Microbiology 101 for Infection Preventionists

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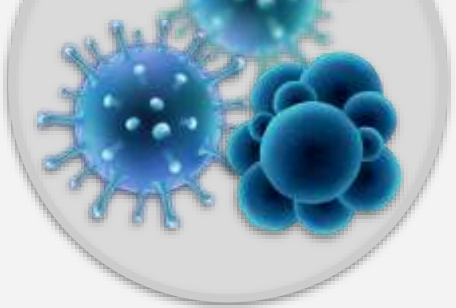
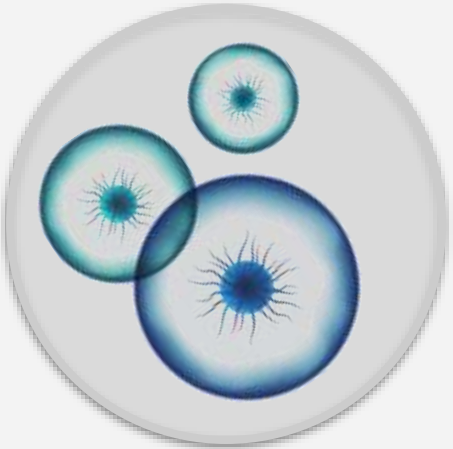
Senior Clinical Advisor, Diversey





Disclosure

Rebecca is employed by Diversey—A Solenis Company. 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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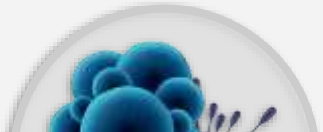
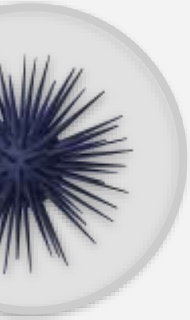
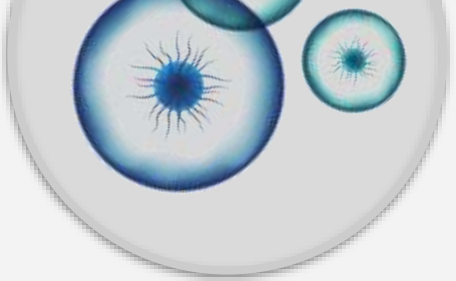
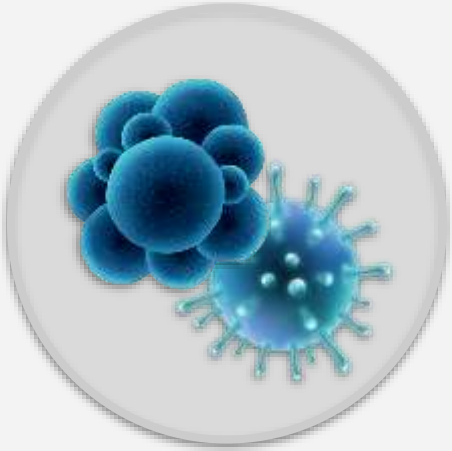


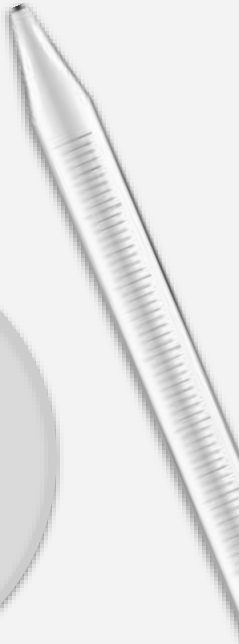
If I can learn micro, anyone can!

- Bachelor's degrees in English & Spanish literature
- Zero microbiology coursework in college, including MPH program.
- I took APIC courses, learned from my colleagues on the job & used Google (a lot!).









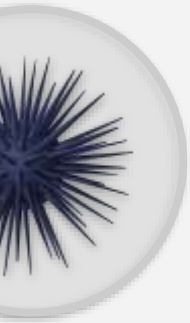
01

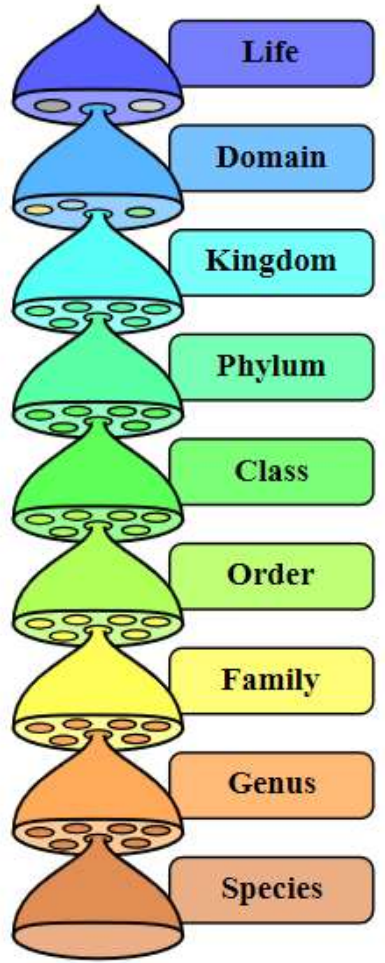
Microbiology

What Are Microorganisms?

- Microbes have existed for over **3 billion years!**
- **Pathogens** are microbes that **cause disease** (“pathogenic”)
  - BUT not all microbes are pathogens
- Categorized according to biological taxonomy

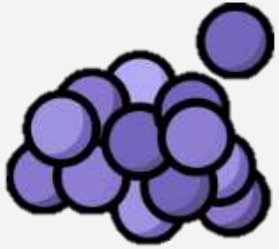
  Example: bacteria are known by genus (*Escherichia*) and species (*coli*)
- Human body has:
  - 10 trillion human cells
  - 100 trillion microbes



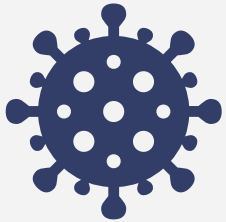


Biological classification:

5 Types of Microbes



Bacteria



Viruses

Fungi

Parasites

Prions


MICROORGANISMS
SIZE
COMPARISON

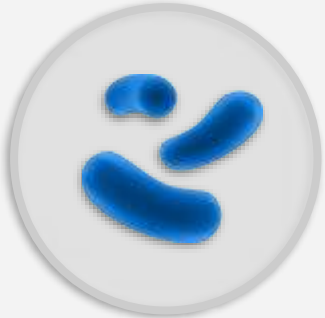
Bacteria

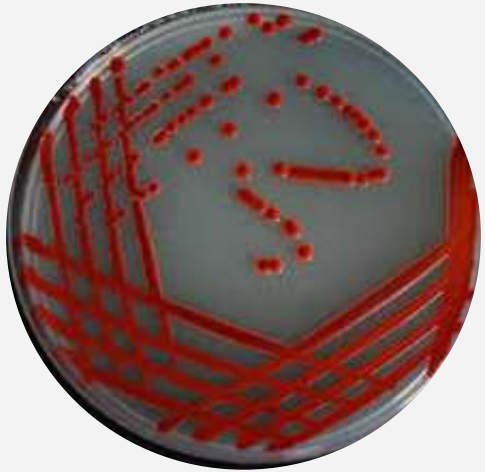
Characteristics
- Single cell
- Most are harmless (normal flora)
- Different growth characteristics
- Named by genus and species

