Microbiology 101 For Infection Preventionists

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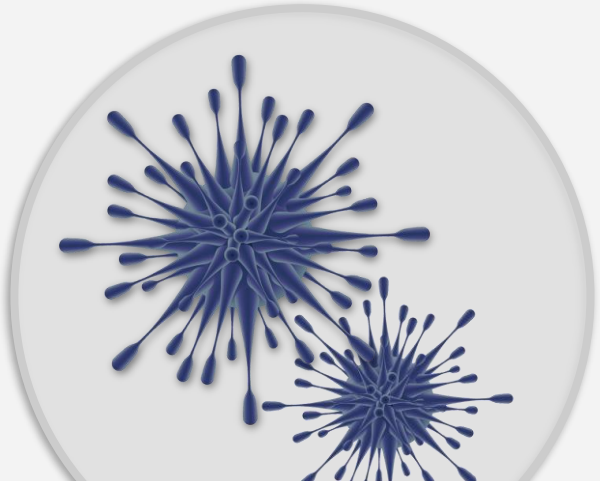

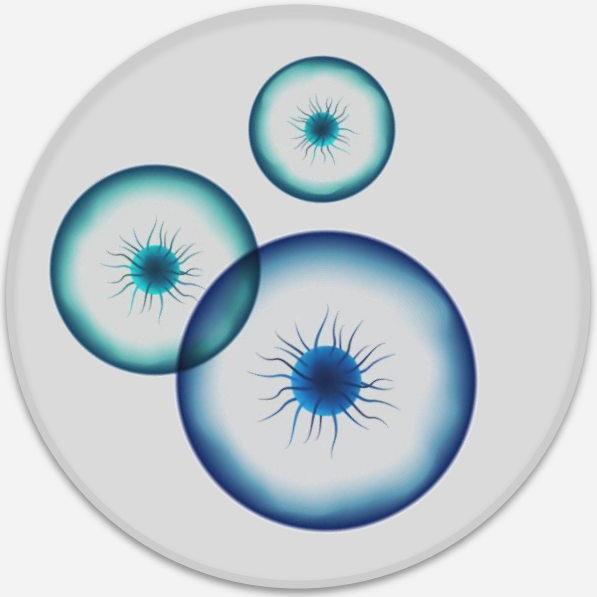

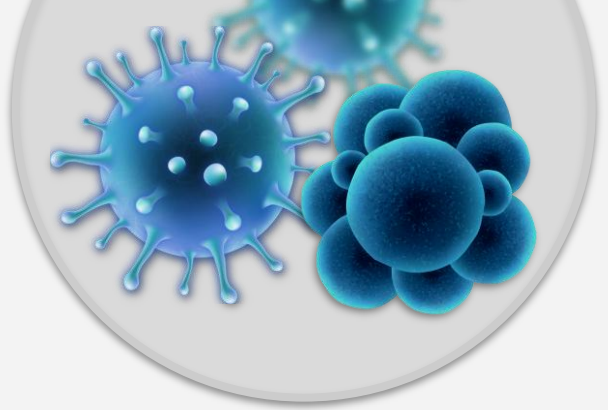

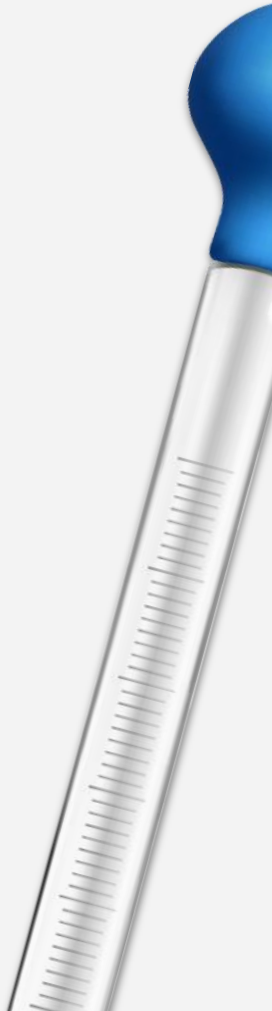

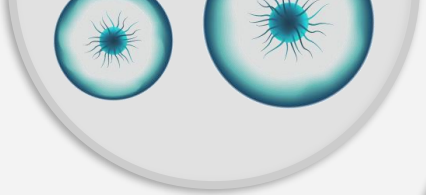

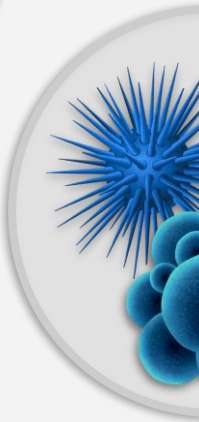

Disclosure

Vydia is employed by Diversey. Her expenses to attend this presentation (travel, accommodation, and salary) are paid by this company. Diversey has had no input into this presentation from a commercial interest.

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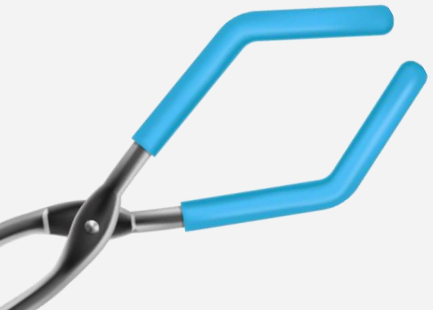
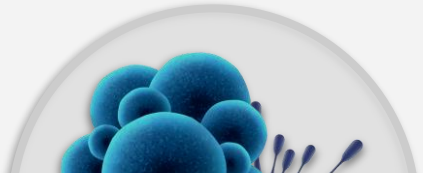
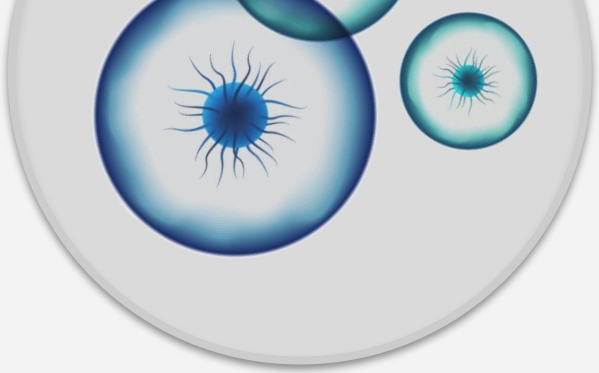
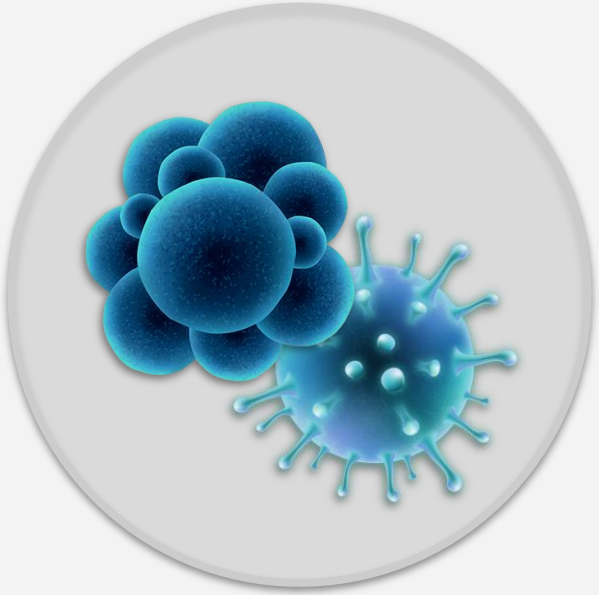
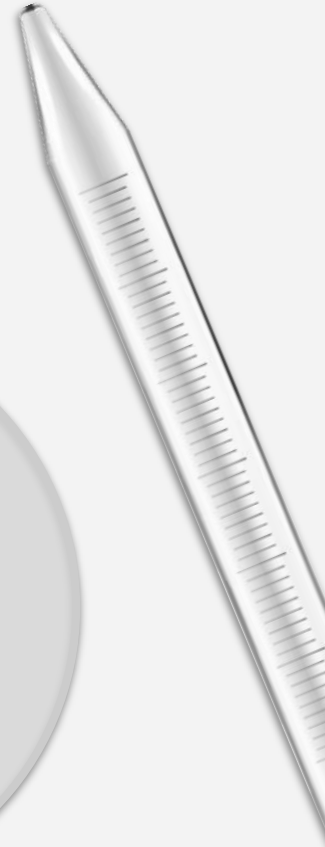






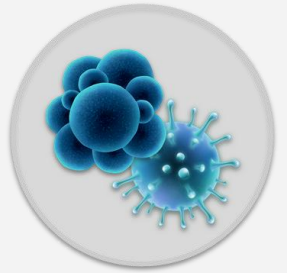




01

Microbiology

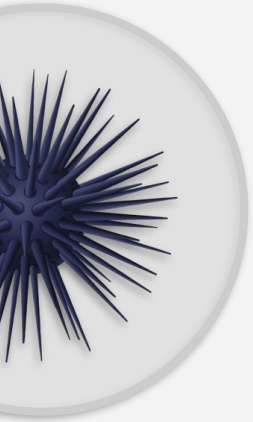
What are Microorganisms?

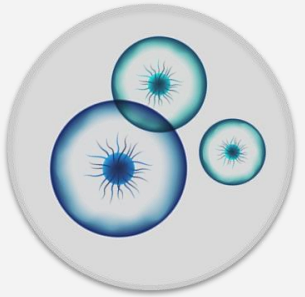


Microbes:

- Have existed for over 3 billion years
- Pathogens are microbes that cause disease but not all microbes are pathogens
- Categorized according to biological taxonomy
    - Kingdom
    - Phylum
    - Class
    - Order
    - Family
    - Genus
    - Species

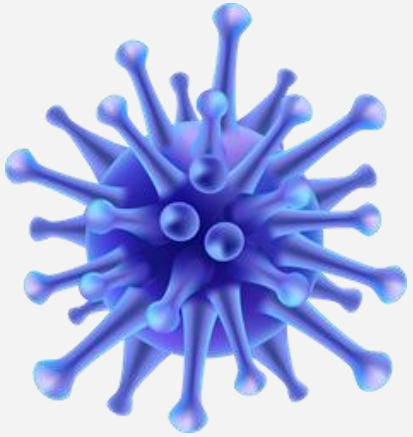
  Example- bacteria are known by genus (Escherichia) and species (coli)

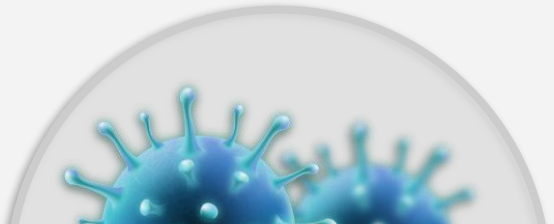




Human body has:

- **30 trillion human cells**
- **39 trillion microbial cells**



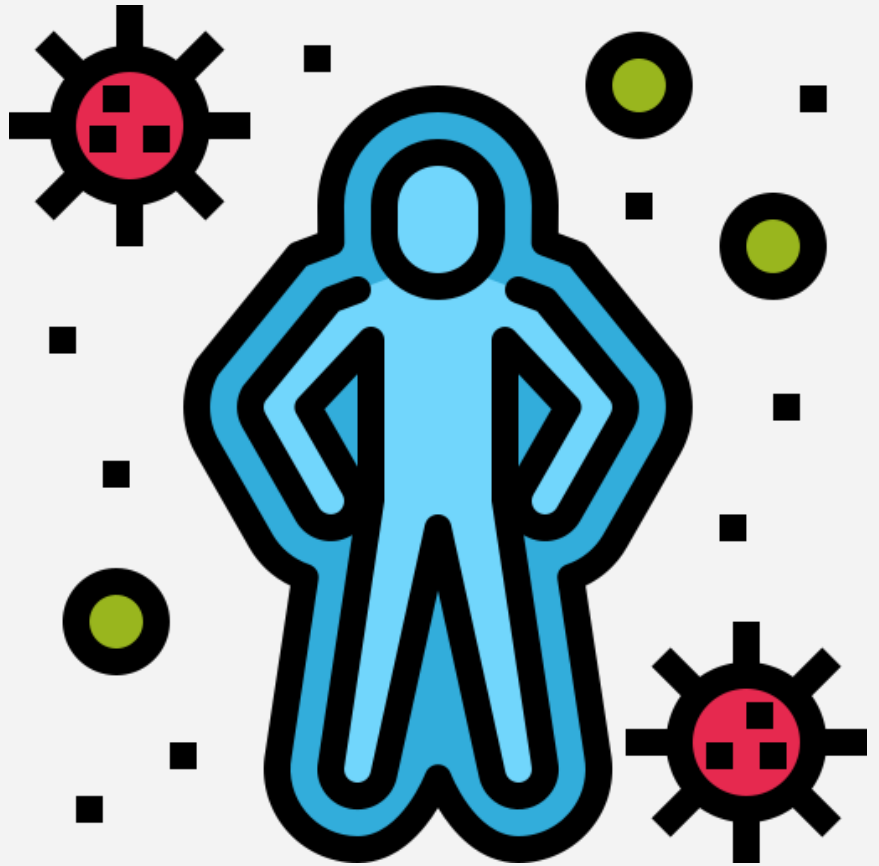


https://www.sciencefocus.com/the-human-body/human-microbiome

What are Microorganisms?

- Worldwide, 16 million people die from infectious disease every year
- There are ~1,400 known species of human pathogens (including viruses, bacteria, fungi, protozoa and helminths), which may seem like a large number but…

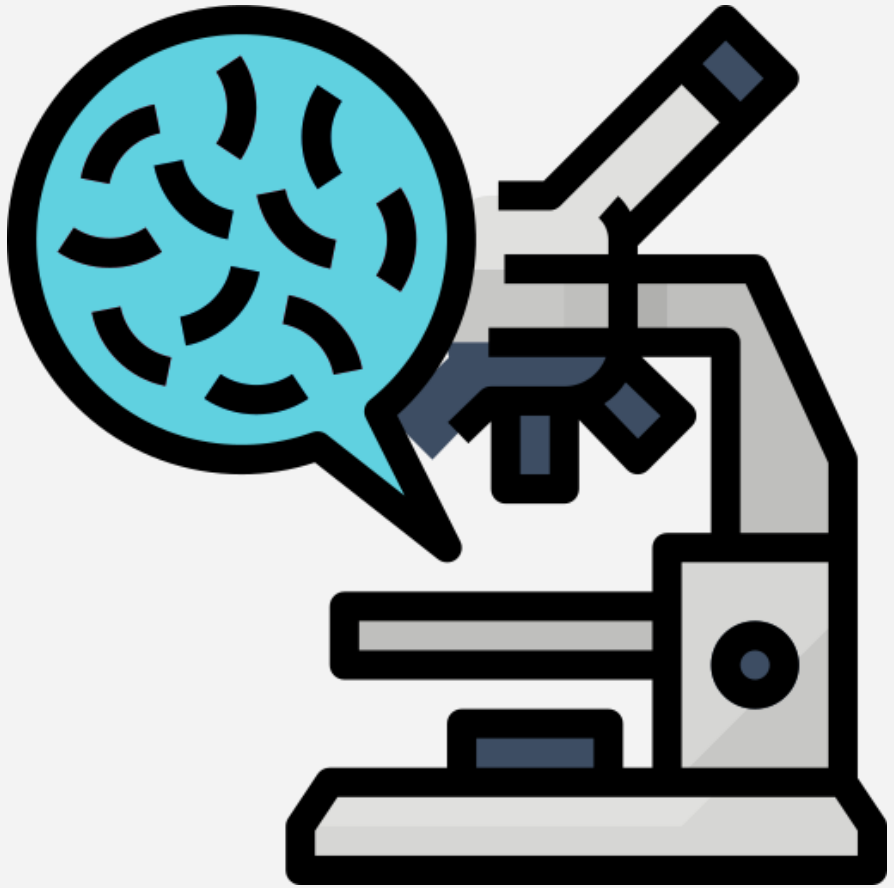
- **Human pathogens account for much < 1% of the total number of microbial species on the planet.**



Nature, Editorial, September 2011

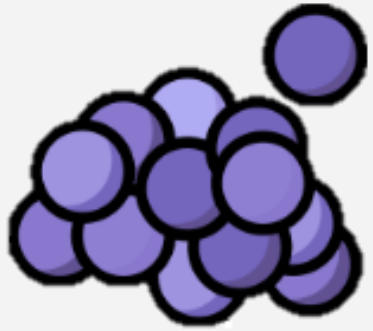
APIC TEXT Microbiology: Key Concepts for IPs

- Microbes can cause infection prevention issues because of their extremely small size, rapid reproductive rates, and resistance to harsh environmental conditions
- The presence of microbes in a clinical sample does not always indicate infection
- A variety of methods can be used to identify microbes
- The Microbiology Lab:
    - Provides information on microbes determined to be of clinical significance
    - Provides susceptibility testing
    - Monitors resistance patterns
    - Is a collaborative partner during outbreak investigations (prevalence screening, environmental sampling etc.)

