spread**
  - I don’t discuss on actual mechanisms of resistance
• **Incidence, prevalence, zoonosis** - terms they need to be familiar with

• **Reservoirs** - need to be familiar with common:
  • humans, animals, inanimate objects
  • need to be prepared to APPLY this knowledge, not just memorize it

• **Transmission**
  • need to be aware of these modes both in terms of protecting themselves and their patients
  • emphasize hand washing and aseptic technique!

• Mention CDC web site as great resource
### Basic disease classification

<table>
<thead>
<tr>
<th>Basis</th>
<th>Examples of terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body system affected</td>
<td>Respiratory disease</td>
</tr>
<tr>
<td>Longevity/severity</td>
<td>Acute, chronic, subacute, latent</td>
</tr>
<tr>
<td>Transmission</td>
<td>Communicable, noncommunicable</td>
</tr>
<tr>
<td>Extent of body affected</td>
<td>Local, systemic</td>
</tr>
<tr>
<td>State of host when infected</td>
<td>Primary, secondary</td>
</tr>
</tbody>
</table>

- Need to be familiar with this basic terminology - they will use it!
- Use HIV-AIDS as great example for primary vs. secondary infections
Nosocomial infections
• about 10% hospital patients in America get one!
  • 20,000 die from their infection!
  • > 5 billion $$
• Who most susceptible? - young, old, immunocomp.
  • A red flag should pop into their head AUTOMATICALLY whenever they’re caring for a patient in one of these groups
• Most common causative agents
  • DO make them remember Gm result, cell shape for these (will see this info come back in lab reports)
  • DO expect them to know where these are usually found in environment
    • critical thinking opportunity - instead of TELLING them what diseases these usually cause, ask them since they now know where e.g. Staph lives, make an educated guess about what kind of infection it might commonly cause
    • Can reverse this, too, e.g. ask if pt. gets a particular infection, which organism might be causing? where should they start looking for the source? Intervention? (Hand washing after bathroom? Cleaning surfaces? Cleaning medical equipment like respirators, etc?)
• Common infections…
  • UTIs
  • Wound infections
  • Respirator-related pneumonia
  • Central lines, other catheters - import. of rotating PIV site every three days
• emphasizing microbial antagonism and normally protective role of normal flora

  • MUST remember which sites of human body are supposed to have flora and which are not

• Opportunistic vs. obligate pathogens and what circumstances might allow an opportunist to cause disease (aseptic technique!)

• Examples used typically the same ones from last slide - common causes of nosocomial infections

• V factors listed on the slide not necessarily imperative, just fit material well. Could easily choose others to illustrate concepts.

• General physiological effects of exo- and endotoxins

  • should be able to discriminate between neuro-, entero-, and cytotoxins

• CT opportunity: Are Gram positives worse, or Gram negatives?
• Discuss these as we cover stages of infectious process
• **MUST** be familiar with these to protect themselves and their patients
  • EVERY TIME they expose their or their patients portals of entry, use aseptic technique (universal precautions)
  • must be on alert every time they contact secretions from any of these potential portals of exit and take appropriate precautions
• Point out eyes are great way for microbes to access respiratory tract - stop touching their eyes! Wash hands!
Bug Parade: Eukaryotic Pathogen Overview

- **Fungi**
  - Cell structure
  - Aspergillus
  - Candida
  - Enterobius

- **Protozoa**
  - Locomotory structures
  - Entamoeba histolytica
  - Taenia
  - Balantidium coli
  - Trophozoites vs. cysts

- **Helminths**
  - Cestodes
  - Ascaris lumbricoides
  - Trichomonas
  - Giardia
  - Necator
  - Toxoplasma
  - Trematodes

- For listed organisms, I ask them to know what **kind of organism** it is and generally what **type of disease** it causes.

- Mostly for benefit of my vet tech students but do have tendency to pop up on State Boards.

- (In my course is a lab, observation)

- For **fungal cell structure**, talk about what a thallus is, what hyphae and mycelia are.

- For Protozoa, recall the three **locomotory structures** & recognize that this is how they used to be classified.

  - ciliates, pseudopods, flagellates
• Understand that nonspecific defenses don’t have to fail before the specific defenses kick in

• Cover basic overview of nonspecific defenses, just basics e.g. don’t think they need to memorize complement cascade e.g.
  
    • DO need to understand what starts it, and what consequences there are to it’s activation, and explain how it complements specific immunity

    • basic gist of interferon, not discriminating between interferon beta and gamma
Specific Immune Response

- **Humoral immunity**
- **Cell-mediated immunity**
- **BIG PICTURE**
  - Antigens
  - Antibodies
  - Cytokines
  - BCRs and TCRs
  - Clonal deletion
  - Clonal selection
  - MHC I and II
- **Primary vs. secondary response**

- **BASICs** of humoral and cell-immunity (NOT regulation of, etc.)
- **ID** Common examples of microbial antigens, distinguish an **antigen** from an **epitope**
- should be familiar with the different **classes** of **antibodies** and general role of each
- **Importance of MHC** - which cells have, what’s their basic function?
  - obvious application is tissue transplantation
- **general roles of cytokines**, not who secrete which, when
- **Similarities** and **differences** in **primary** and **secondary** immune response
Antigens & Antibodies in the Lab

• Agglutination & precipitation reactions
  – Blood typing
  – Antibody titers
• Labeled antibody tests
  – ELISA

• Should be able to describe basics of agglutination and precipitation reactions
  • explain basis of blood typing and antibody titers (very common for titers to be ordered)
• Familiarity with ELISA as common diagnostic test (won’t be performing themselves in practice but should have basic understanding of how these work)
Immunization

• **History**
• **Vaccine types**
  – Attenuated
  – Inactivated
  – Subunit
  – Toxoid
• **Safety**

• History of and historical significance of immunization
• Basic understanding of vaccine types:
  • attenuated - risks to immunocompromised patients
  • inactivated
  • subunit
  • toxoid
• Safety issues and importance of helping patients making informed choices
Immune hypersensitivities

• Type I (allergies)
• Type II
  – Transfusion reactions
  – Hemolytic disease of the newborn

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Information Competency

- Peer-reviewed vs. popular journals
- Web site sources
- Ways to optimize searches

- Lots of apathy… expect teacher (or someone else) to be there to feed them answers. In life, sometimes there IS no such person
  - too often they give up and don’t even try to find answer
  - they CAN’T be this way in their career! They need to be motivated to get answers for questions that arise. Sometimes just showing them that they DO have the power to find the answer does the trick.
- DON’T understand that web sites are not peer-reviewed
- Encourage healthy, reasonable amount of skepticism of web sources
- Usually don’t/aren’t aware of using basic Boolean operators in searches
- I used to assume they already had this knowledge coming in, or would get it elsewhere in college, but am finding this is not true. It is SO important to have this knowledge I use a lab to teach it in collaboration with librarian. They do a “library research project” which entails them asking a question about ANYTHING related to microbiology, and then demonstrating that they can find two peer-reviewed sources and two web page sources to answer their question. NOT a term paper. Easy to grade (sources appropriate or not?) They learn about an interesting topic in the process.