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





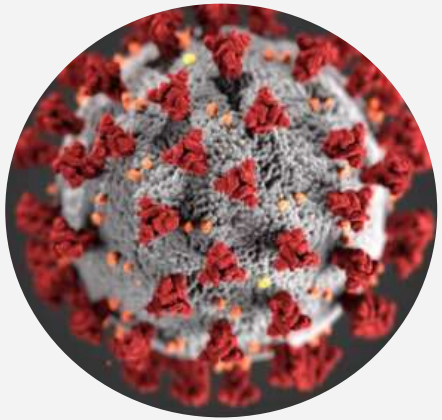
Viruses

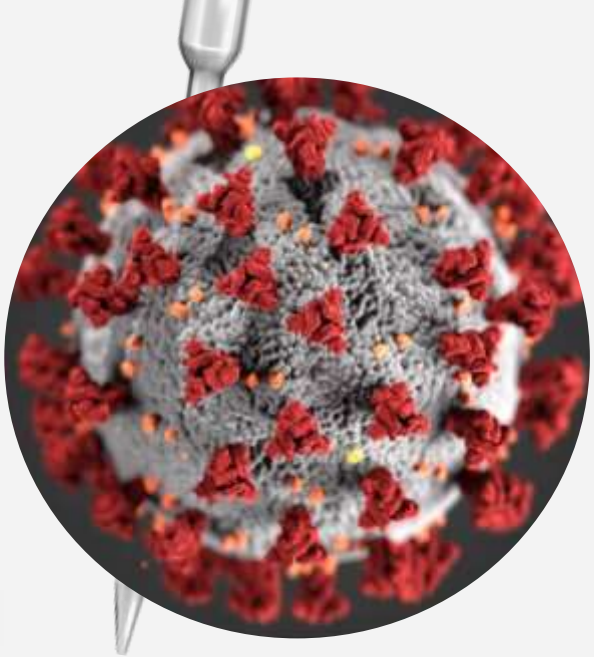
Characteristics
- Acellular
- Only able to replicate in a host's cell
- 10,000 times smaller than bacteria

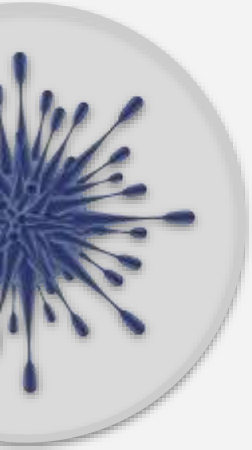
How to identify
- Culture- grown inside cells
- NOT visible under a light microscope
- Identified using specific stains and methods and other specialized laboratory tests

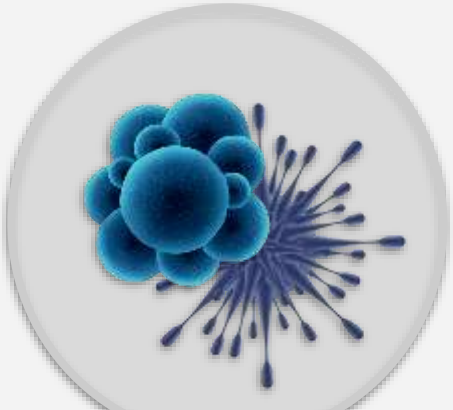
Examples of Pathogens
- Influenza
- Varicella (chickenpox)
- Covid-19

Treatment
- Antivirals or supportive therapy









Can you kill a virus?

Fungi

Characteristics

- Unicellular and multicellular
- Most are not dangerous (yeast, mold, mushrooms)
- Some can be harmful to health

How to identify

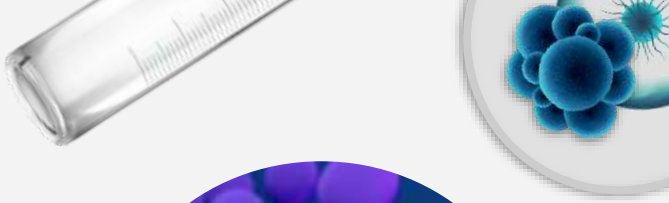
- Culture and special stains and other specialized laboratory tests

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

Scabies

Treatment

- Antiparasitic

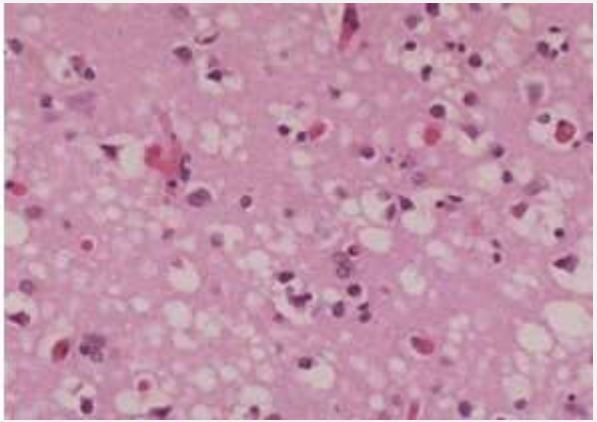
Prions

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 (**typically a sent to a reference laboratory!)**



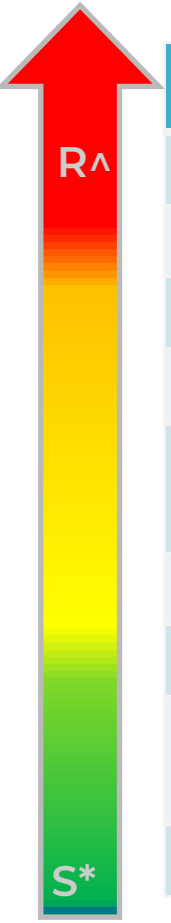
Examples of Pathogens

- Creutzfeldt-Jakob Disease (CJD)

Treatment

- Supportive treatment

Effect of Disinfectants on Microorganisms



Organism	Type	Examples
Bacterial Spores	Spore	Bacillus anthracis, C. difficile
Mycobacteria	Bacteria	M. tuberculosis, M. Terrae (Can)
Small non-enveloped virus	Virus	Poliovirus, Norovirus, Hep A
Fungal spores	Fungus	Aspergillus, Penicillium, Trichophyton
Gram negative bacteria	Bacteria	E. coli, Klebsiella including **CRE**, Pseudomonas, Acinetobacter
Fungi (Vegetative)	Fungus	Candida species
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**

^ *Resistant*
* *Sensitive*

Adapted from Rutala & Weber. ICHE 2014;35(7):862; McDonnell & Burke, J Hosp Infect 2011;78(3):163-70.