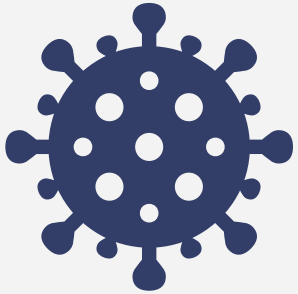


APIC Text accessed March 17, 2025

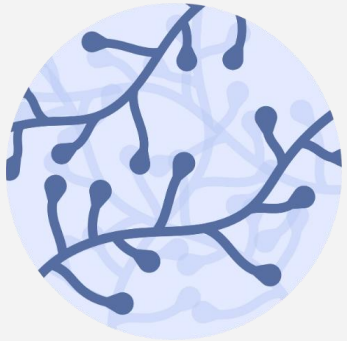
5 Types of Microbes



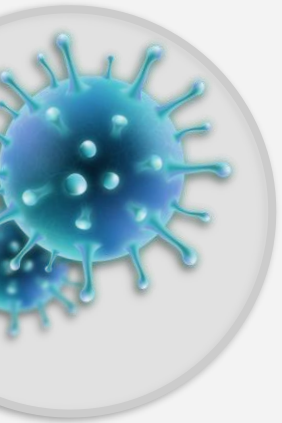
Bacteria



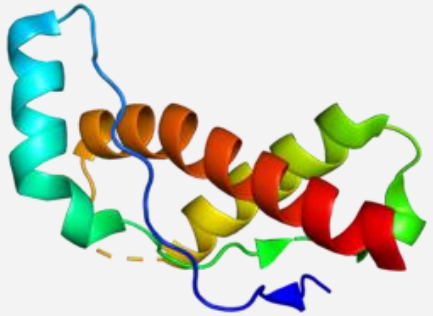
Viruses



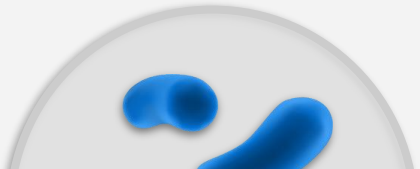
Fungi



Parasites



Prions



Bacteria

Characteristics

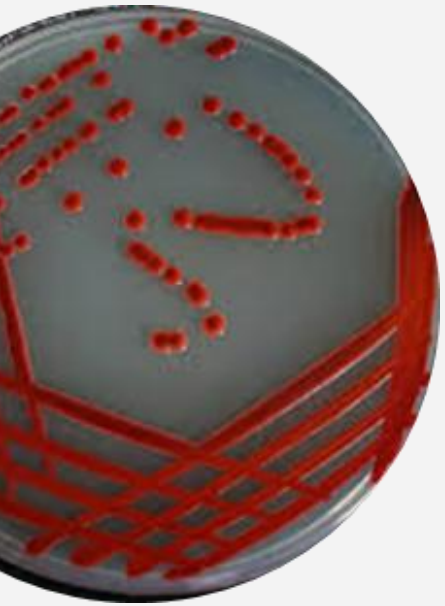
- Single cell
- Most are harmless (normal flora)
- Different growth characteristics
- Named by genus and species

How to identify

- Visible under a light microscope- gram stain
- Culture
- Other specialized laboratory tests

Examples of Pathogens

- Methicillin-resistant *Staphylococcus aureus*
- *Streptococcus pneumoniae*
- *Pseudomonas aeruginosa*



Treatment

- Antibiotics

Viruses

Characteristics

- Acellular (lack cellular structures)
- Only able to replicate in a host's cell
- 10,000 times smaller than bacteria

How to identify

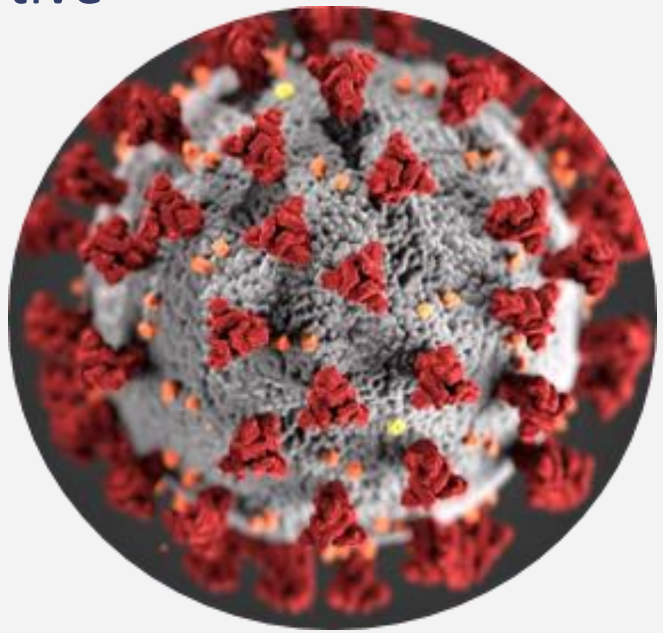
- Culture- grown inside cells
- NOT visible under a light microscope
- Identified using specific stains and methods and other specialized laboratory tests

Examples of Pathogens

- Influenza
- Varicella (chickenpox)
- SARS-CoV-2

Treatment

- Antivirals or supportive therapy



Fungi

Characteristics

- Unicellular and multicellular
- Yeasts and mold- most are not dangerous but some can be harmful to health

How to identify

- Culture and special stains and other specialized laboratory tests

Examples of Pathogens

- Candida auris
- Aspergillus fumigatus

Treatment

- Antifungals

Parasites

Characteristics

- Live on or in a host and gets nutrients at the expense of the host
- Unicellular or multicellular

How to identify

- Light microscopy, blood tests and other specialized laboratory tests

Examples of Pathogens

- Malaria (Plasmodium)
- Cryptosporidium
- Giardia

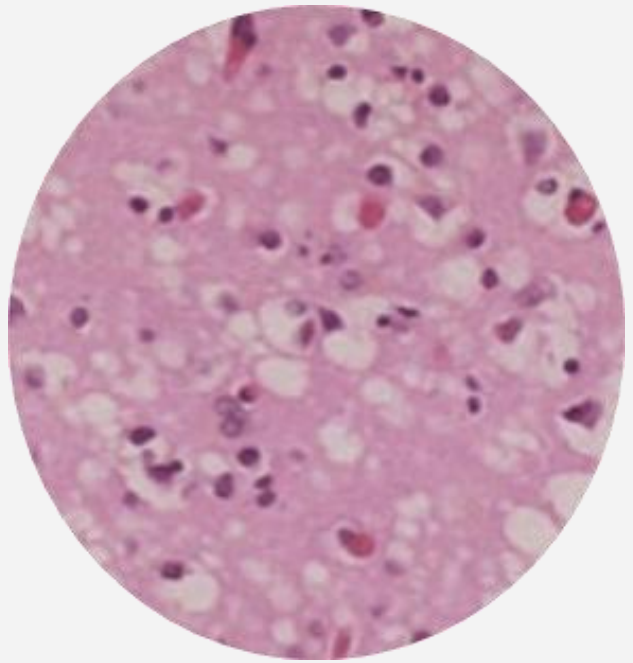
Treatment

- Antiparasitics

Prions

Characteristics

- Pathogenic agent able to induce abnormal folding of specific normal cellular proteins
- Causes Prion disease or transmissible spongiform encephalopathies (TSEs)- rare progressive neurogenerative disorders
- Affects both humans and animals



How to identify

- Brain biopsy or autopsy and other specialized laboratory tests

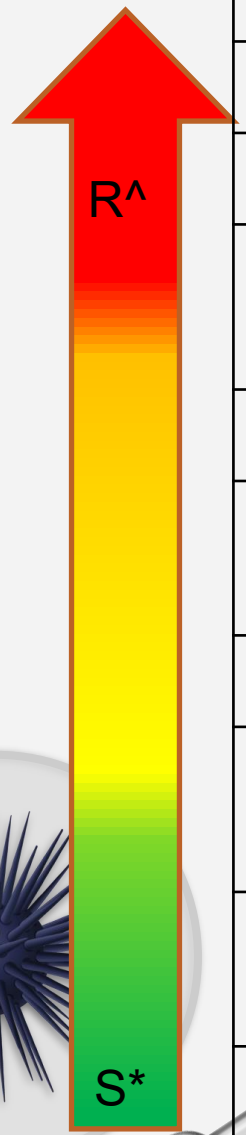
Examples of Pathogens

- Creutzfeldt-Jakob Disease (CJD)

Treatment

- Supportive treatment

Effect of Disinfectants on Microorganisms



Organism	Type	Examples
Bacterial Spores	Spore	Bacillus anthracis, Clostridioides difficile
Mycobacteria	Bacteria	M. tuberculosis
Small non-enveloped virus	Virus	Poliovirus, Norovirus, Hep A, Measles
Fungal spores	Fungus	Aspergillus, Penicillium, Trichophyton
Gram negative bacteria	Bacteria	E. coli, Klebsiella including **CRE**, Pseudomonas, Acinetobacter
Fungi (Vegetative)	Fungus	Candida
Large virus (non-enveloped)	Virus	Adenovirus, Rotavirus
Gram positive bacteria	Bacteria	Staphylococcus including **MRSA,** Enterococcus including **VRE**
Virus (enveloped)	Virus	HIV, HBV, HCV, Influenza, **Mpox, SARS-CoV2**

^*Resistant*
* *Sensitive*

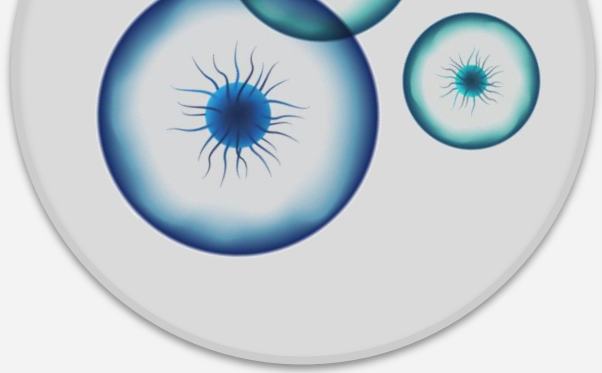
Adapted from Rutala et al. ICHE 2014;35(7):862

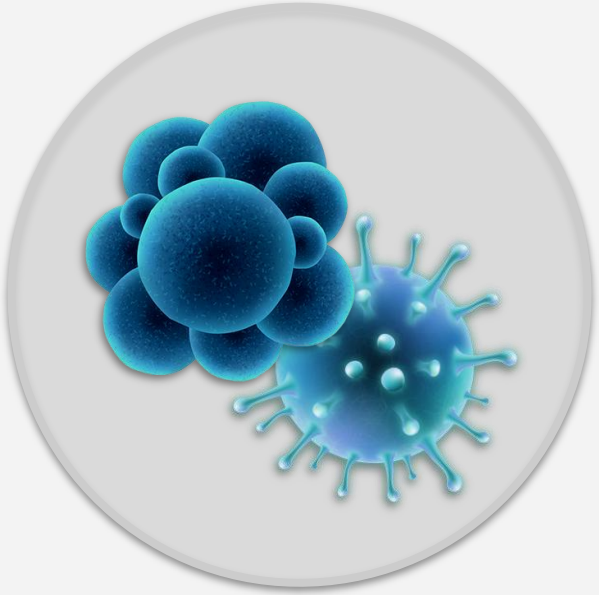
ANTIMICROBIAL RESISTANCE

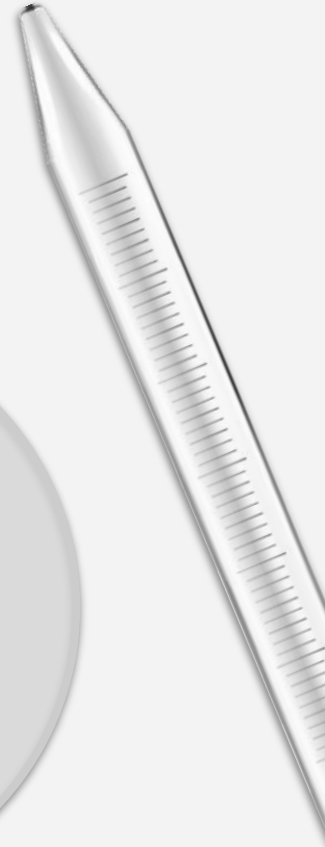
≠

DISINFECTANT RESISTANCE

Rozman U, Pušnik M, Kmetec S, Duh D, Šostar Turk S. Reduced Susceptibility and Increased Resistance of Bacteria against Disinfectants: A Systematic Review. Microorganisms. 2021 Dec 10;9(12):2550. doi: 10.3390/microorganisms9122550. PMID: 34946151; PMCID: PMC8706950.





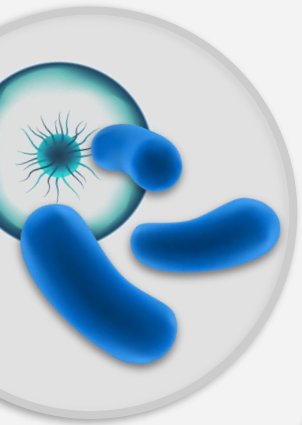


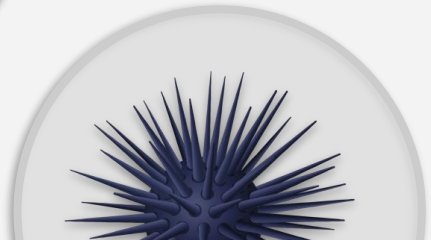
03

Microbiology Testing and Reporting

Gram Stain - Bacteria

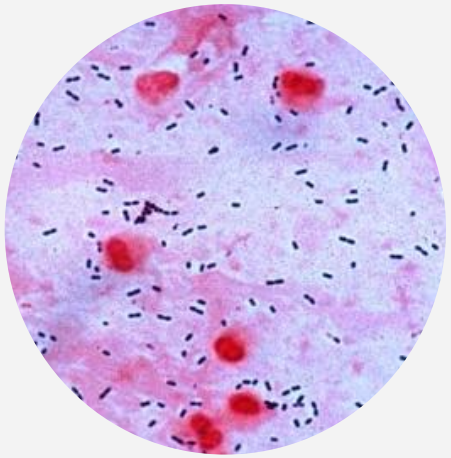
After the provider's initial assessment, the gram stain is going to be one of the the first clues as to what is going on with the patient.





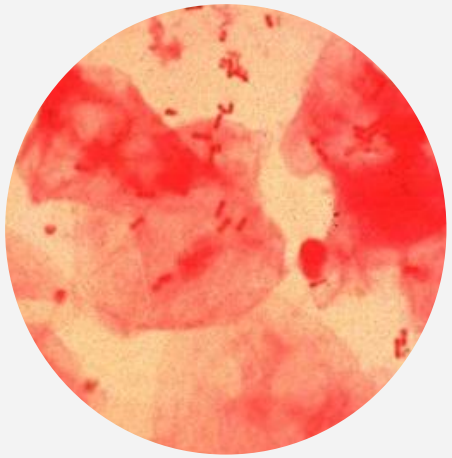
Gram Positive Result

Indicates the bacteria has a thick cell wall with proteins (peptidoglycan).
Gram positive cells appear **purple**.



Gram Negative Result

Indicates the bacteria does not have an extra layer in the cell wall.
Gram negative cells appear **pink/red**.



Bacterial Cellular Morphologies

SHAPE:

Coccus- spherical shape

Bacillus- rod shaped

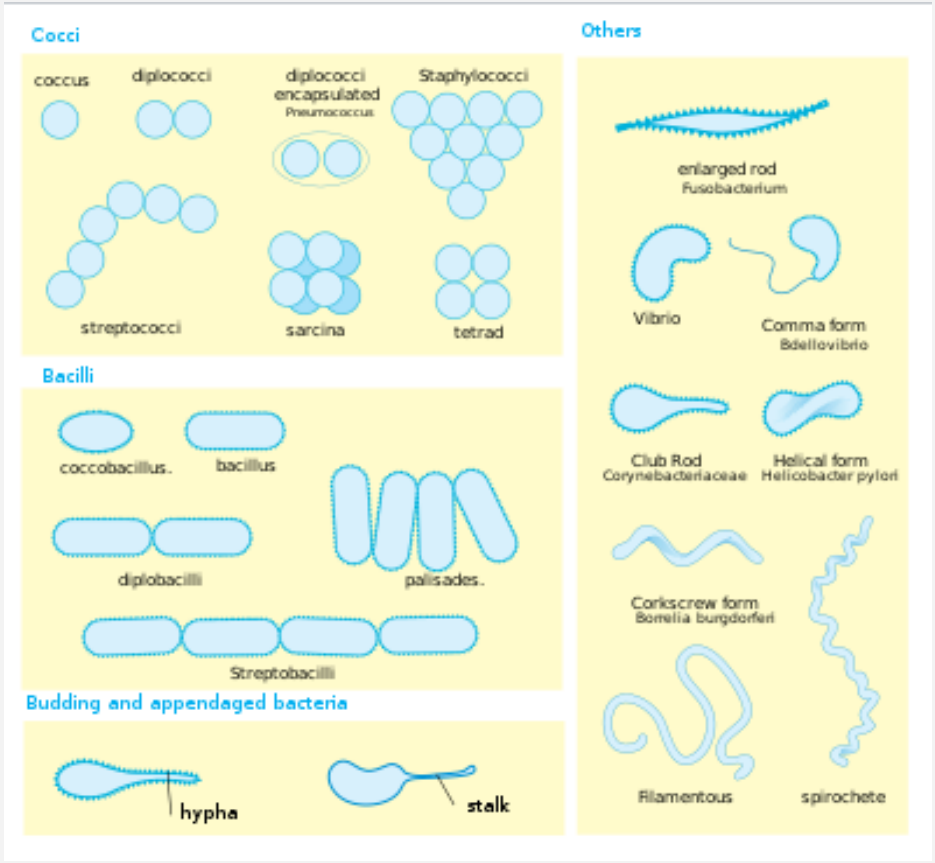
Coccobacillus- intermediate shape between coccus and bacillus

ARRANGEMENT:

Chains

Clusters

Diplo (arrangements of 2)



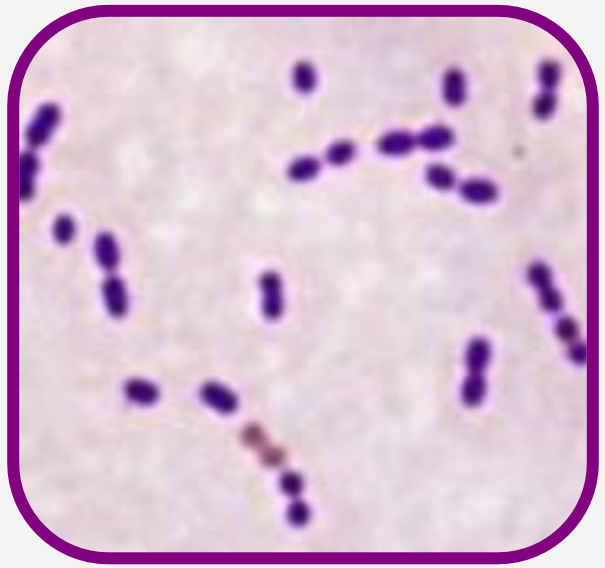
https://en.wikipedia.org/wiki/Bacterial_cellular_morphologies