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.

Examples of exceptions to the hierarchy of disinfectants

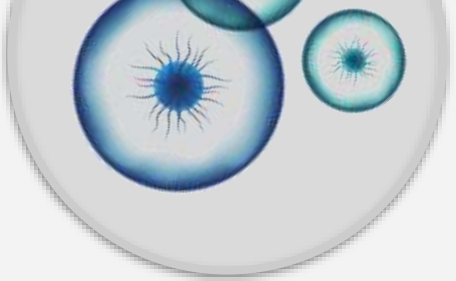
Human papillomavirus (HPV)

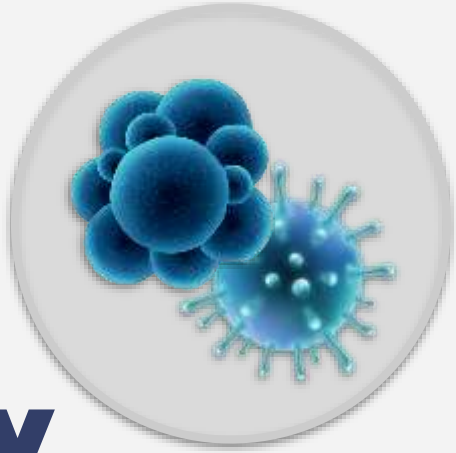
https://www.cdc.gov/mmwr/pdf/rr/rr6305.pdf

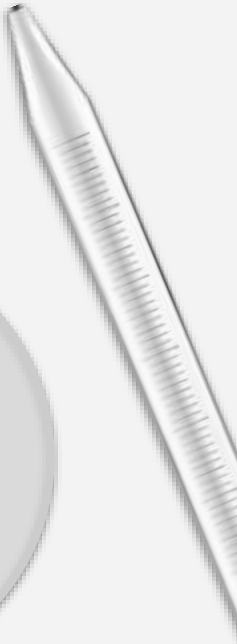
Candida auris

03

Microbiology Testing & Reporting

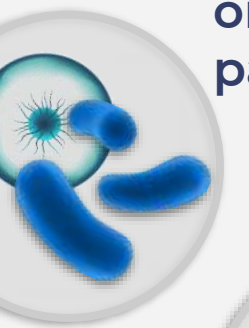






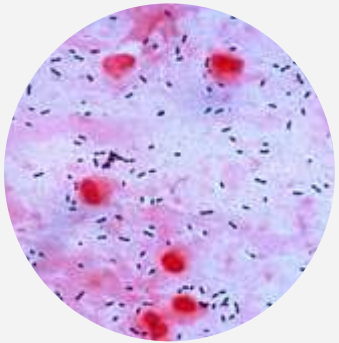
Gram Stain - Bacteria

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.



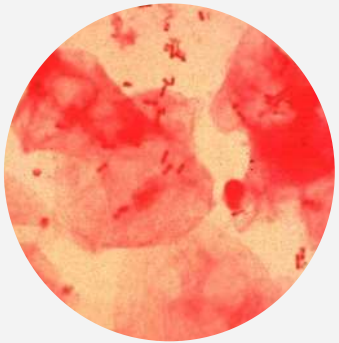
Gram Positive Result

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

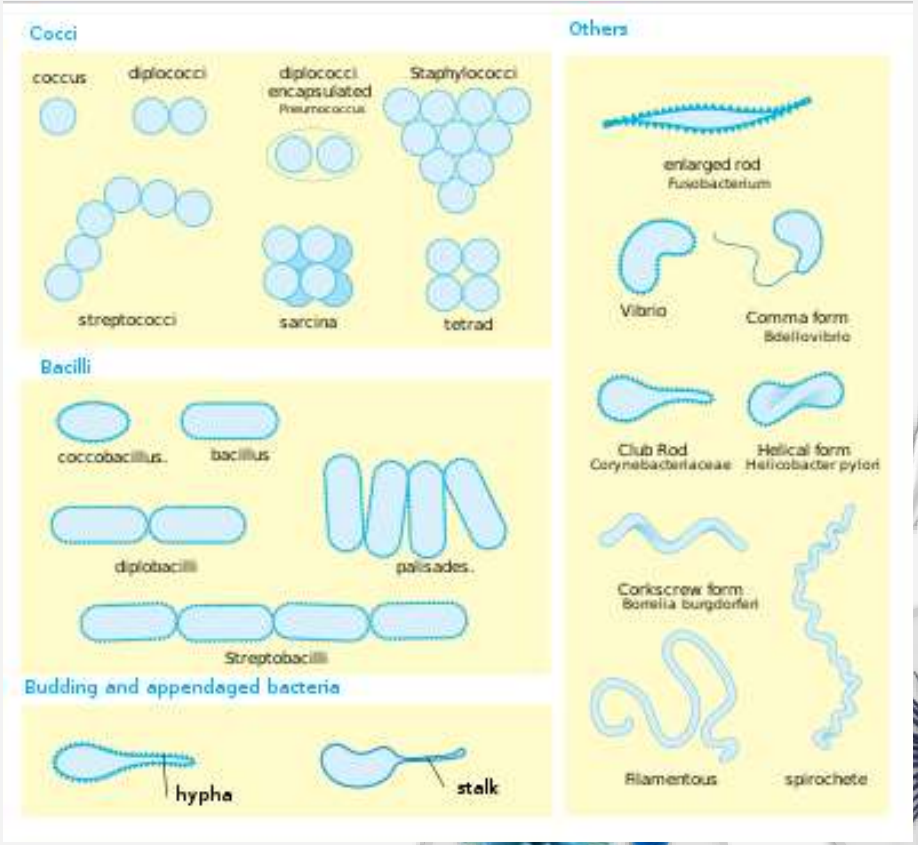
Coccobacillus- intermediate shape between coccus and bacillus

ARRANGEMENT:

Chains

Clusters

Diplo (arrangements of 2)



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

Examples: Organism & Gram Stain

GRAM POSITIVES (PURPLE!)

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**

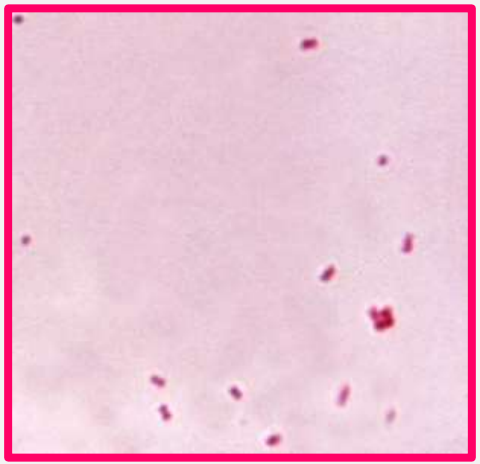
https://en.wikipedia.org/wiki/Staphylococcus_aureus

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

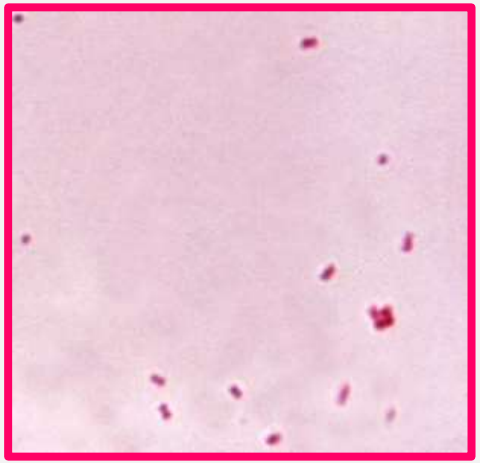
Pseudomonas aeruginosa **- gram-negative bacilli**

https://textbookofbacteriology.net/pseudomonas.html

POP QUIZ: WHICH GRAM STAIN RESULTS REQUIRES IMMEDIATE IP ATTENTION & ACTION?

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

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



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

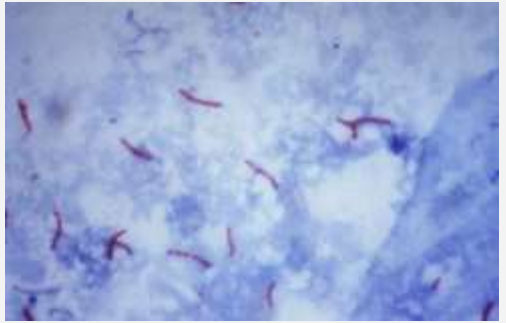
https://phil.cdc.gov/details.aspx?pid=6423

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

https://textbookofbacteriology.net/pseudomonas.html

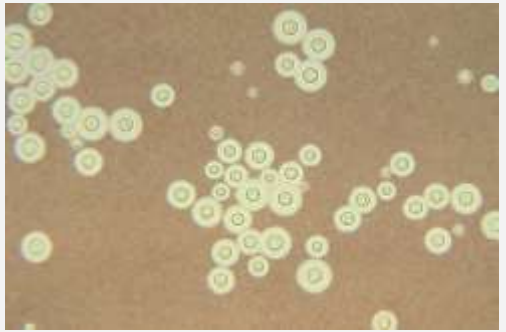
Other Common Stains

Acid-fast stain (Ziehl-Neelsen stain)- determines if a sample of tissue, blood, or other body substance is infected with tuberculosis (TB) and other illnesses.

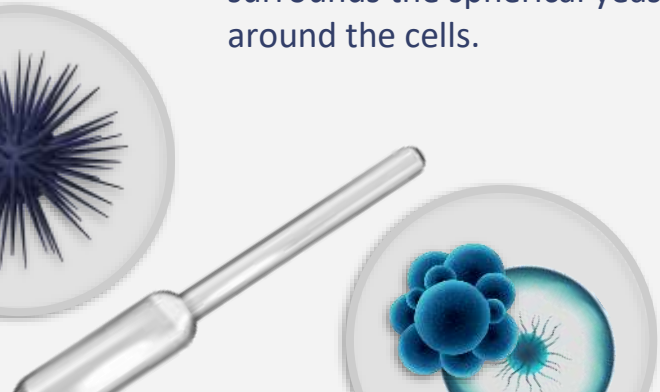


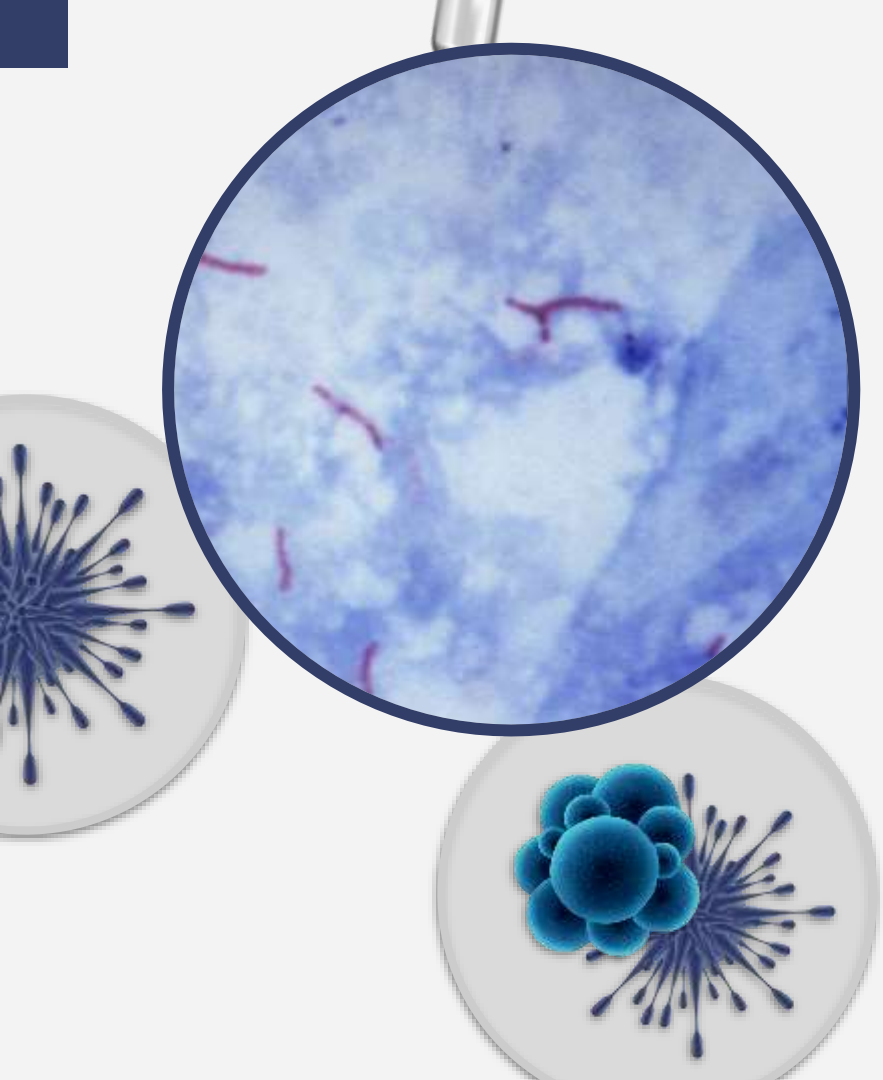
https://en.wikipedia.org/wiki/Ziehl%E2%80%93Neelsen_stain

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.