Examples: Organism & Gram Stain

GRAM POSITIVES

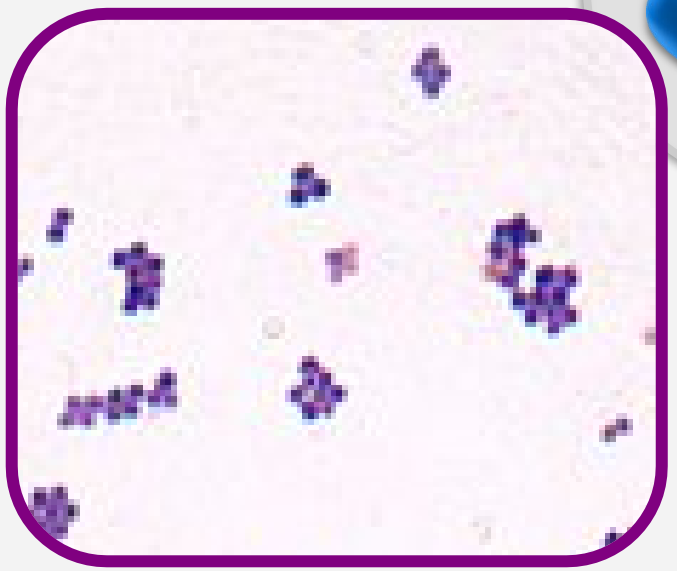
***Bacillus anthracis* - gram positive bacilli**

https://phil.cdc.gov/details.aspx?pid=2226



***Streptococcus pneumoniae* - gram positive cocci in pairs and short chains**

https://www.merckmanuals.com/en-ca/professional/multimedia/image/gram-stain-streptococcus-pneumoniae-

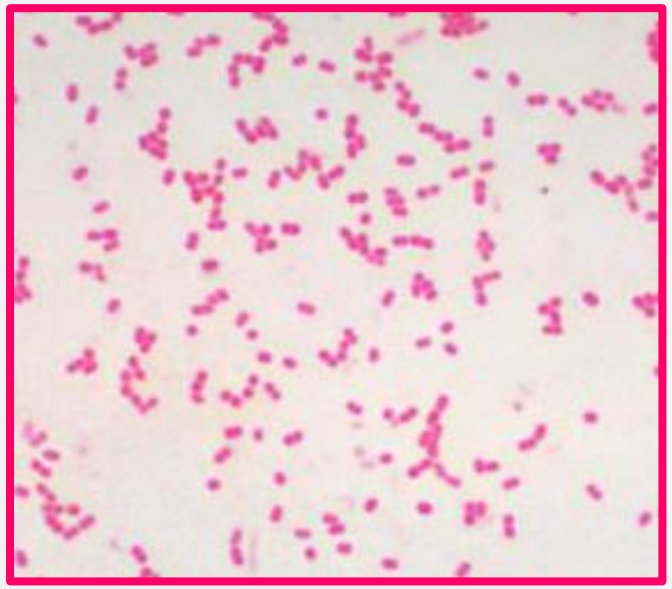


***Staphylococcus aureus* - gram positive cocci in clusters**

https://en.wikipedia.org/wiki/Staphylococcus_aureus

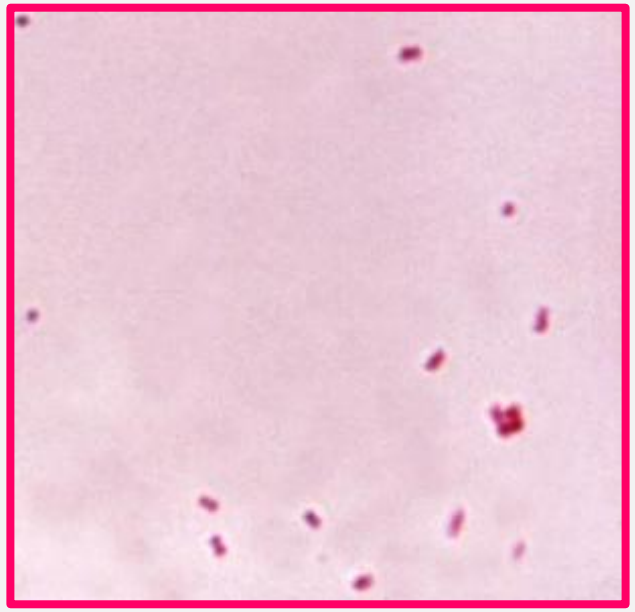
Examples: Organism & Gram Stain

GRAM NEGATIVES



***Acinetobacter baumanii* - short gram-negative bacilli**

https://phil.cdc.gov/Details.aspx?pid=1260



***Neisseria meningitidis* – gram-negative diplococci**

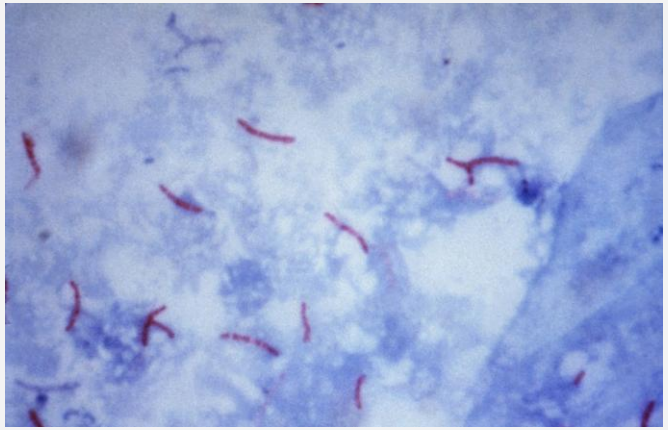
https://phil.cdc.gov/details.aspx?pid=6423

***Pseudomonas aeruginosa* - gram-negative bacilli**

https://textbookofbacteriology.net/pseudomonas.html

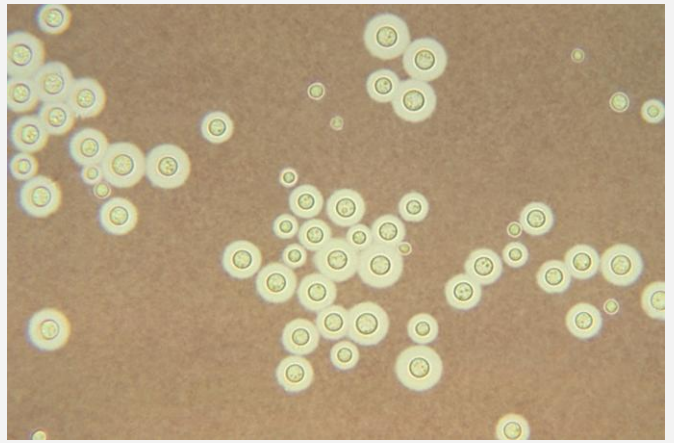
Other Common Stains

Acid-fast stain (Ziehl-Neelsen stain)- used primarily to identify the Mycobacterium genus in tissue, blood, or other body substances and includes Mycobacterium tuberculosis (TB) and other illnesses.

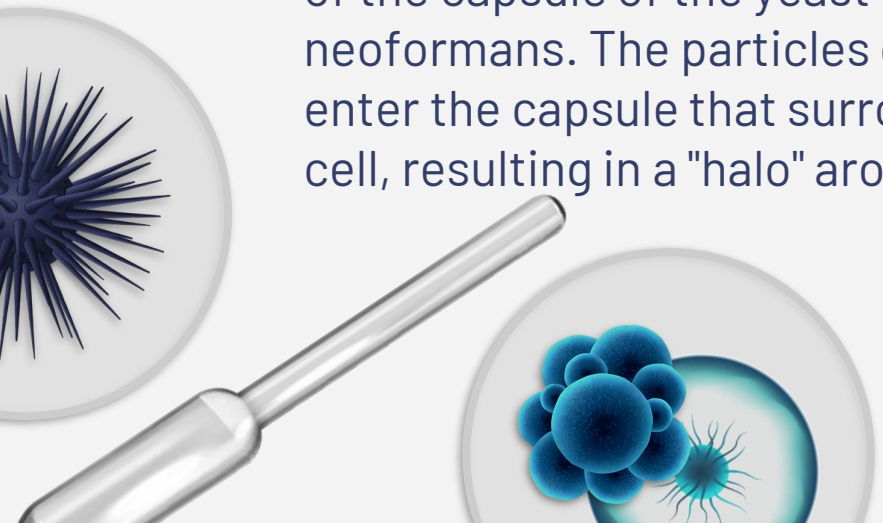


https://en.wikipedia.org/wiki/Ziehl%E2%80%93Neelsen_stain

Capsule stain- India ink is used for easy visualization of the capsule of the yeast Cryptococcus neoformans. The particles of ink pigment do not enter the capsule that surrounds the spherical yeast cell, resulting in a "halo" around the cells.



https://en.wikipedia.org/wiki/Cryptococcus_neoformans



Bacterial Identification: Culture

- Bacteria are grown in a petri dish using special growth media
- Time it takes to grow is organism dependent- some take hours and others take days
- May be able to identify a bacteria to genus and species based on culture alone

Traditional Bacterial Culture

- Cultures can be done manually but advancements have led to automation

BD Kiestra- Total Laboratory Automation

Microorganism Identification: MALDITOF

Matrix-Assisted Laser Desorption Ionization Time of Flight (MALDITOF)

Laboratory automation providing faster and more accurate results than conventional identification methods for the identification and antimicrobial susceptibility testing of most bacterial and fungal clinical isolates.

Decreases the turnaround time for the provision of definitive identification and susceptibility results to clinicians.

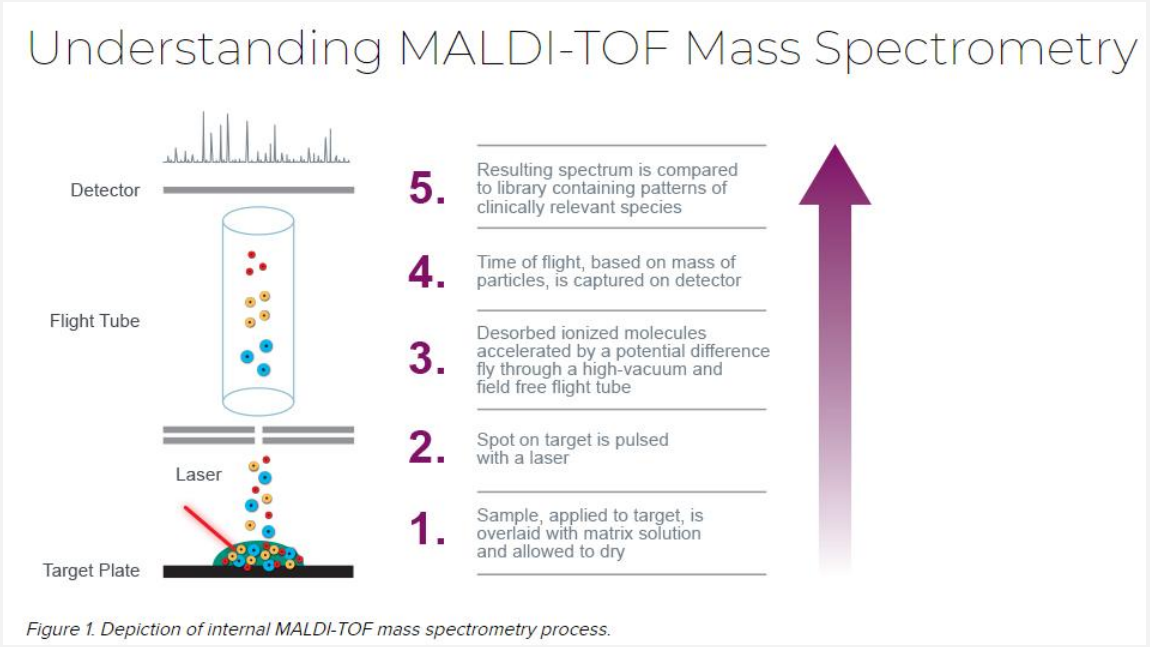
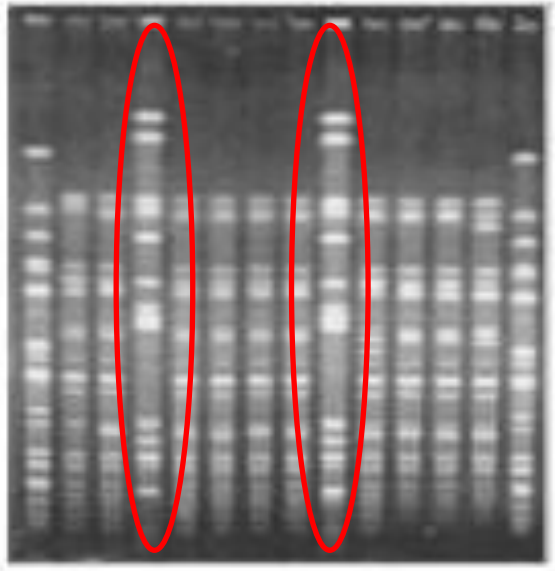


Figure 1. Depiction of internal MALDI-TOF mass spectrometry process.

https://www.beckmancoulter.com/products/microbiology/maldi-tof-mass-spectrometry

Pulsed-Field Gel Electorphoresis (PFGE) (DNA Fingerprinting)

- Laboratories use high-tech equipment to make the DNA fingerprints.
- Each type of bacteria has unique DNA which makes up a pattern of bands called a fingerprint.
- Bacterial fingerprints are found by cutting the bacteria's DNA into tiny pieces and then placing them on an agarose gel.
- Electricity is sent through the gel and the DNA pieces separate.
- Small pieces of DNA get carried farther down the gel than bigger pieces. This process creates a banding pattern or "fingerprint".
- PFGE is useful for assisting epidemiological investigations of illnesses caused by a common-source of pathogen such as MRSA causing an outbreak in a health care setting.



Pulse Field Gel Electrophoresis

https://www.cdc.gov/salmonella/typhimurium/pfge_process.html#:~:text=Laboratories%20use%20high%2Dtech%20equipment,fingerprints%20just%20like%20people%20do.

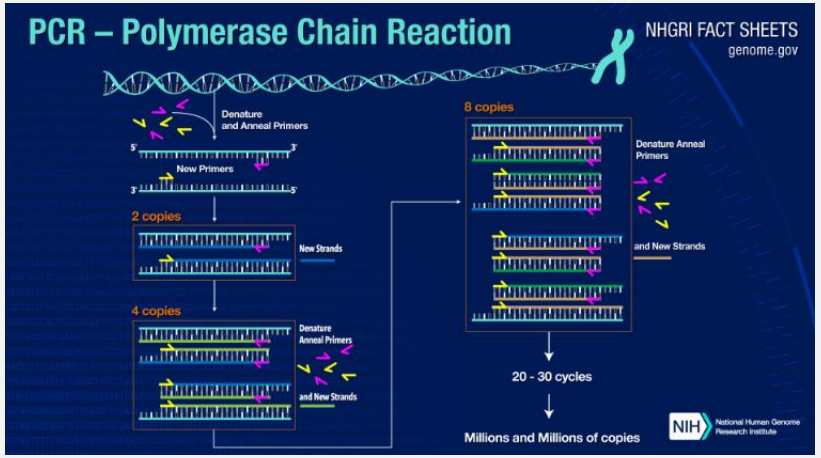
Microorganism Identification:

Polymerase Chain Reaction (PCR)

Diagnosis of infectious diseases has been revolutionized by the development of molecular techniques, mainly with the applications of polymerase chain reaction (PCR).

How does it work?

- The sample is heated so the DNA denatures
- The DNA separates into two pieces of single-stranded DNA
- An enzyme (Taq polymerase) synthesizes two new strands of DNA (using the original strands as templates)
- Denaturing and synthesis occurs multiple times leading to the more than a billion copies of the original DNA segment
- This can be completed in a few hours using a machine called a thermocycler which alters the temperature of the reaction every few minutes to allow DNA denaturing and synthesis.



https://www.intechopen.com/chapters/66383

https://www.genome.gov/about-genomics/fact-sheets/Polymerase-Chain-Reaction-Fact- Sheet#:~:text=How%20does%20PCR%20work%3F,the%20original%20strands%20as%20templates.

Microorganism Identification:

Polymerase Chain Reaction (PCR)

Advantages

- Can be used for a wide range of microorganisms
- High sensitivity and specificity
- Faster turnaround times
- Good for organisms that cannot be grown in vitro, or when where existing culture techniques are insensitive and/or need prolonged incubation times

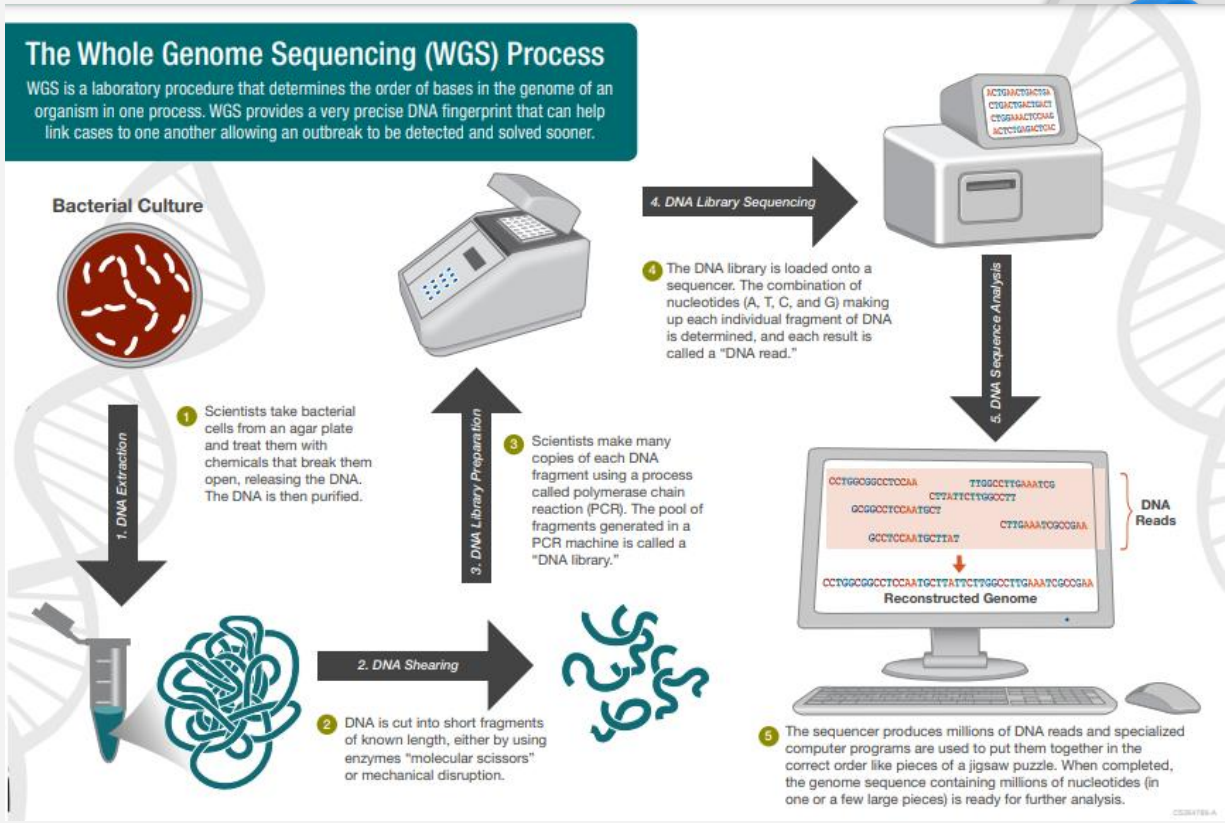
https://www.intechopen.com/chapters/66383

https://www.genome.gov/about-genomics/fact-sheets/Polymerase-Chain-Reaction-Fact- Sheet#:~:text=How%20does%20PCR%20work%3F,the%20original%20strands%20as%20templates.