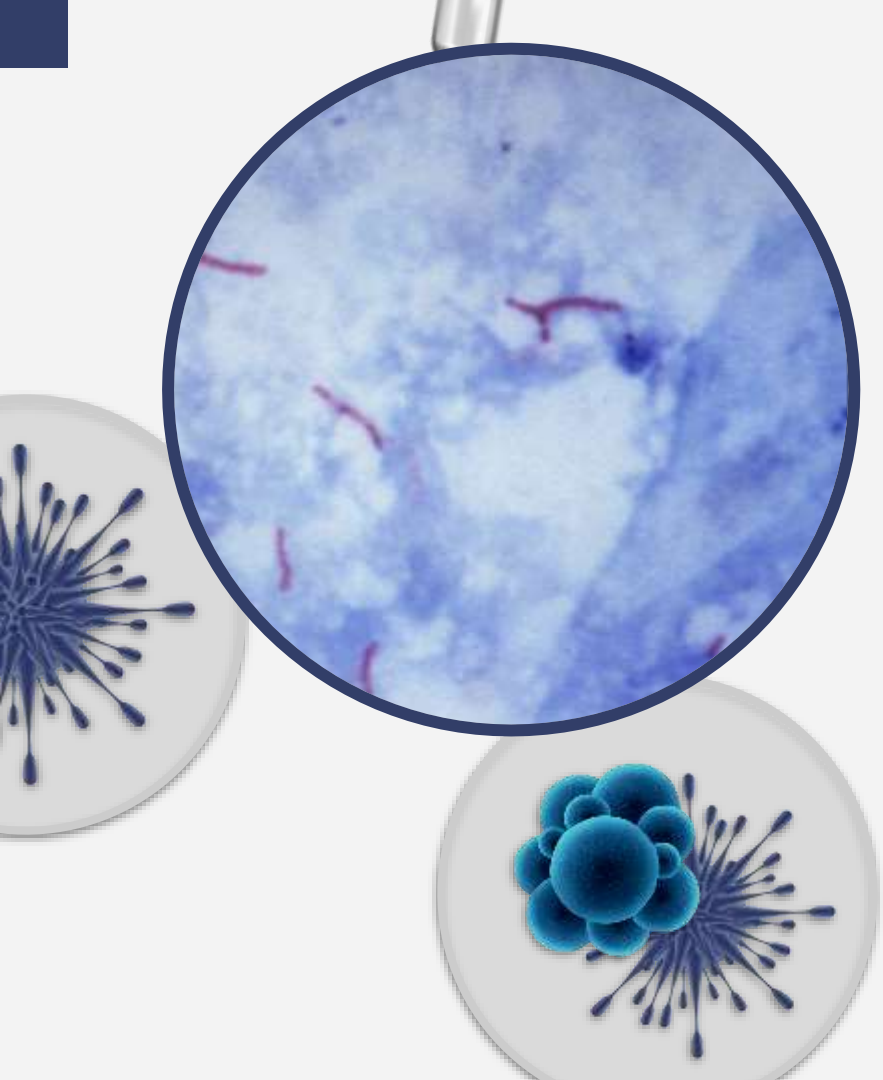


https://en.wikipedia.org/wiki/Cryptococcus_neoformans





When the micro lab calls with a positive on an active inpatient AFB result, what do you do first?



Positive AFB **PLUS** suspicion of pulmonary TB requires immediate placement into AIIR.

Contact ID/med director & give employee health a heads up. BUT DO NOT SEND AN EXPOSURE YET! You do not have organism identification.

Reassure staff that IP will follow up if MTB is identified. You do not need to stay late after ensuring isolation is active.

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

Traditional Bacterial Culture

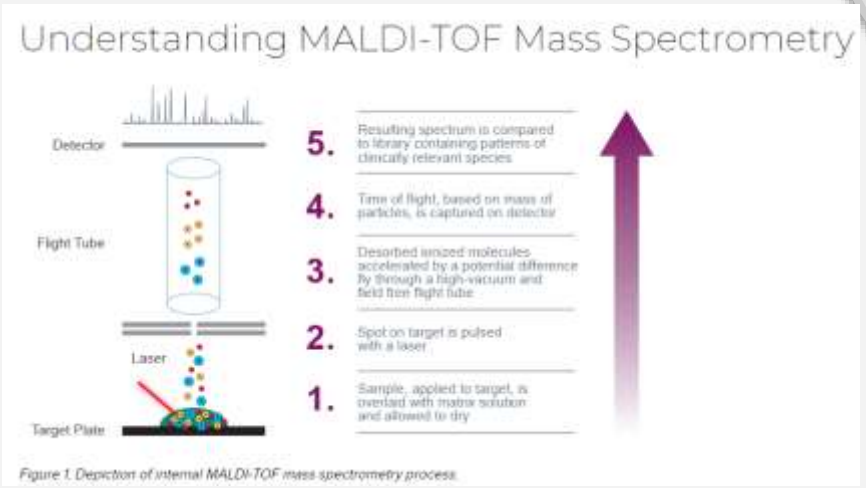
BD Kiestra- Total Laboratory Automation

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.



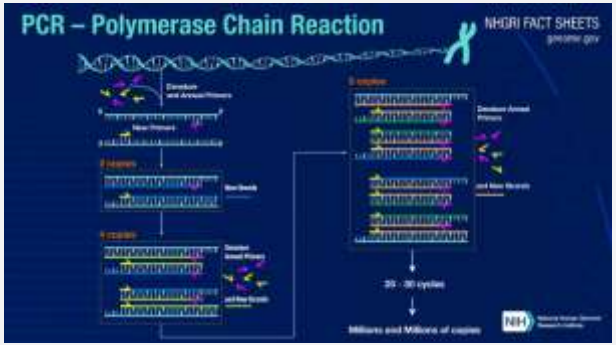
https://www.beckmancoulter.com/products/microbiology/maldi-tof-mass-spectrometry

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)

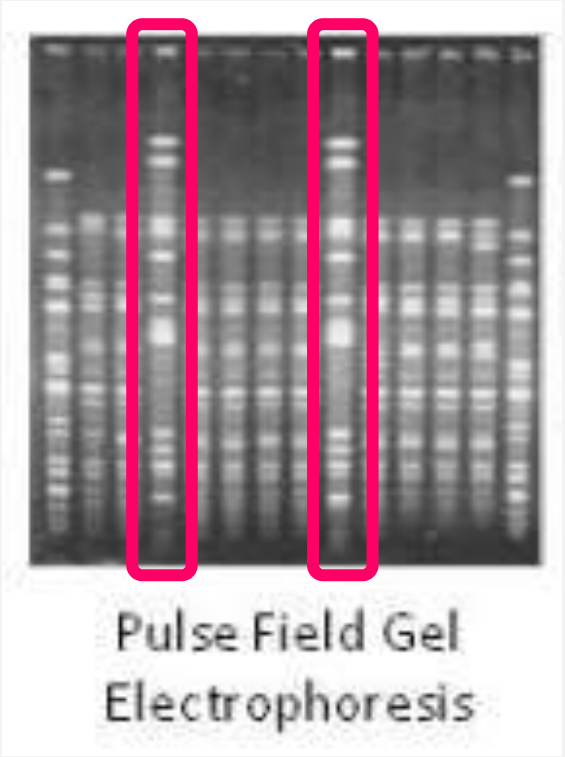
Advantages

- Effectively developed 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.

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 Escherichia coli O157 : H7 in food poisoning or MRSA causing an outbreak in health care.



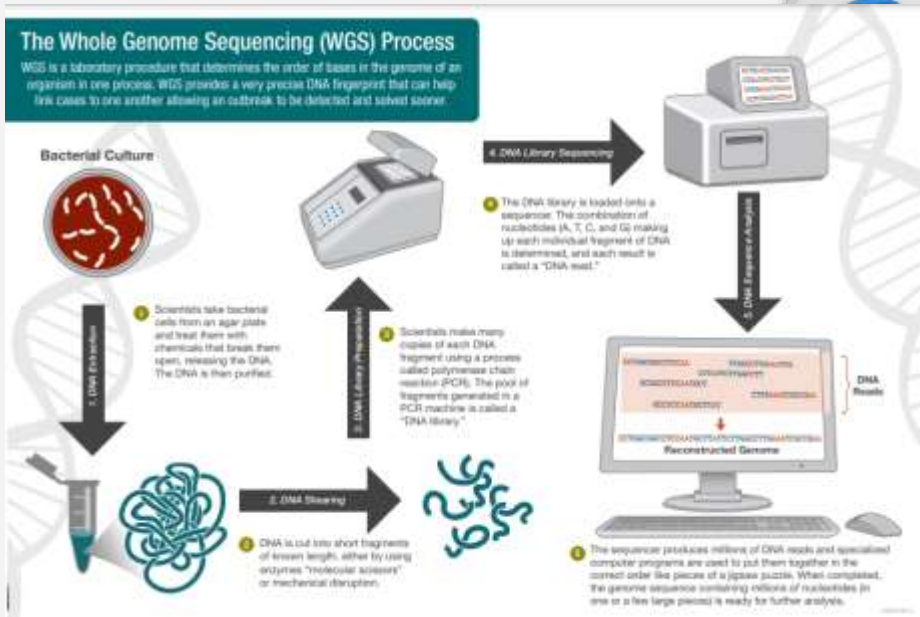
https://www.cdc.gov/salmonella/typhimurium/pfge_process.html#:~:text=Laboratories%20use%20high%2Dtech%20equipment,fingerprints%20just%20like%20people%20do.

Whole Genome Sequencing (WGS)

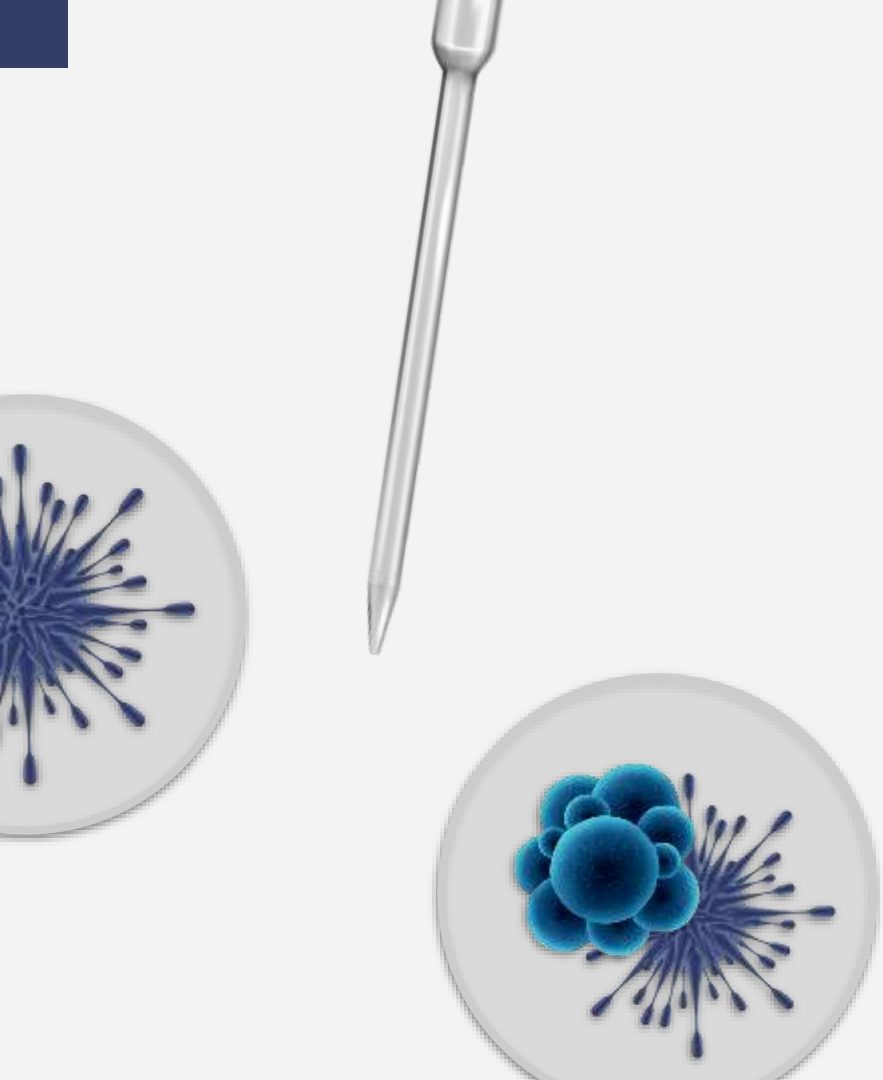
- All organisms (bacteria, vegetable, mammal) have a unique genome composed of nucleotide bases (A, T, C, and G)
- If you know the sequence of the bases in an organism, you have identified its unique DNA fingerprint, or pattern.
- Determining the order of bases is called sequencing.
- WGS is a laboratory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



Typically performed by state lab & can help identify the source of an outbreak!



Bottom line:
As the facility IP, you need to understand what methods are used in YOUR lab.