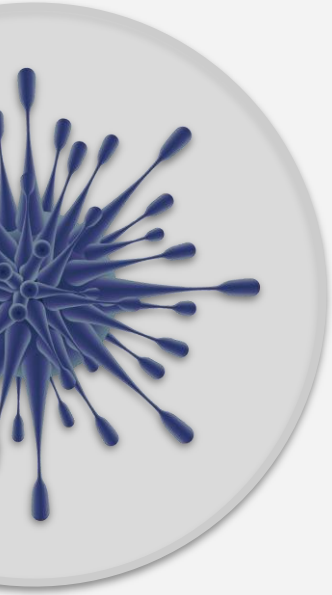
Whole Genome Sequencing (WGS)

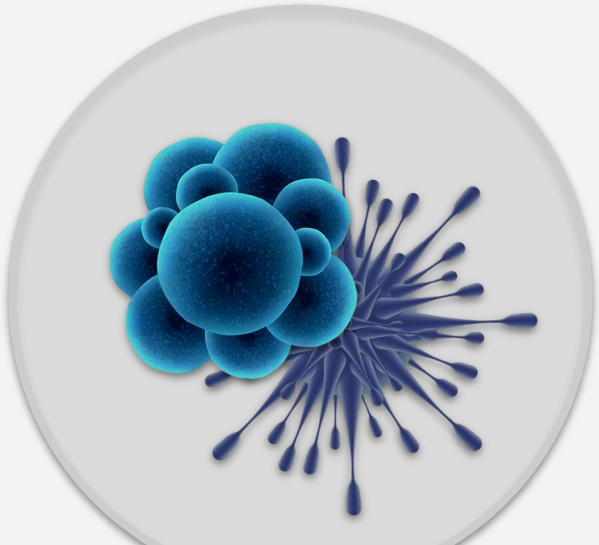
- All organisms (bacteria, vegetable, mammal) have a unique genome composed of nucleotide bases (A, T, C, and G)
- If you know the sequence of the bases in an organism, you have identified its unique DNA fingerprint, or pattern.
- Determining the order of bases is called sequencing.
- WGS is a laboratory procedure that determines the order of bases in the genome of an organism in one process.

* **Gives an exact DNA profile of an organism**



https://www.cdc.gov/pulsenet/pathogens/wgs.html





As an ICP, you need to understand what testing methods are used in YOUR lab.

If reference labs are used, know who to contact for questions!

Antibiotic Susceptibility Testing

Intrinsic or Acquired Resistance?

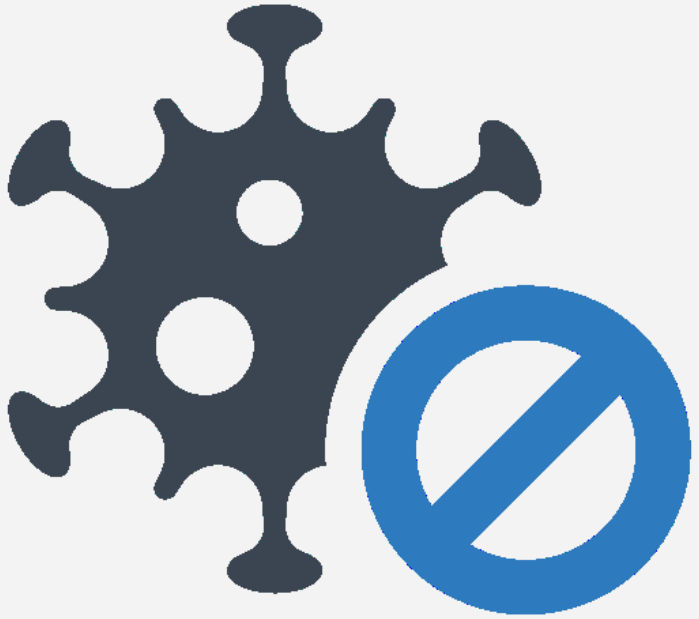
Intrinsic Resistance: Resistance mechanism on original bacterial chromosome

Acquired Resistance: Changes to original genome - bacteria becomes resistant

Mutations: original genes altered but no new genes acquired.

Transferable: new genes acquired through plasmids or transposable elements.

*Transferable resistance is of concern to Infection Prevention because resistance can be passed to different bacteria & can spread person to person.



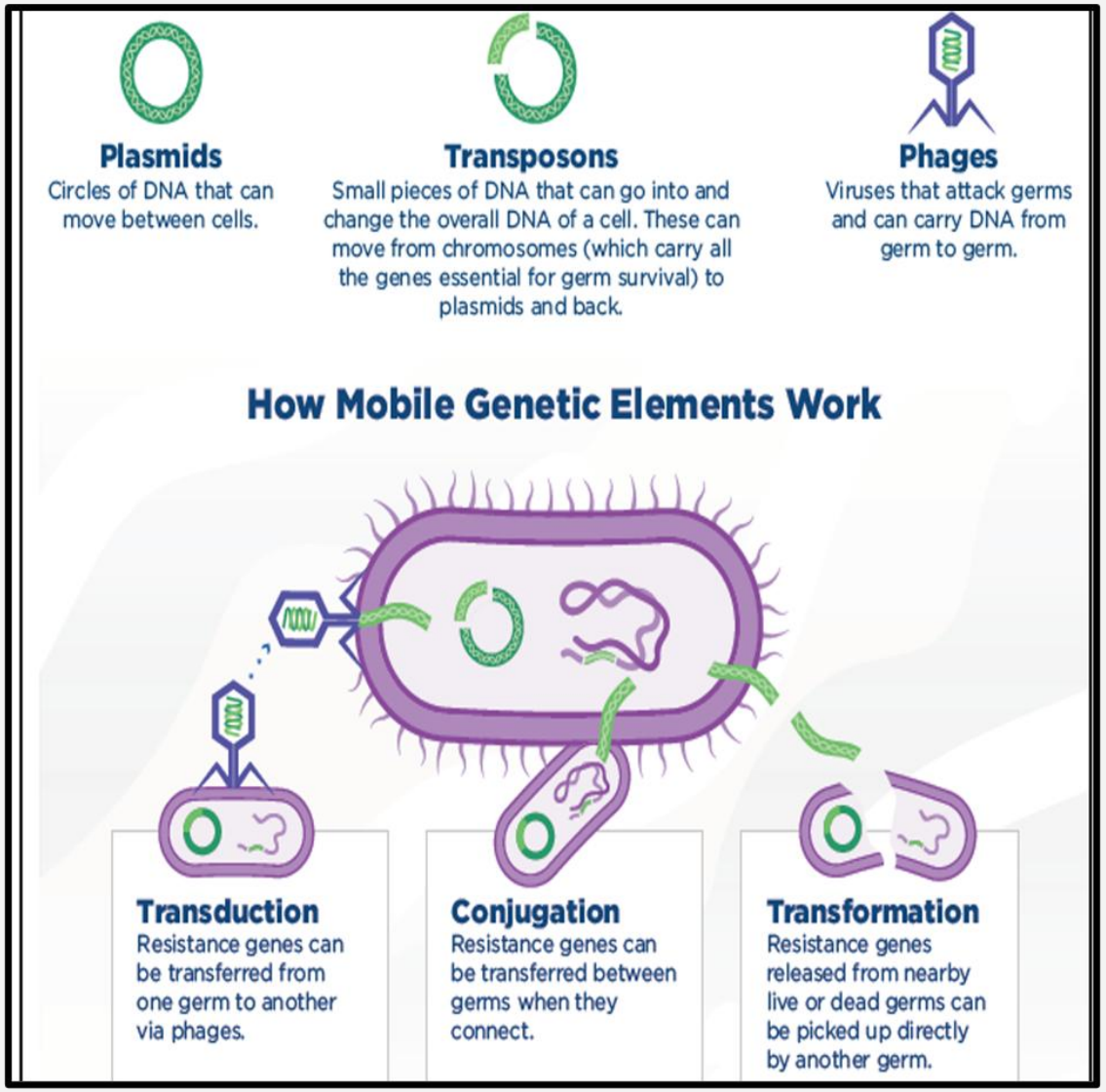
Example: Gram Negative Bacteria with Intrinsic Resistance

MIML240 APPENDIX B- LIST OF ORGANISMS WITH INTRINSIC RESISTANCE

GRAM NEGATIVE BACILLI

Antibiotic / Organism	Ampicillin	Aminoglycoside	Cefazolin, Cefalothin	Cefuroxime	Cefotaxime/ Ceftraixone	Nitrofurantoin	SXT
Acinetobacter baumanii, calcoaceticus	R						
Burkholderia cepacia complex	R	R			R		
Citrobacter freundii	R		R	R			
Citrobacter koseri	R						
Enterobacter aerogenes	R		R	R			
Enterobacter cloacae complex	R		R	R			
Hafnia alvei	R		R				
Klebsiella pneumoniae	R						
Morganella morganii	R		R	R		R	
Proteus mirabilis	-					R	
Proteus penneri	R		R	R		R	
Proteus vulgaris	R		R	R		R	
Providencia rettgeri	R		R			R	
Providencia stuartii	R		R			R	
Pseudomonas aeruginosa	R				R	R	R
Serratia marcescens	R		R	R		R	
Stenotrophomonas maltophilia	R	R			R		
Yersinia enterocolitica	R		R				

ACQUIRED RESISTANCE: TRANSFER OF MOBILE GENETIC ELEMENTS



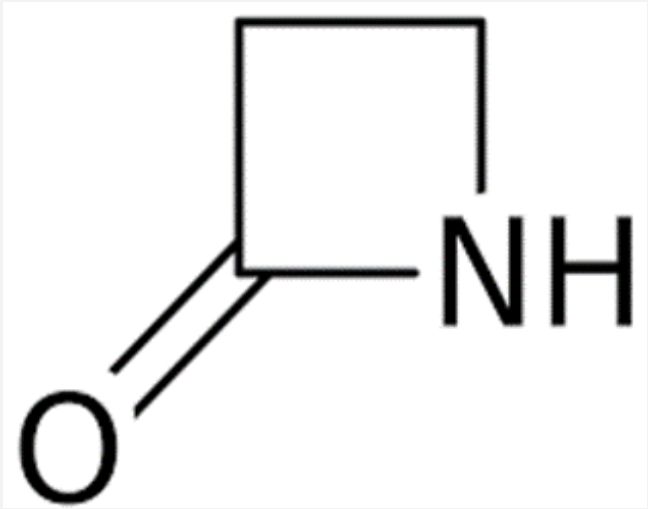
Example: Beta-Lactam Antibiotics

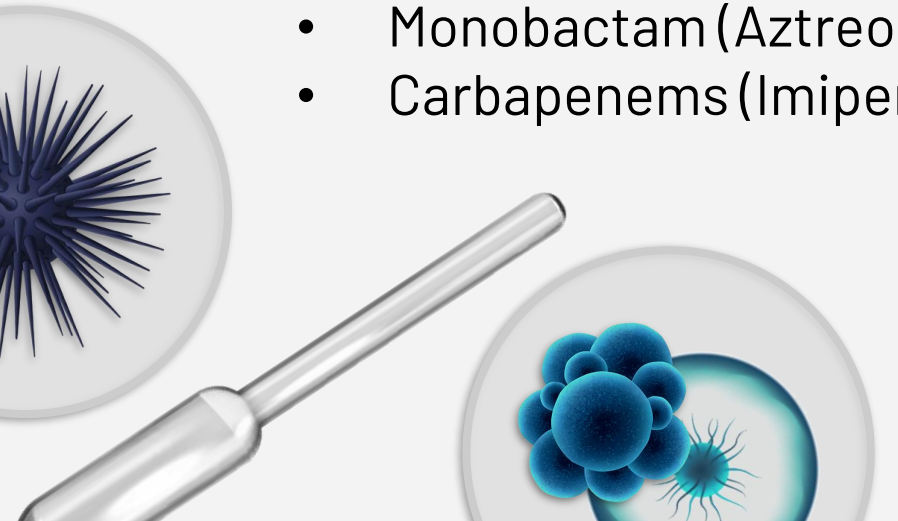
- β-lactam antibiotics contain a β-lactam ring in their chemical structure
- β-lactam antibiotics are often used to treat infections caused by Enterobacterales

Antibiotics with beta lactam ring:

- Penicillins, ampicillins, piperacillin
- 1st, 2nd, 3rd generations of cephalosporins
- 2nd, 3rd are oxyimino-cephalosporins
- Monobactam (Aztreonam)
- Carbapenems (Imipenem, meropenem, ertapenem)

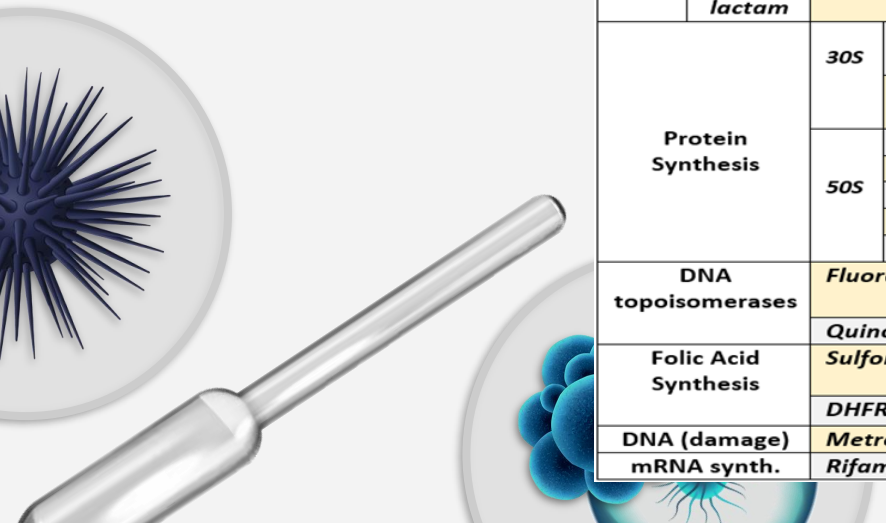
Beta lactam ring





Major Classes of Antibiotics & How They Inhibit or Kill Bacteria

INHIBIT		CLASIFICATION		ANTIBIOTICS			
Cell Wall Synthesis	Beta Lactams	Penicillins	Penicillinase – Sensible				
			Natural Penicillins (narrow spectrum)	Penicillin G: Na, K, Procainic, Benzathine (IV, IM) Penicillin V: VO			
			Aminopenicillins (broad spectrum)	Ampicillin Amoxicillin			
			Penicinillase – Resistant (very narrow spectrum)				
			Nafcillin	Oxacillin	Dicloxacillin		
			Antipseudomonal (extended spectrum)				
			Carboxipenicillins	Ticarcillin Carbenicillin			
			Ureidopenicillins	Piperacillin Azlocillin Mezlocillin			
		Cephalosporins	1° Generation	Cefazolin	Cephalexine	Cephapirin	
				Cefadroxil	Cephadrine	Cephalotin	
			2° Generation	Cefuroxime	Cefamandole	Cefprozil	
				Cefoxitin	Cefonicid	Cefmetazole	
				Cefotetan	Cefaclor		
			3° Generation	Cefoperazone	Ceftriaxone	Ceftazidime	
				Cefpodoxime	Ceftizoxime	Cefotaxime	
				Cefdinir	Ceftibuten	Cefixime	
				Cefditoren			
			4° Generation	Cefepime	Cefpirome *		
			5° Generation	Ceftaroline			
		Carbapenems		Meropenem	Ertapenem	Doripenem	Imipenem + Cylastatine
		Monobactams		Aztreonam			
	**	* Beta-lactamase inhib.		Sulbactam	Tazobactam	Clavulanic Acid	
	No lactam	Glycopeptides		Vancomycin	Bacitracin		
				Teicoplanin	Polymyxin B		
Protein Synthesis		30S	Amino-glycosides	Gentamycin	Neomycin	Streptomycin	
				Amikacin	Tobramycin		
			Tetracyclins	Doxycycline	Demeclocylin *	Minocycline	
				Tetracyclin	Tigecyclin		
		50S	Oxazolidonones	Linezolid			
			Streptogramins	Quinupristin/Dalfopristin			
			Cloramphenicol				
			Macrolides	Erythromycin	Azithromycin	Clarithromycin	
			Lincosamides	Clindamycin	Lincomycin		
DNA topoisomerases		Fluorquinolones		Ciprofloxacin	Norfloxacin	Levofloxacin	Ofloxacin
				Sparfloxacin	Moxifloxacin	Gemifloxacin	Enofloxacin
		Quinolones		Nalidixic Acid			
Folic Acid Synthesis		Sulfonamides		Sulfamethoxazole (SMX)	Ag Sulfadiazine	Sulfasalazine	Sulfisoxazole
		DHFR inhibitors		Trimethroprim (TMP)		Pirymethamine	
DNA (damage)		Metronidazole					
mRNA synth.		Rifampim					