If reference labs are used, know who to contact for these 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 IC concern because can pass to different bacteria & can spread person to person.**

Example: Gram Negative Bacteria with Intrinsic Resistance

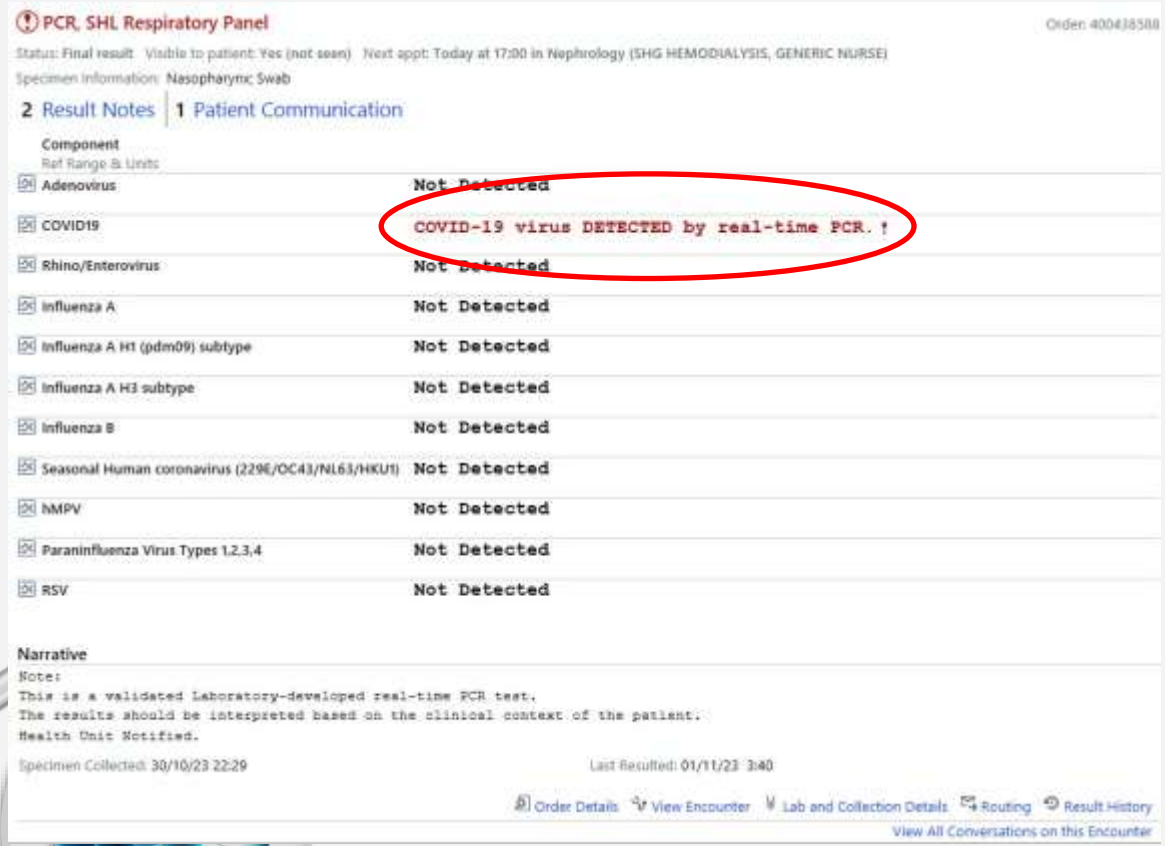
MIML240 APPENDIX B- LIST OF ORGANISMS WITH INTRINSIC RESISTANCE

GRAM NEGATIVE BACILLI

Organism \ Antibiotic	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				

Sample Microbiology Reports...

Lab Result #1



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

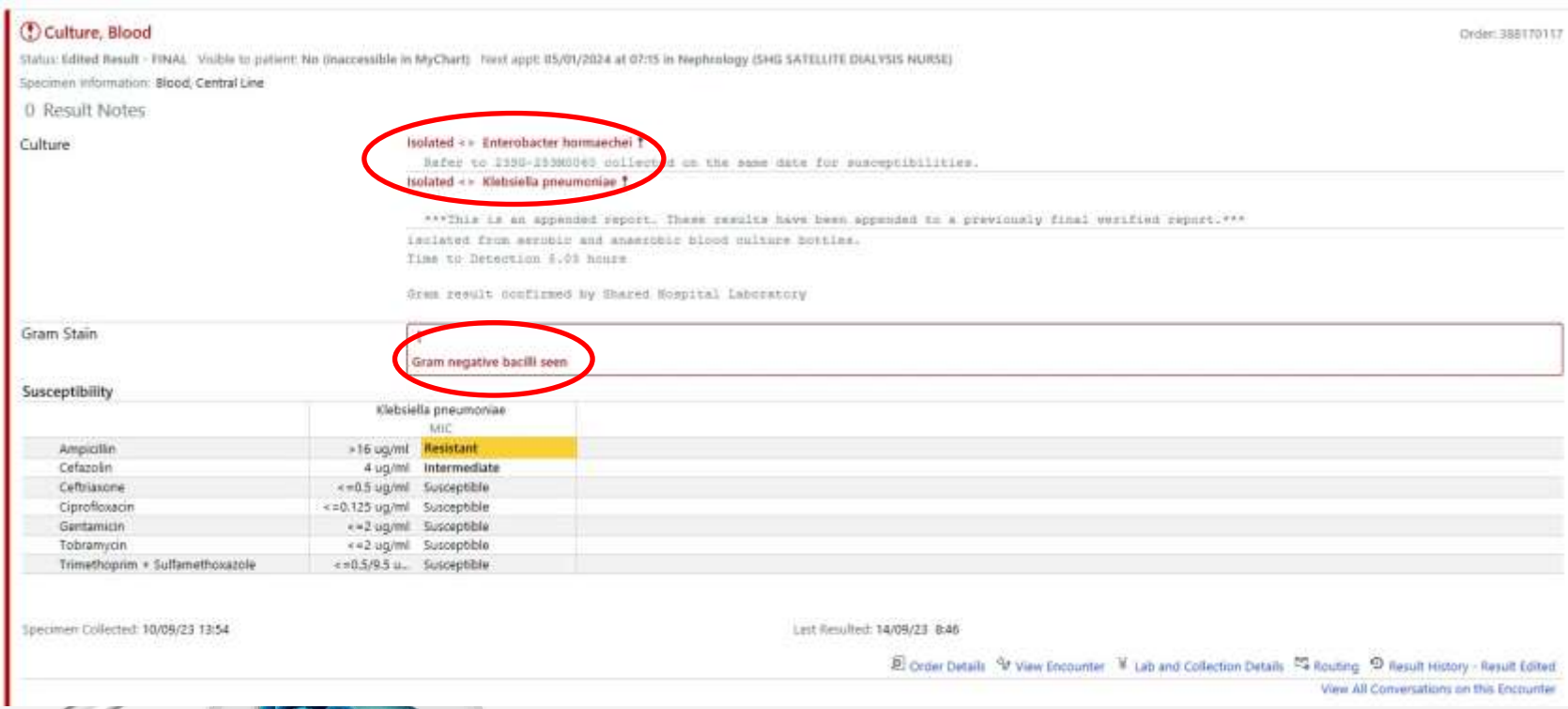
Note:
This is a validated Laboratory-developed real-time PCR test.
The results should be interpreted based on the clinical context of the patient.
Health Unit Notified.