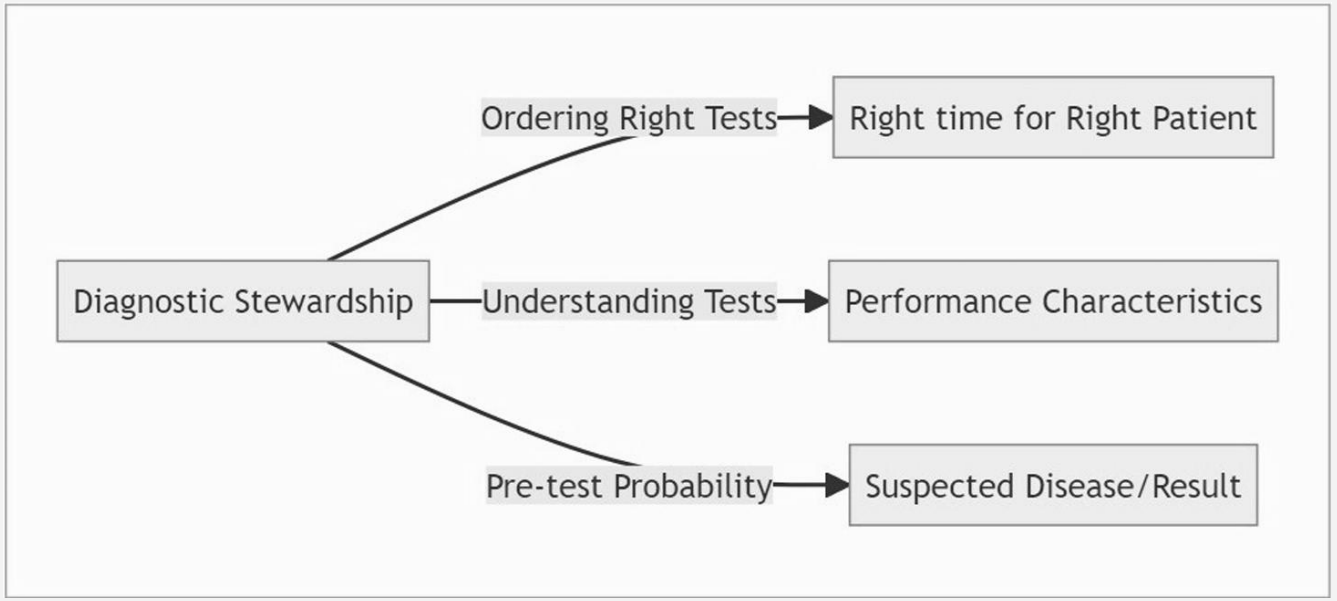
Michener Institute, Toronto

Diagnostic Stewardship (DS)

DS is crucial for infection prevention and control:

- promotes the appropriate use of diagnostic tests
- Leads to more accurate and timely diagnoses
- Enables better patient management
- Reduces the risk of inappropriate antimicrobial use and subsequent antibiotic resistance

Overview of core principles in DS:



Schinas et. al., 2023

Sample Microbiology Reports…

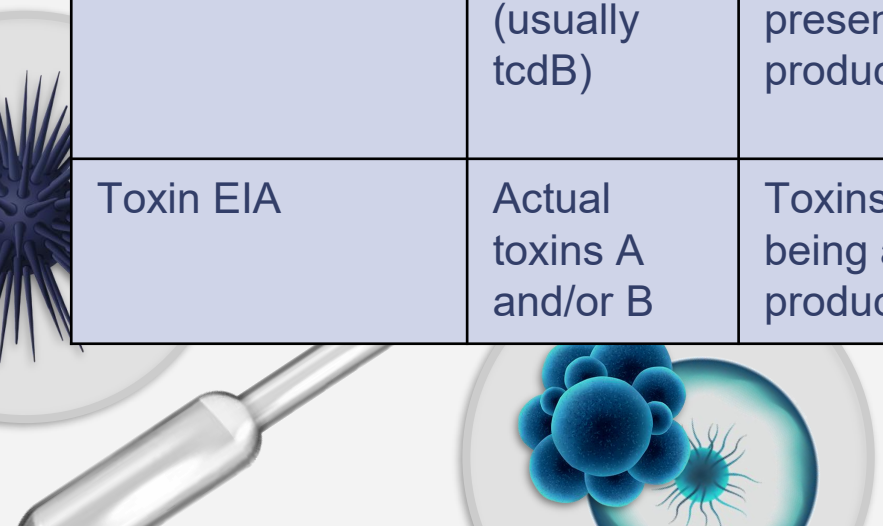
Clostridioides difficile Testing:

Test	What it detects	What it tells you	Sensitivity	Specificity	Key Use
GDH Antigen	GDH enzyme (present in all Cdiff strains)	Cdiff is present but doesn't tell if its toxigenic	High	Low	Initial screening test- further follow-up needed
PCR/NAAT	Toxin genes (usually tcdB)	Toxigenic Cdiff is present (CAN produce toxin)	High	High	Confirms presence of toxin-capable strain
Toxin EIA	Actual toxins A and/or B	Toxins are being actively produced	Moderate	High	Confirms active toxin production

GDH is broad and sensitive, catches all strains (toxigenic or not)

PCR confirms Cdiff is present and detects strains with the ability to produce toxins

Toxin EIA confirms whether toxins are being made right now which is most directly linked to active disease



https://www.publichealthontario.ca/en/Laboratory-Services/Test-Information-Index/Clostridium-difficile
https://www.cdc.gov/c-diff/hcp/diagnosis-testing/index.html

Lab Result #1

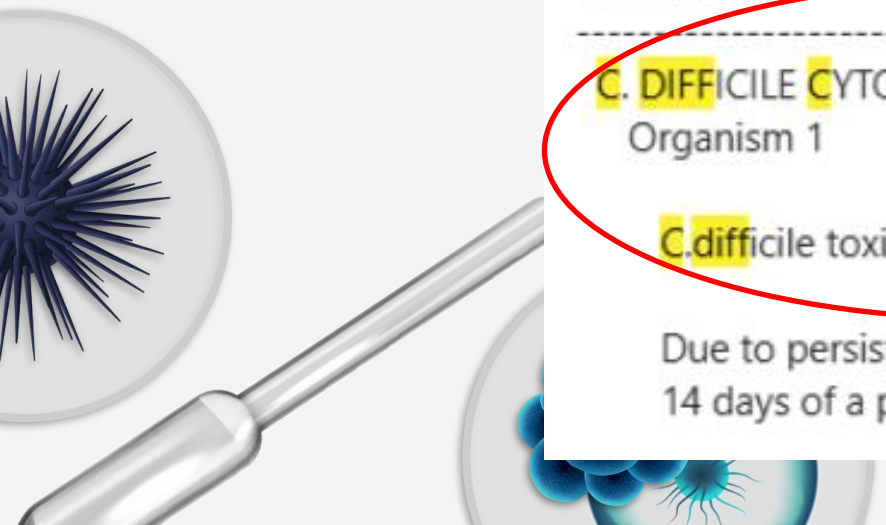
PATIENT: [redacted]
ACCT #: [redacted] AGE/SX: 71/F DOB: [redacted]
REG DR: [redacted] (Med) STATUS: ADM IN BED: 1 DIS:

SPEC #: [redacted]
RECD: 2[redacted]
SOURCE: STOOL
SPDESC:
ORDERED: CD CYTOTOXIN
ACT WKST: CDIFF [redacted]

Procedure	Result
C. DIFFICILE CYTOTOXIN	Final
Organism 1	POSITIVE for C. difficile

C.difficile toxin gene detected.

Due to persistent shedding of toxin, repeat testing within 14 days of a positive result is NOT indicated.



Lab Result #2

PCR, SHL Respiratory Panel Order: 400438588

Status: **Final result** Visible to patient: **Yes (not seen)** Next appt: **Today at 17:00 in Nephrology (SHG HEMODIALYSIS, GENERIC NURSE)**

Specimen Information: Nasopharynx; Swab

2 Result Notes | 1 Patient Communication

Component Ref Range & Units	
Adenovirus	Not Detected
COVID19	COVID-19 virus DETECTED by real-time PCR. !
Rhino/Enterovirus	Not Detected
Influenza A	Not Detected
Influenza A H1 (pdm09) subtype	Not Detected
Influenza A H3 subtype	Not Detected
Influenza B	Not Detected
Seasonal Human coronavirus (229E/OC43/NL63/HKU1)	Not Detected
hMPV	Not Detected
Paraninfluenza Virus Types 1,2,3,4	Not Detected
RSV	Not Detected

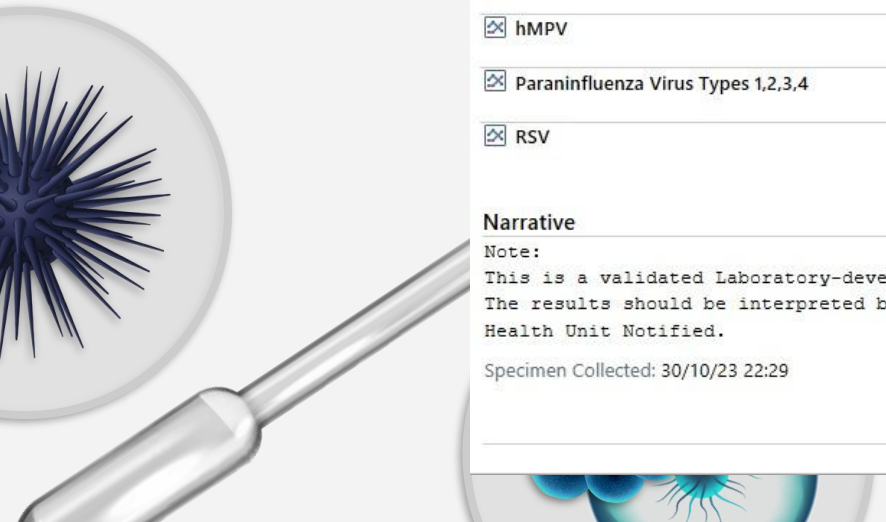
Narrative

```
Note:
This is a validated Laboratory-developed real-time PCR test.
The results should be interpreted based on the clinical context of the patient.
Health Unit Notified.
```

Specimen Collected: 30/10/23 22:29 Last Resulted: 01/11/23 3:40

Order Details | View Encounter | Lab and Collection Details | Routing | Result History

View All Conversations on this Encounter



Lab Result #3

Culture, Blood Order: 388170117

Status: **Edited Result - FINAL** Visible to patient: **No (inaccessible in MyChart)** Next appt: **05/01/2024 at 07:15 in Nephrology (SHG SATELLITE DIALYSIS NURSE)**

Specimen Information: Blood, Central Line

0 Result Notes

Culture

Isolated <> Enterobacter hormaechei !

Refer to 23SG-253M0060 collected on the same date for susceptibilities.

Isolated <> Klebsiella pneumoniae !

This is an appended report. These results have been appended to a previously final verified report.

isolated from aerobic and anaerobic blood culture bottles.
Time to Detection 5.03 hours

Gram result confirmed by Shared Hospital Laboratory

Gram Stain

Gram negative bacilli seen

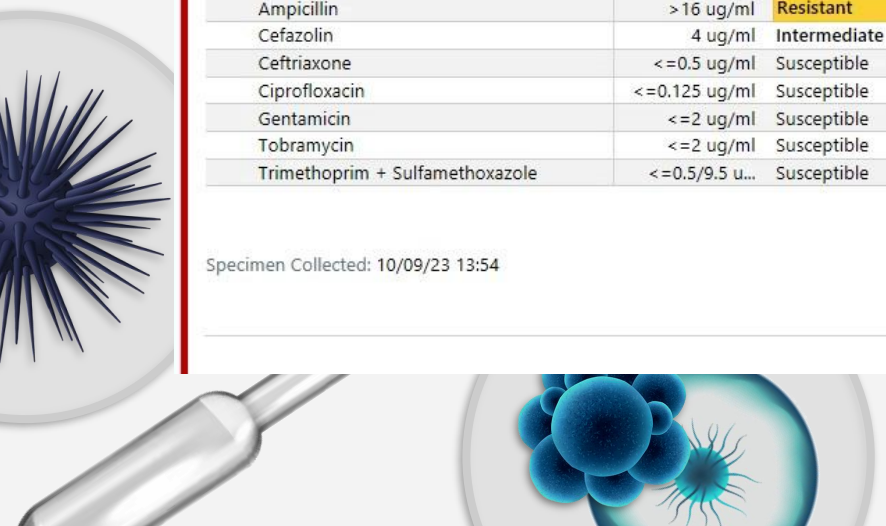
Susceptibility

	Klebsiella pneumoniae MIC	
Ampicillin	>16 ug/ml	**Resistant**
Cefazolin	4 ug/ml	**Intermediate**
Ceftriaxone	<=0.5 ug/ml	Susceptible
Ciprofloxacin	<=0.125 ug/ml	Susceptible
Gentamicin	<=2 ug/ml	Susceptible
Tobramycin	<=2 ug/ml	Susceptible
Trimethoprim + Sulfamethoxazole	<=0.5/9.5 u...	Susceptible

Specimen Collected: 10/09/23 13:54 Last Resulted: 14/09/23 8:46

Order Details | View Encounter | Lab and Collection Details | Routing | Result History - Result Edited

View All Conversations on this Encounter



Lab Result #4

Culture, Urine Order: 395010312

Status: **Final result** Visible to patient: **Yes (not seen)** Next appt: **None**

Specimen Information: **Urine, Midstream**

0 Result Notes

Culture

>100 X 10E6 CFU/L <> Klebsiella variicola !

>100 X 10E6 CFU/L <> Enterococcus faecalis !

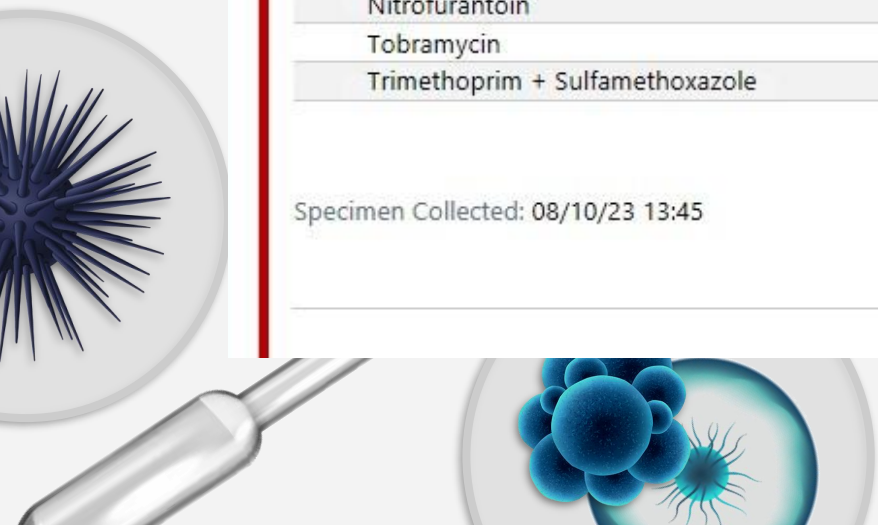
Susceptibility

	Klebsiella variicola MIC		Enterococcus faecalis DISK DIFFUSION
Ampicillin	8 ug/ml	Resistant	Susceptible
Cefazolin	<=2 ug/ml	Susceptible	
Ciprofloxacin	<=0.125 ug/ml	Susceptible	
Gentamicin	<=2 ug/ml	Susceptible	
Nitrofurantoin	<=32 ug/ml	Susceptible	
Tobramycin	<=2 ug/ml	Susceptible	
Trimethoprim + Sulfamethoxazole	<=0.5/9.5 u...	Susceptible	

Specimen Collected: 08/10/23 13:45 Last Resulted: 13/10/23 12:56

Order Details View Encounter Lab and Collection Details Routing Result History

View All Conversations on this Encounter



Lab Result #5

Culture, Wound, Deep/Subcutaneous Order: 413847008

Status: **Final result** Visible to patient: **No (inaccessible in MyChart)** Next appt: **None**

Specimen Information: Elbow, Left; Swab

0 Result Notes

Culture

Heavy Growth <> Staphylococcus aureus !

Susceptibility comment: Staphylococci that test susceptible to oxacillin are also susceptible to cloxacillin and cefazolin.

Heavy Growth <> Streptococcus Group A !

Empirically sensitive to Penicillin.

Scant Growth <> Mixed Coliforms & skin flora !

Gram Stain

Many Pus cells seen

Many Gram positive cocci seen

Susceptibility

	Staphylococcus aureus MIC	
Clindamycin	0.25 ug/ml	Susceptible [1]
Erythromycin	>4 ug/ml	Resistant
Oxacillin	0.5 ug/ml	Susceptible
Trimethoprim + Sulfamethoxazole	<=0.5/9.5 u...	Susceptible

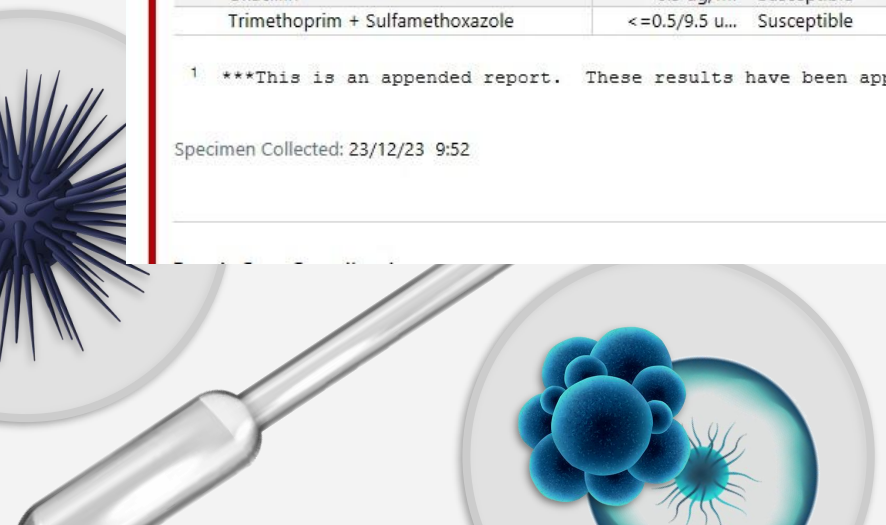
1 ***This is an appended report. These results have been appended to a previously preliminary verified report.***

Specimen Collected: 23/12/23 9:52

Last Resulted: 26/12/23 20:27

Order Details | View Encounter | Lab and Collection Details | Routing | Result History

View All Conversations on this Encounter



Lab Result #6

Blood culture Order: 388414976

Status: **Final result** Visible to patient: **No (inaccessible in MyChart)** Next appt: **None** Dx: **ESRD on hemodialysis**

Specimen Information: Blood, Peripheral

0 Result Notes

Culture

Isolated <> Raoultella ornithinolytica !

"Culture Positive after [illegible] Hours
Isolated from Anaerobic and Aerobic Blood Culture Bottles
Gram result confirmed by Shared Hospital Laboratory

Gram Stain

!
Gram negative bacilli seen

Susceptibility

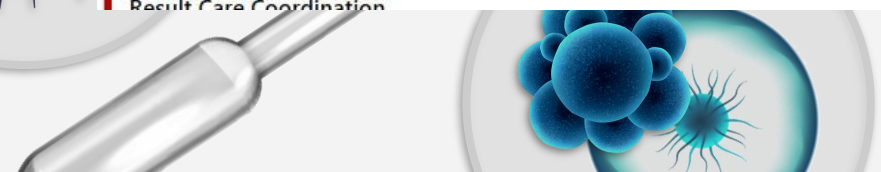
	Raoultella ornithinolytica MIC	
Ampicillin	16 ug/ml	Resistant
Cefazolin	<=2 ug/ml	Susceptible
Ciprofloxacin	<=0.125 ug/ml	Susceptible
Gentamicin	<=2 ug/ml	Susceptible
Tobramycin	<=2 ug/ml	Susceptible
Trimethoprim + Sulfamethoxazole	<=0.5/9.5 u...	Susceptible

Specimen Collected: 11/09/23 14:48 Last Resulted: 14/09/23 11:58

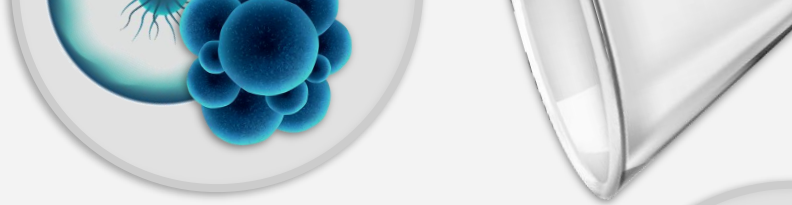
Order Details | View Encounter | Lab and Collection Details | Routing | Result History - Result Edited

View All Conversations on this Encounter

Result Care Coordination



Sensitivity: SAUR vs MRSA



Staphylococcus aureus

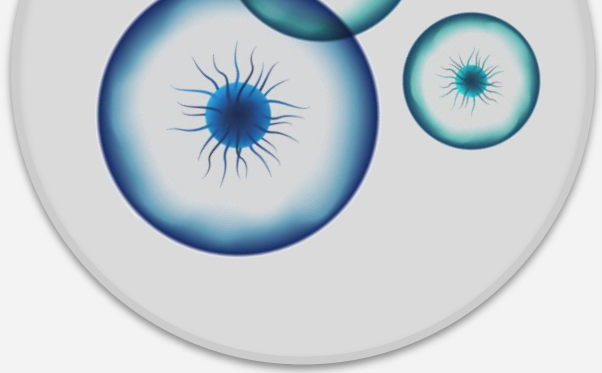
Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Cefoxitin Screen	NEG	-	Erythromycin	<= 0.25	S
Benzylpenicillin	>= 0.5	R	Clindamycin	<= 0.25	S
Ampicillin			Quinupristin/Dalfopristin	<= 0.25	S
Oxacillin	0.5	S	Linezolid	2	S
Gentamicin High Level (synergy)			Vancomycin	<= 0.5	S
Streptomycin High Level (synergy)			Tetracycline	<= 1	S
Gentamicin	<= 0.5	S	Tigecycline	<= 0.12	S
Ciprofloxacin	<= 0.5	S	Nitrofurantoin	32	S
Levofloxacin	<= 0.12	S	Rifampicin	<= 0.5	S
Moxifloxacin	<= 0.25	S	Trimethoprim/ Sulfamethoxazole	<= 10	S
Inducible Clindamycin Resistance	NEG	-			

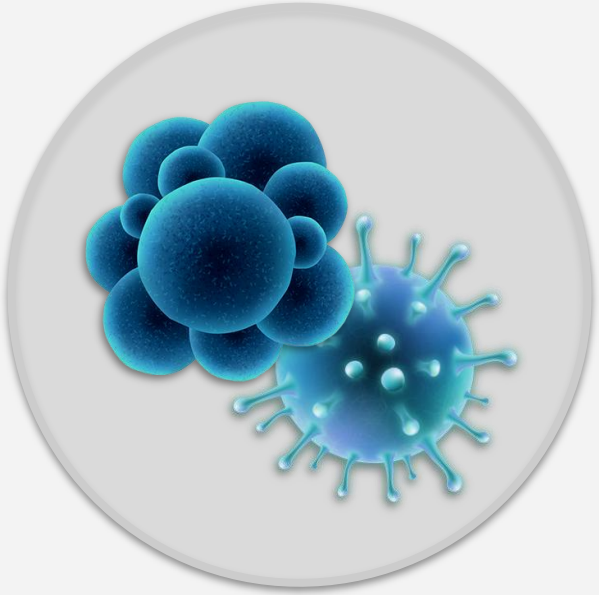
Methicillin Resistant Staphylococcus aureus

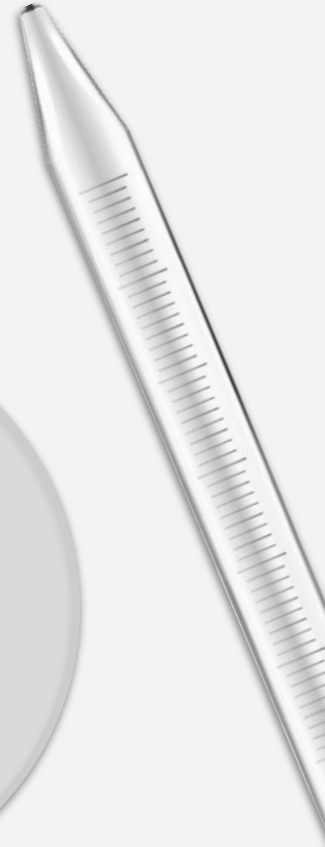
Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Cefoxitin Screen	POS	+	Erythromycin	<= 0.25	S
Benzylpenicillin	>= 0.5	R	Clindamycin	>= 8	R
Ampicillin			Quinupristin/Dalfopristin	0.5	S
Oxacillin	>= 4	R	Linezolid	2	S
Gentamicin High Level (synergy)			Vancomycin	>= 32	R
Streptomycin High Level (synergy)			Tetracycline	>= 16	R
Gentamicin	<= 0.5	S	Tigecycline	0.5	S
Ciprofloxacin	<= 0.5	S	Nitrofurantoin	<= 16	S
Levofloxacin	<= 0.12	S	Rifampicin	1	S
Moxifloxacin	<= 0.25	S	Trimethoprim/ Sulfamethoxazole	<= 10	S
Inducible Clindamycin Resistance	NEG	-			

04

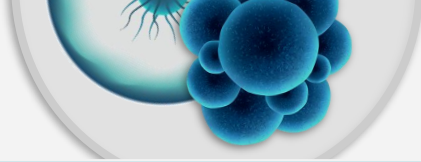
Key Organisms in Healthcare







Global Top 10 Organisms Causing Death

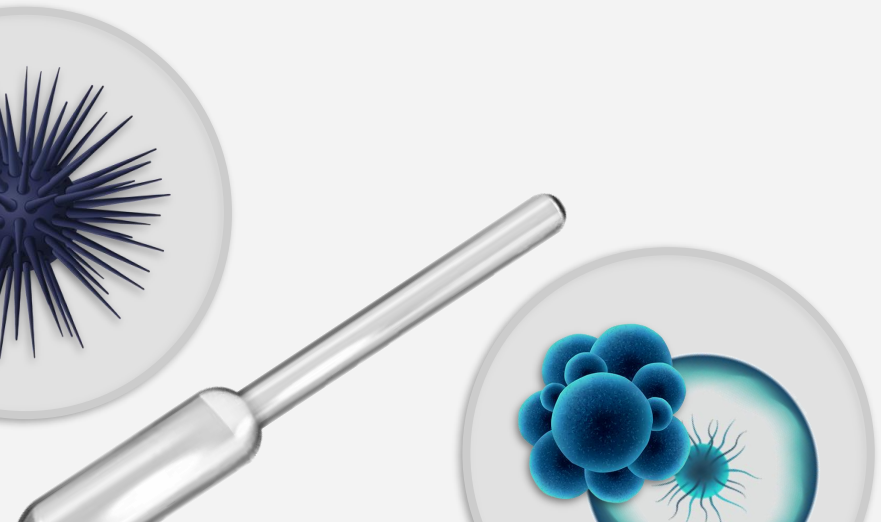


Rank	Pathogen	All-cause age-standardised mortality rate
1	*Staphylococcus aureus*	14.6
2	*E. coli*	12.6
3	*Streptococcus pneumoniae*	11.4
4	*Klebsiella pneumoniae*	11.4
5	*Pseudomonas aeruginosa*	7.4
6	*Acinetobacter baumannii*	5.8
7	*Enterobacter species*	4.2
8	Group B *Streptococcus*	4.4
9	*Enterococcus faecalis*	2.8
10	*Enterococcus faecium*	2.8
27	*Clostridioides difficile*	0.4

GBD 2019 Antimicrobial Resistance Collaborators

Prevalent Organisms in Healthcare

Top 15 Healthcare Associated Infection (HAI) Pathogens Reported to the National Healthcare Safety Network, Adults 2018-2021



Pathogen	# Pathogens	% Pathogens	Rank
Escherichia coli	73,556	16.2	1
Staphylococcus aureus	51,131	11.3	2
Enterococcus faecalis[2]	39,129	8.6	3
Select *Klebsiella* spp.	38,496	8.5	4
Pseudomonas aeruginosa	36,004	7.9	5
Coagulase-negative staphylococci	32,276	7.1	6
Enterobacter spp.	18,431	4.1	7
Enterococcus faecium[2]	16,904	3.7	8
Candida albicans[2]	16,458	3.6	9
Proteus spp.	13,953	3.1	10
Bacteroides spp.	11,602	2.6	11
Viridans group streptococci	9,962	2.2	12
Other *Candida* spp.[2]	9,803	2.2	13
Other *Enterococcus* spp.[2]	9,091	2.0	14
Candida glabrata[2]	7,622	1.7	15
Other pathogen	68,522	15.1	
Total	452,940	100.0	

https://www.cdc.gov/nhsn/hai-report/data-tables-adult/table-3.html

Antimicrobial Resistant Bacteria and Fungi

COVID-19 Impacts on

18 Antimicrobial-Resistant Bacteria and Fungi

Threat Estimates

The following table summarizes the latest national death and infection estimates for 18 antimicrobial-resistant bacteria and fungi. The pathogens are listed in three categories—urgent, serious, and concerning—based on level of concern to human health identified in 2019.

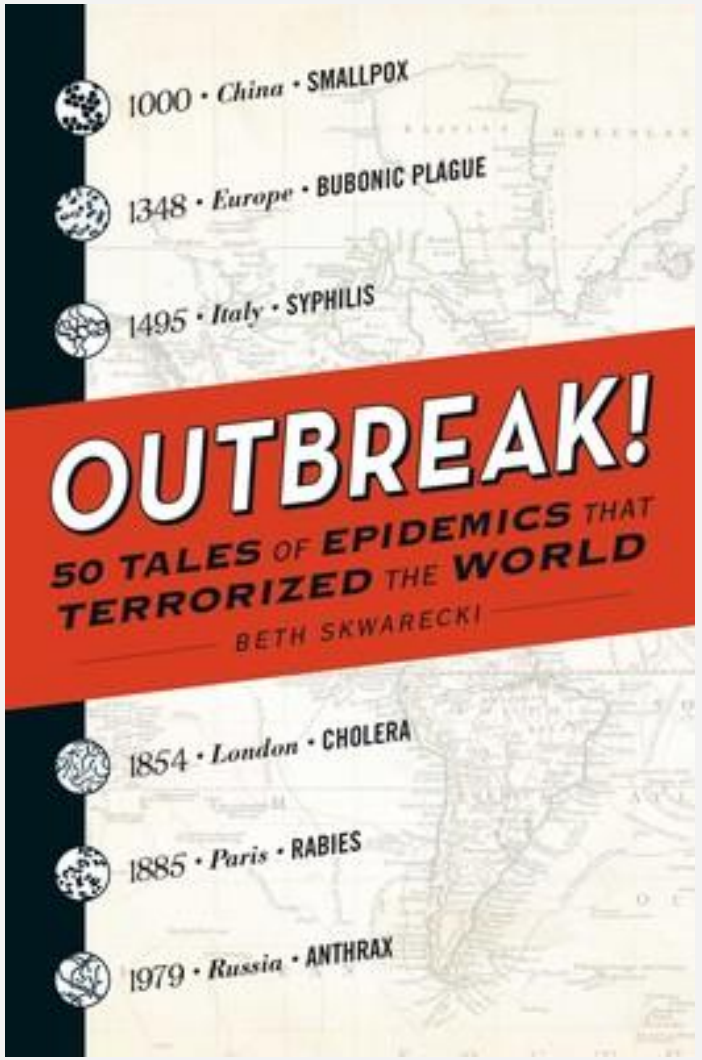
	Resistant Pathogen	2017 Threat Estimate	2018 Threat Estimate	2019 Threat Estimate	2017-2019 Change	2020 Threat Estimate and 2019-2020 Change
URGENT	Carbapenem-resistant *Acinetobacter*	8,500 cases 700 deaths	6,300 cases 500 deaths	6,000 cases 500 deaths	Stable*	7,500 cases 700 deaths **Overall: 35% increase*** **Hospital-onset: 78% increase***
URGENT	Antifungal-resistant *Candida auris*	171 clinical cases†	329 clinical cases	466 clinical cases	▲ Increase	754 cases **Overall: 60% increase**
URGENT	*Clostridioides difficile*	223,900 infections 12,800 deaths	221,200 infections 12,600 deaths	202,600 infections 11,500 deaths	▼ Decrease	Data delayed due to COVID-19 pandemic
URGENT	Carbapenem-resistant Enterobacterales	13,100 cases 1,100 deaths	10,300 cases 900 deaths	11,900 cases 1,000 deaths	▼ Decrease*	12,700 cases 1,100 deaths Overall: Stable* **Hospital-onset: 35% increase***
URGENT	Drug-resistant *Neisseria gonorrhoeae*	550,000 infections	804,000 infections	942,000 infections	▲ Increase	Data unavailable due to COVID-19 pandemic
SERIOUS	Drug-resistant *Campylobacter*	448,400 infections 70 deaths	630,810 infections	725,210 infections	▲ Increase	Data delayed due to COVID-19 pandemic‡ 26% of infections were resistant, a 10% decrease
SERIOUS	Antifungal-resistant *Candida*	34,800 cases 1,700 deaths	27,000 cases 1,300 deaths	26,600 cases 1,300 deaths	▼ Decrease*	28,100 cases 1,400 deaths **Overall: 12% increase*** **Hospital-onset: 26% increase***
SERIOUS	ESBL-producing Enterobacterales	197,400 cases 9,100 deaths	174,100 cases 8,100 deaths	194,400 cases 9,000 deaths	▲ Increase*	197,500 cases 9,300 deaths **Overall: 10% increase*** **Hospital-onset: 32% increase***
SERIOUS	Vancomycin-resistant Enterococcus	54,500 cases 5,400 deaths	46,800 cases 4,700 deaths	47,000 cases 4,700 deaths	Stable*	50,300 cases 5,000 deaths **Overall: 16% increase*** **Hospital-onset: 14% increase***

https://www.cdc.gov/drugresistance/pdf/covid19-impact-report-508.pdf

Role of the Lab During Outbreak Investigation

Clinical laboratories play a pivotal role in both endemic and epidemic epidemiology:

- Assist in the identification of an outbreak by confirming organism identities, recognizing organism clusters and by detecting unusual organisms or antimicrobial susceptibility patterns.
- Retrieve and review archival data to determine background (baseline) rates of organism isolation and help determine if an outbreak situation actually exists.
- Save certain microbes isolated to assist in testing to determine if the microbes are the same or related.
- IPAC should work closely with the laboratory team, especially when planning for a potential outbreak.
- May be part of an multidisciplinary outbreak response team (to plan for point prevalence screening etc.)

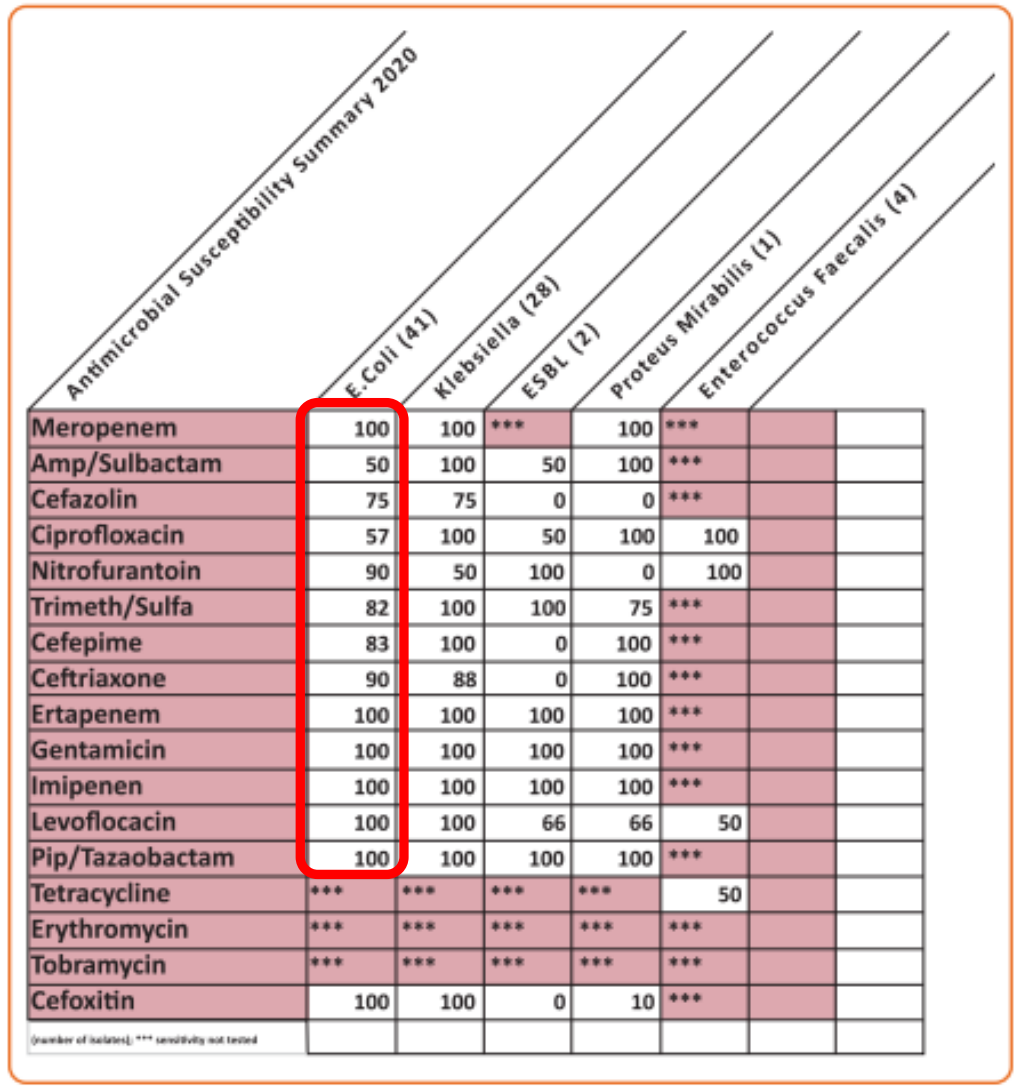


https://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/microbiology-basics

https://www.simonandschuster.ca/books/Outbreak!/Beth-Skwarecki/9781440596278

Antibiograms:

- Summarizes antimicrobial susceptibility testing results for bacterial isolates in a healthcare setting **over a period of time**
- Guides empiric antibiotic therapy – ensures that prescribed antibiotics are effective against the pathogens most likely to be encountered
- Improves treatment efficacy allowing facilities to guide treatment while culture and sensitivity results are pending
- Can enhance patient safety and improve treatment outcomes
- Can support antimicrobial stewardship initiatives

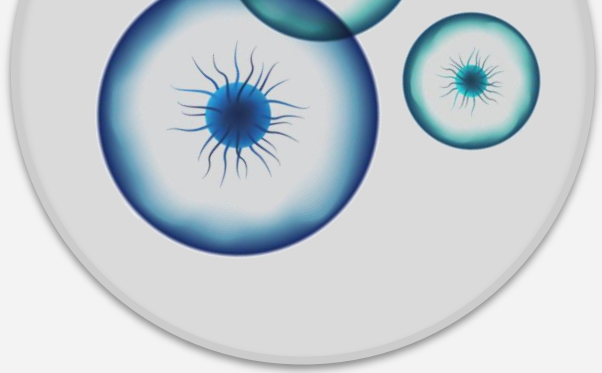


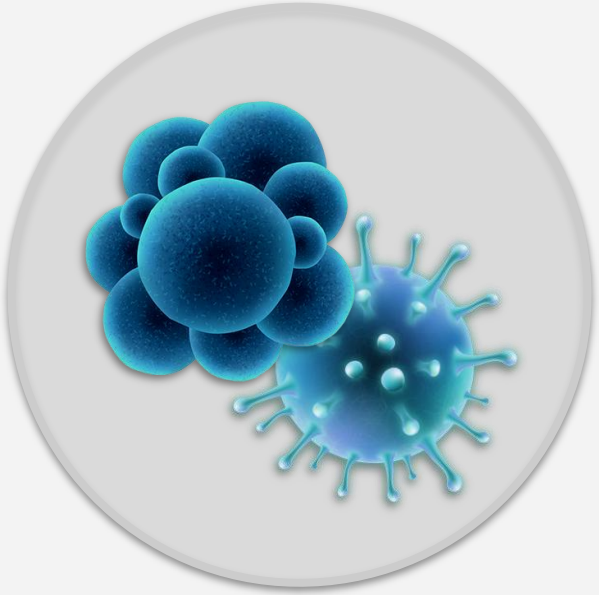
Antimicrobial Susceptibility Summary 2020	E.Coli (41)	Klebsiella (28)	ESBL (2)	Proteus Mirabilis (1)	Enterococcus Faecalis (4)		
Meropenem	100	100	***	100	***		
Amp/Sulbactam	50	100	50	100	***		
Cefazolin	75	75	0	0	***		
Ciprofloxacin	57	100	50	100	100		
Nitrofurantoin	90	50	100	0	100		
Trimeth/Sulfa	82	100	100	75	***		
Cefepime	83	100	0	100	***		
Ceftriaxone	90	88	0	100	***		
Ertapenem	100	100	100	100	***		
Gentamicin	100	100	100	100	***		
Imipenen	100	100	100	100	***		
Levoflocacin	100	100	66	66	50		
Pip/Tazaobactam	100	100	100	100	***		
Tetracycline	***	***	***	***	50		
Erythromycin	***	***	***	***	***		
Tobramycin	***	***	***	***	***		
Cefoxitin	100	100	0	10	***		
(number of isolates); *** sensitivity not tested							

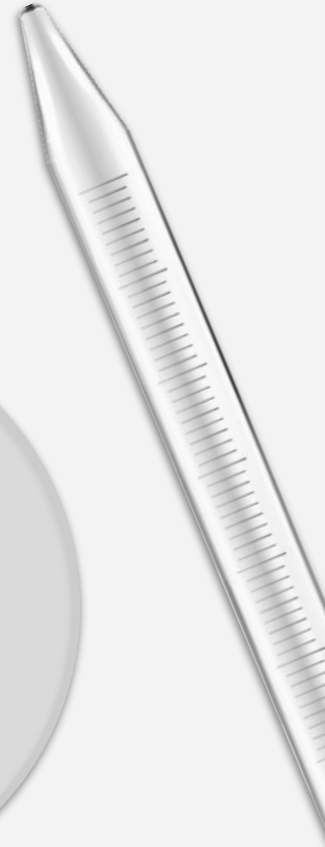
Sample of an antibiogram for residents from Morrow Home Community Sparta Wisconsin LTCF 2020.

05

Changing Dynamics of Infectious Diseases







Emerging (EID) and Re-Emerging (REID) Infectious Diseases

EIDs are:

- Outbreaks of previously unknown diseases
- Known disease that is rapidly increasing in incidence or geographic area in the last 2 decades
- Persistence of infectious diseases that cannot be controlled

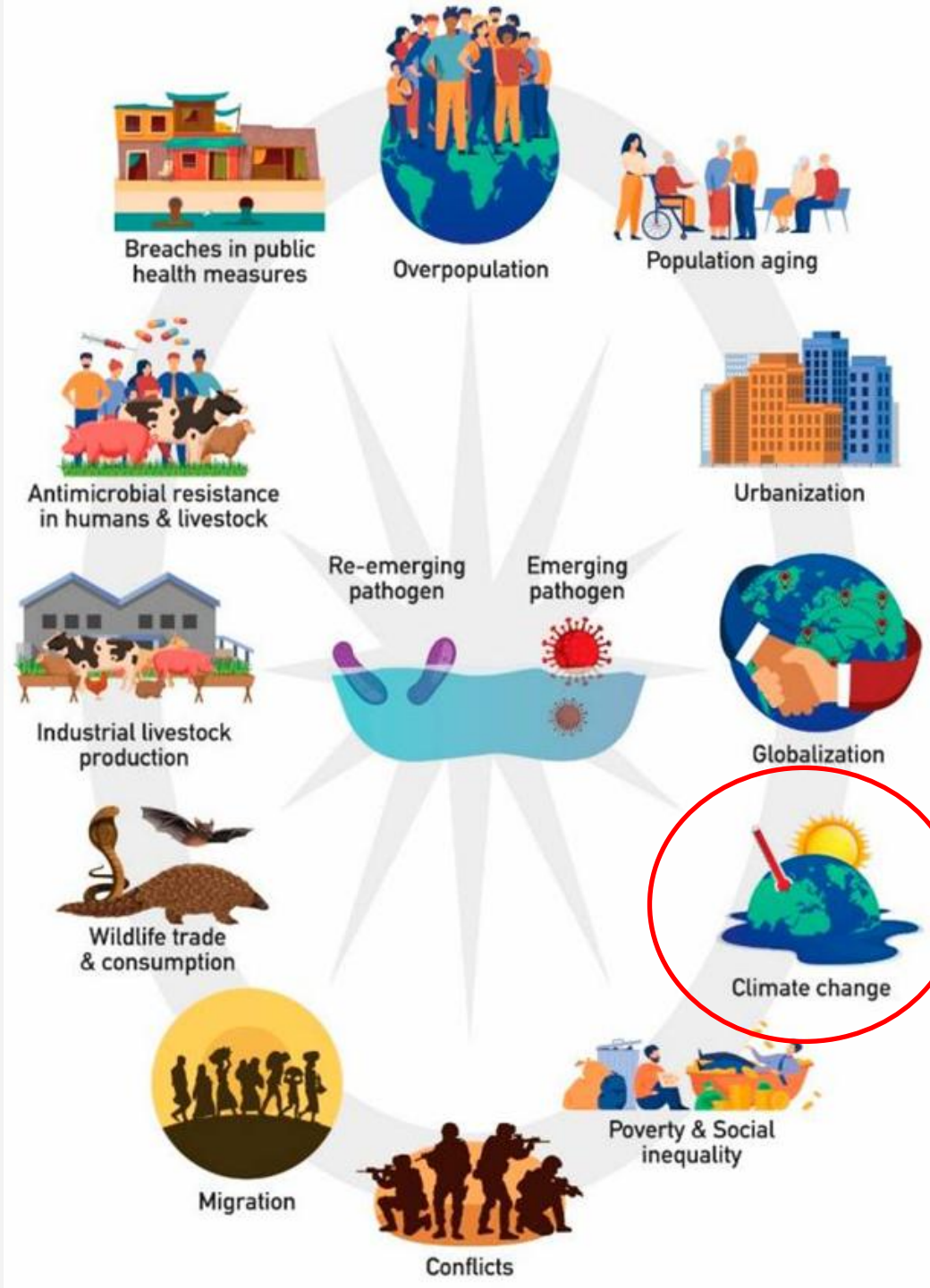
REIDs are:

- Diseases that reappear after they have been on a significant decline
- Re-emergence may happen because of a breakdown in public health measures for diseases that were once under control
- Can also happen when new strains of known disease-causing organisms appear
- Human behavior can affect re-emergence such as the return of vaccine preventable diseases- As a result of immunization declines, the global community is at risk for a resurgence in vaccine-preventable infections including measles, pertussis, and polio-all highly contagious diseases that result in significant morbidity and mortality in children.

National Institute of Allergy and Infectious Diseases/National Library of Medicine

Most EIDs and REIDs have a zoonotic origin- the disease has emerged from an animal and crossed the species barrier to infect humans

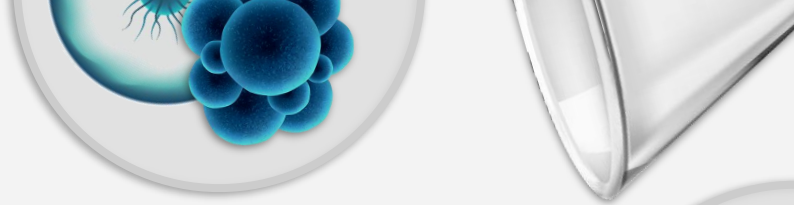
Factors that Precipitate the Occurrence and Transmission of EIDs and REIDs…



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8780145/

OUR RISK FOR INFECTIOUS DISEASES

Is Increasing Because of Climate Change



- These are just some of the infectious diseases that are on the rise and spreading to new areas of the United States.
- Milder winters, warmer summers, and fewer days of frost make it easier for these and other infectious diseases to **expand into new geographic areas and infect more people.**

As the climate changes, the risk also increases for health threats such as:

- Anaplasmosis
- Anthrax
- Antibiotic-resistant infections
- Cryptosporidiosis
- Dengue
- Ehrlichiosis
- Fungal diseases like valley fever and histoplasmosis
- Giardiasis
- Hantavirus
- Harmful algal bloom-associated illness
- Lyme disease
- Plague
- Rabies
- Spotted fever rickettsiosis
- Salmonellosis
- Vibriosis
- West Nile virus disease

https://www.cdc.gov/ncezid/pdf/climate-change-and-infectious-diseases-H.pdf

Dengue

Health Alert Network (HAN)

EXPLORE TOPICS

Ongoing Risk of Dengue Virus Infections and Updated Testing Recommendations in the United States

Public Health
MARCH 18, 2025

Important Updates on Locally Acquired Malaria Cases Identified in Florida, Texas, and Maryland

Print

HAN HEALTH ALERT NETWORK

This is an official CDC HEALTH UPDATE

Distributed via the CDC Health Alert Network
August 28, 2023, 2:15 PM ET
CDCHAN-00496

Summary

The Centers for Disease Control and Prevention (CDC) is issuing this Health Alert Network (HAN) Health Update to share new information with clinicians, public health authorities, and the public about locally acquired malaria cases identified in the United States. On August 18, 2023, a single case of locally acquired malaria was reported in Maryland in the National Capital Region. This case was caused by the *Plasmodium falciparum (P. falciparum)* species and is unrelated to the cases involving local transmission of *Plasmodium vivax (P. vivax)* malaria in Florida and Texas described in the HAN Health Advisory 494 issued on June 26, 2023. As an update to that report, to date, Florida has identified seven cases and Texas has identified one case of locally acquired *P. vivax* malaria, but there have been no reports of local transmission of malaria in Florida or Texas since mid-July 2023.

Year-Over-Year Change in Dengue Cases

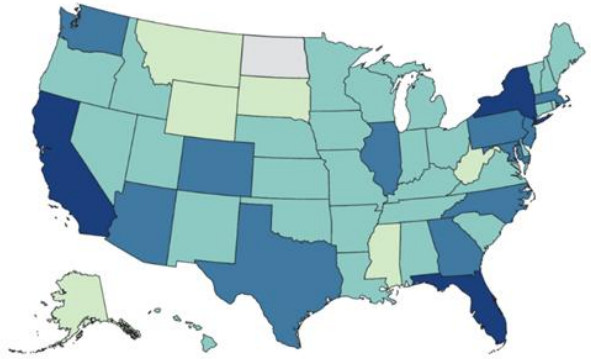
2024
6,076 locally acquired cases (3,179 travel-related)

2023
1,104 locally acquired cases (1,452 travel-related)

2022
1,044 locally acquired cases (1,494 travel-rela...

2021
609 locally acquired cases (20...

2020
983 locally acquired cases (354 travel-related)



Territories and freely associated states

AS GU PR VI MP FM PW MH

Legend

No reported cases | 1 to 4 | 5 to 49 | 50 to 249 | 250+

Image Source: U.S. Centers for Disease Control and Prevention, Accessed on January 1, 2025
https://www.cdc.gov/dengue/data-research/facts-stats/current-data.html

6,076 Locally Acquired Cases

3,179 Travel-associated Cases

3 States Reporting Locally Acquired Human Cases

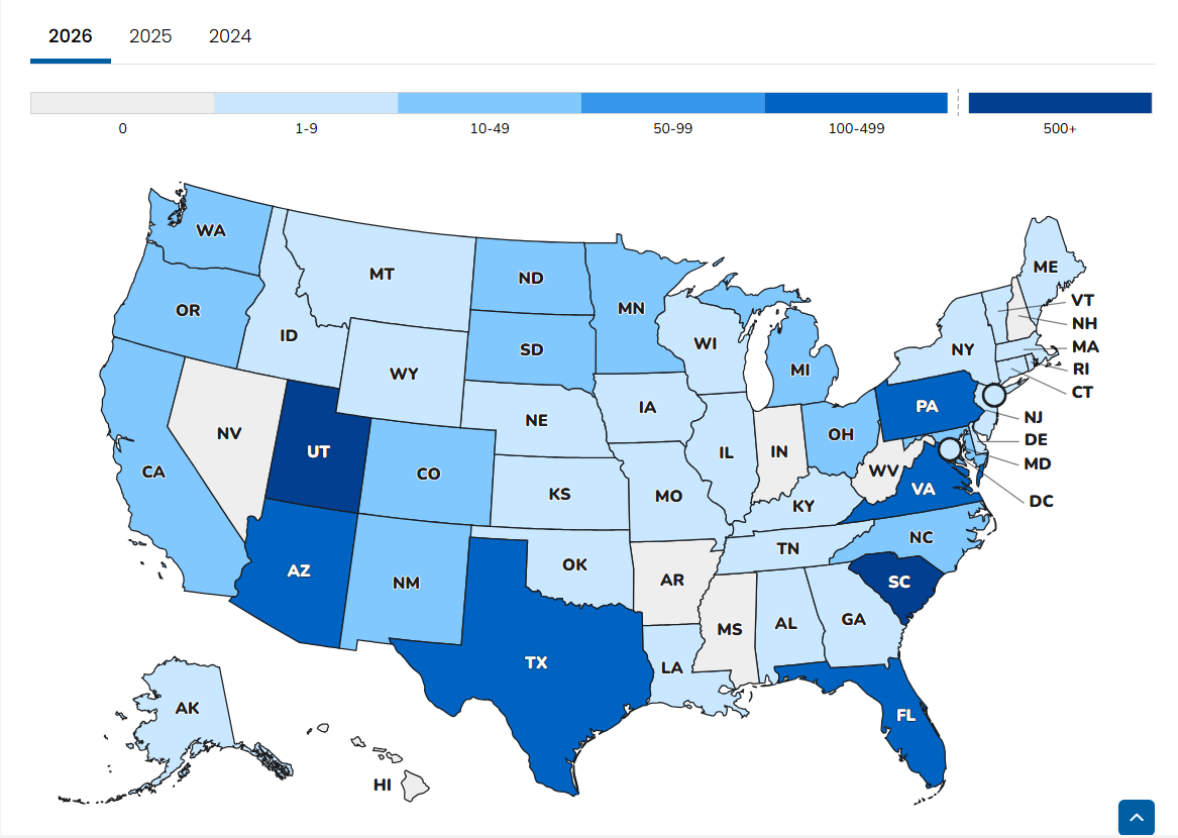
Measles as of July 23, 2026

U.S. Hospitalizations

	2026	2025
Total Hospitalized	**7%** (151 of 2,318 cases)	**11%** (243 of 2,289 cases)
Percent of Age Group Hospitalized		
Under 5 years	10% (45 of 456)	18% (106 of 584)
5-19 years	3% (38 of 1,141)	6% (58 of 1,017)
20+ years	10% (68 of 709)	12% (79 of 675)
Age unknown	0% (0 of 12)	0% (0 of 13)

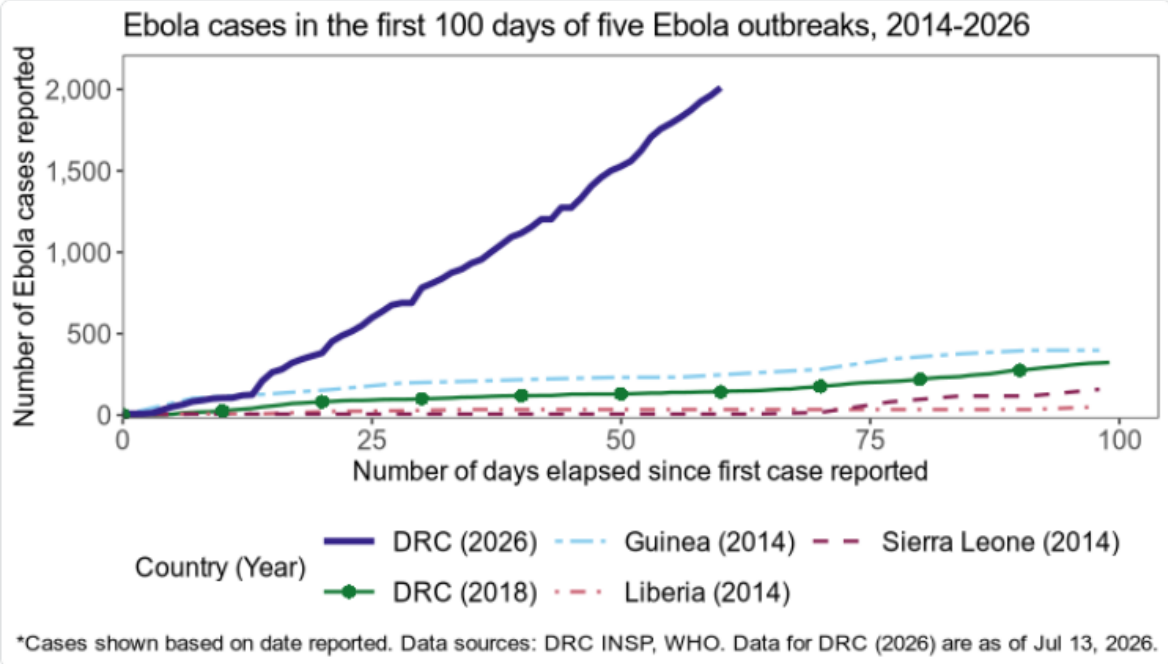
U.S. Deaths

	2026	2025
Total Deaths	**0**	**3**



Ebola

- CDC is responding to an outbreak of Ebola in the Democratic Republic of the Congo (DRC) and Uganda.
- The outbreak is caused by Bundibugyo virus, a type of Ebola virus.
- There is currently no approved vaccine or specific treatment for the Bundibugyo strain of Ebola virus that is causing this outbreak



Reported	Count
DRC (as of Jul 25, 2026)	
Confirmed cases	3200
Confirmed deaths	1405
Probable cases	0
Probable deaths	0
Uganda (as of Jul 21, 2026)	
Confirmed cases	20
Confirmed deaths	2
Probable cases	1
Probable deaths	1
France (as of Jun 24, 2026)	
Confirmed cases	1
Confirmed deaths	0
Probable cases	0
Probable deaths	0
Totals	
Confirmed cases	3221
Confirmed deaths	1407
Probable cases	1
Probable deaths	1

Ebola Outbreak: Current Situation | Ebola | CDC

US H5 Bird Flu Situation

(as of July 7, 2026)

National situation summary since 2024

Person-to-person spread

NONE There is no known person-to-person spread at this time.

Current public health risk

LOW The current public health risk is Low.

Cases in the U.S.

71 cases

Deaths in U.S.

2 deaths

Situation summary of confirmed and probable human cases since 2024

Confirmed Cases | Probable Cases

State or territory

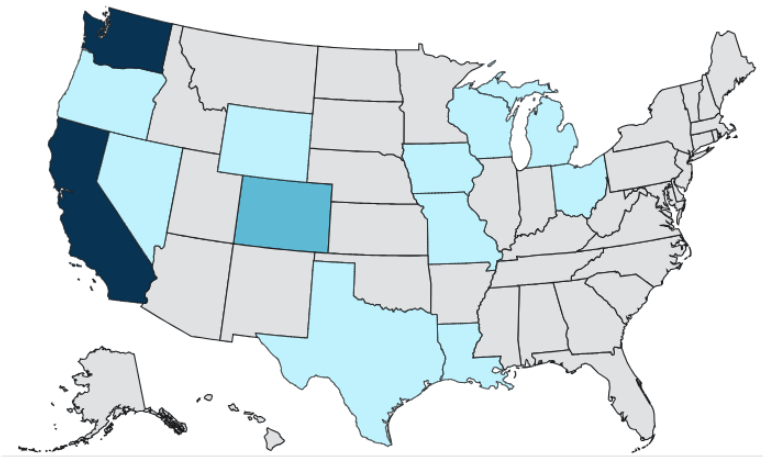
National

National Total Cases: 71

Cases	Exposure Source
41	Dairy Herds (Cattle)*
24	Poultry Farms and Culling Operations*
3	Other Animal Exposure†
3	Exposure Source Unknown‡

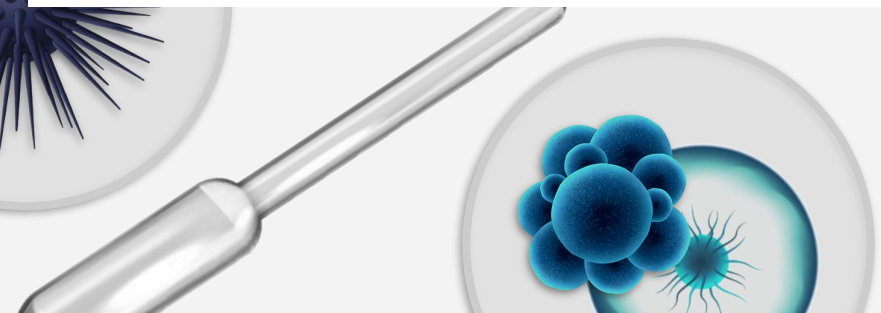
NOTE: One additional case was previously detected in a poultry worker in Colorado in 2022. Louisiana reported the first H5 bird flu death in the U.S.

*Exposure Associated with Commercial Agriculture and Related Operations
†Exposure was related to other animals such as backyard flocks, wild birds, or other mammals
‡Exposure source was not able to be identified



Total cases

0 | 1-5 | 6-10 | >10



https://www.cdc.gov/bird-flu/situation-summary/index.html

RESOURCES

Benefits:
Easy to ready & search in a table format.

Inexpensive!

Downside:
Last updated in 2018, doesn't include current threats (SARS CoV-2, *Candida auris*

Examples of Significant Bacterial Toxins

BACTERIA	TOXIN(S)	EFFECTS
Clostridium botulinum	botulinum toxin	Interferes with neuromuscular transmission, causing dystonia (uncontrollable muscle contractions).
Clostridium difficile	toxin A: enterotoxin toxin B: cytotoxin	Mucosal inflammation, cell/tissue damage, and pseudomembrane formation, which can lead to ulcers in the mucosa of the colon.
Clostridium tetani	tetanospasmin	Interferes with nerve conduction at the neuromuscular junction, causing continuous muscle contraction/spams.
Corynebacterium diphtheriae	diphtheria toxin	Toxic to myocardial cells, the respiratory system, nerves, and kidneys.
Escherichia coli	Shiga toxin	Multifactorial involvement between the organism and the host. Colonizes the gut, resulting in diarrhea and intestinal lesions. Reaction of tissues with toxins results in an inflammatory response. Toxin can damage kidneys.

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RESOURCES

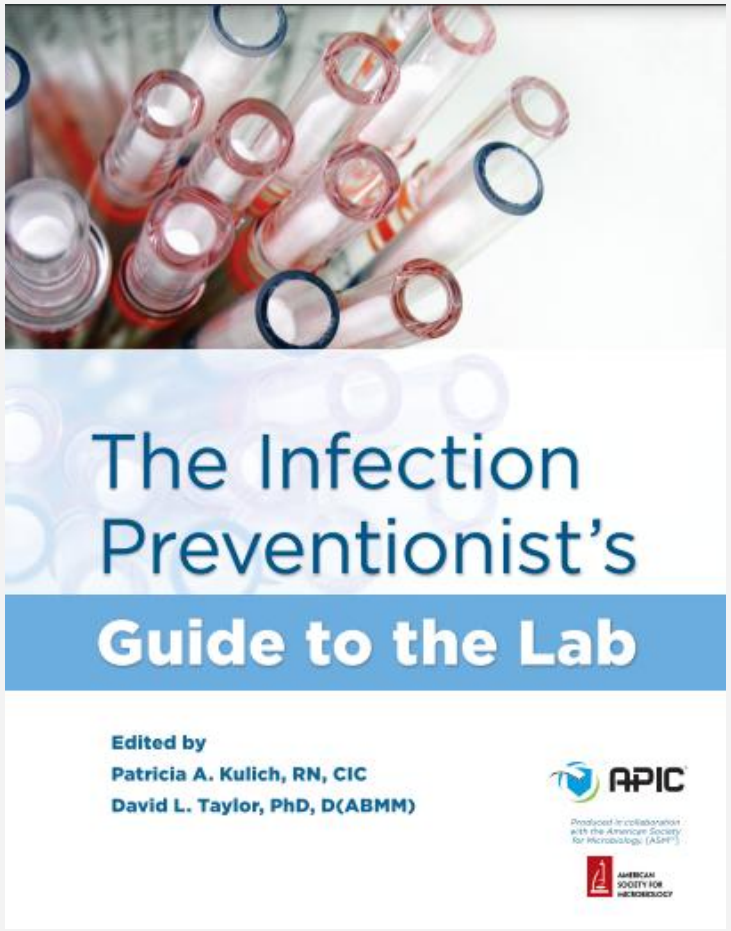


Table 1-1: Specimen Selection, Collection, and Transport by Body Site

Upper Respiratory Tract										
General Category	Laboratory Test	Indications	Specific Microbes	Specimen	Frequency	Test Type	Interpretation	Advantages/ Disadvantages	Sample Transport	Key Points
Oral cavity	• Gram stain principally • Infrequently cultures	Oral lesions, suspicion of oral yeast infection ("thrush"), necrotizing gingivitis	*Candida* sp., *Fusobacterium* sp. or other anaerobes or spirochetes in cases of necrotizing gingivitis	• Swab of lesions or purulent material • Bacterial transport media	Once	Swab	• Gram stain reveals yeast • Gram stain reveals fusiform bacilli or spirochetes	Swabs not very sensitive or specific	Swab and transport within 2 hours to laboratory (≤2 h) at room temperature (RT)	Culture rarely indicated
Nares	Culture or polymerase chain reaction (PCR) for methicillin-resistant *Staphylococcus aureus* (MRSA)	Epidemiological screening for MRSA	MRSA	• Swab of anterior nares • Bacterial transport media	• Once at assessment • Repeat as needed clinically	Nasal swab	Positive culture or PCR indicates colonization with MRSA	• PCR very sensitive and specific but more costly • Specialized test	Swab and transport ≤2 h at RT	Concurrent cultures of wounds or perianal skin also recommended to compensate for lower sensitivity of nares culture method

My experience: Provides very technical info that isn't necessarily practical for day to day infection prevention

Digital PDF only $49 for APIC Members

https://secure.apic.org/web/apic/EStore/store.aspx

***Published in 2012**

RESOURCES

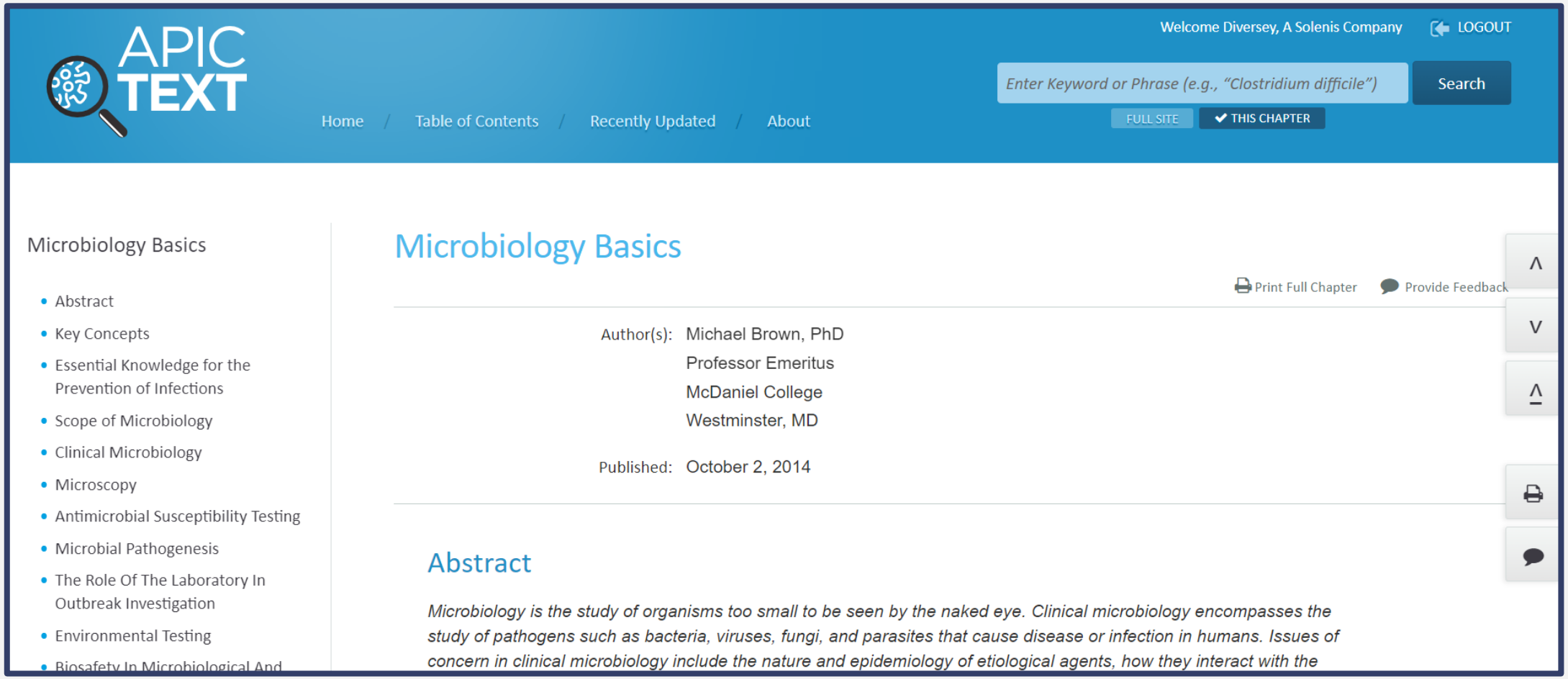
Home > Education & Certification > Course Catalog

EPI® Education Series: Basic Microbiology for Infection Preventionists

Learn the fundamentals of microbiology to foster the relationship between you and your facility's micro lab.

https://apic.org/course/basic-microbiology-for-infection-preventionists/

RESOURCES: APIC TEXT



https://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/microbiology-basics

Let’s end with a fun fact!

SUMMARY

- Provided an overview of different types of microorganisms
- Reviewed characteristics of major groups of microorganisms along with information on identification and susceptibility testing
- Provided examples of laboratory reports an IP may see, reviewed how to interpret these
- Discussed how the LAB and IP can work together
- Reviewed common organisms causing HAIs and potential future threats to human health- emerging and re-emerging diseases

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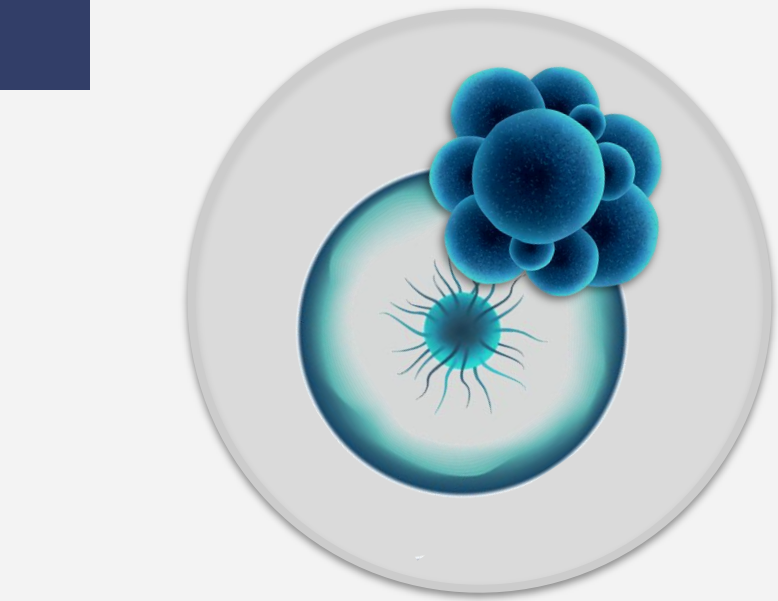

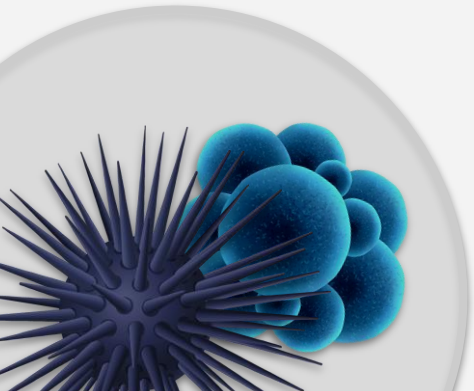

Thanks!

Questions?

References

Centers for Disease Control and Prevention, HAI Pathogens and Antimicribial Resistance Report, 2018-1021
https://www.cdc.gov/nhsn/hai-report/data-tables-adult/table-3.html

Dingle, T, et. al. MALDITOF Mass Spectrometry for Microorganism Identification. Clinics in Laboratory Medicine 2013;33(3):589-609

GBD 2019 Antimicrobial Resistance Collaborators. Global mortality associated with 33 bacterial pathogens in 2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2022 Dec 17;400(10369):2221-2248. doi: 10.1016/S0140-6736(22)02185-7. Epub 2022 Nov 21. PMID: 36423648; PMCID: PMC9763654.

Mora, C, et. al. Over half of known human pathogenic diseases can be aggravated by climate change. Nat. Clim. Chang. 12, 869–875 (2022). https://doi.org/10.1038/s41558-022-01426-1

Schinas G et. al., Understanding and Implementing Diagnostic Stewardship: A Guide for Resident Physicians in the Era of Antimicrobial Resistance. Microorganisms. 2023 Aug 31;11(9):2214. doi: 10.3390/microorganisms11092214.

Schinas et. al. Understanding and Implementing Diagnostic Stewardship: A Guide for Resident Physicians in the Era of Antimicrobial Resistance. Microorganisms 2023. 11(2214). https://doi.org/10.3390/microorganisms11092214

World Health Organization, Openwho.org, Basic Microbiology Course
https://openwho.org/courses/IPC-MICRO-EN/items/7raDDBfSdfeZS93tghAZFu