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 #2



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 2350-25380060 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 8.05 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 #3

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 #4

Culture, Wound, Deep/Subcutaneous

Order: 413847000

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 †
Erythromycin	>4 ug/ml	Resistant
Oxacillin	0.5 ug/ml	Susceptible
Trimethoprim + Sulfamethoxazole	<=0.5/9.5 u...	Susceptible

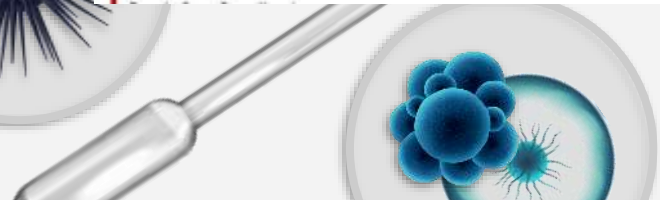
† ***This is an appended report. These results have been appended to a previously preliminary verified report.***

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 #5

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 [1] [illegible] & 12.11] Hours

Isolated from Anaerobic and Aerobic Blood Culture Bottles

Gram result confirmed by Shared Hospital Laboratory

Gram Stain

*

Gram negative bacilli seen

Susceptibility

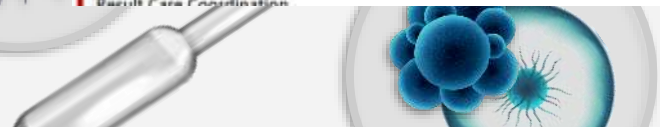
	Raoultella ornithinolytica MIC	
Ampicillin	16 ug/ml	Resistant
Cefazolin	<=2 ug/ml	Susceptible
Ciprofloxacin	<=0.125 ug/ml	Susceptible
Gentamicin	<=2 ug/ml	Susceptible
Tobramycin	<=2 ug/ml	Susceptible
Trimethoprim + Sulfamethoxazole	<=0.5/9.5 u...	Susceptible

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

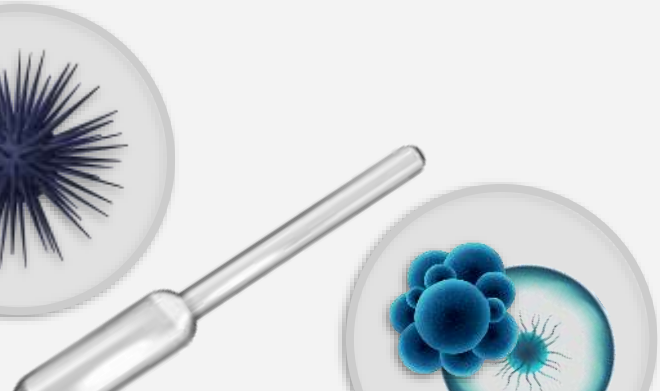
Global Top 10 Organisms Causing

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

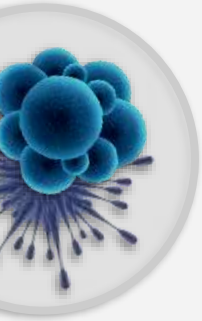


Pathogen	# Pathogens	% Pathogens	Rank
Escherichia coli	73,556	16.2	1
Staphylococcus aureus	51,131	11.3	2
Enterococcus faecalis[2]	39,129	8.6	3
Select *Klebsiella* spp.	38,496	8.5	4
Pseudomonas aeruginosa	36,004	7.9	5
Coagulase-negative staphylococci	32,276	7.1	6
Enterobacter spp.	18,431	4.1	7
Enterococcus 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

CDC: Diseases and Organisms in Healthcare

Acinetobacter	Influenza
Burkholderia cepacia	*Klebsiella*
Candida auris	Methicillin-resistant *Staphylococcus aureus* (MRSA)
Clostridioides difficile	Nontuberculous Mycobacteria (NTM)
Clostridium Sordellii	Norovirus
Enterobacterales (carbapenem-resistance)	*Pseudomonas aeruginosa*
ESBL-producing Enterobacterales	*Staphylococcus aureus*
Gram-negative bacteria	Tuberculosis (TB)
Hepatitis	Vancomycin-intermediate *Staphylococcus aureus* and Vancomycin-resistant *Staphylococcus aureus*
Human Immunodeficiency Virus (HIV/AIDS)	Vancomycin-resistant Enterococci (VRE)



https://www.cdc.gov/hai/organisms/organisms.html

Antimicrobial Resistant Bacteria & Fungi

COVID-19 Impacts on

18 Antimicrobial-Resistant Bacteria and Fungi

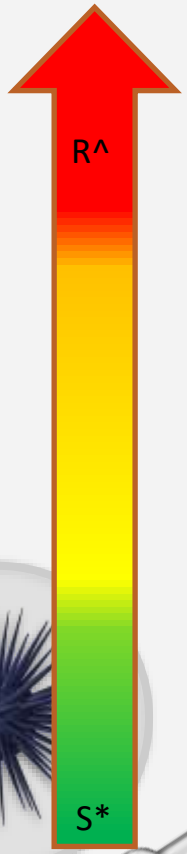
Threat Estimates

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.

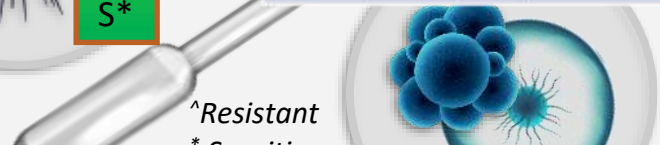
	Resistant Pathogen	2017 Threat Estimate	2018 Threat Estimate	2019 Threat Estimate	2017-2019 Change	2020 Threat Estimate and 2019-2020 Change
URGENT	Carbapenem-resistant *Acinetobacter*	8,500 cases 700 deaths	6,300 cases 500 deaths	6,000 cases 500 deaths	Stable*	7,500 cases 700 deaths **Overall: 35% increase*** **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

Effect of Disinfectants on Microorganisms



Organism	Type	Examples
Bacterial Spores	Spore	*Bacillus anthracis, Clostridioides difficile*
Mycobacteria	Bacteria	*M. tuberculosis*
Small non-enveloped virus	Virus	Norovirus, Rhinovirus, HAV
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, Coronavirus



^*Resistant*

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

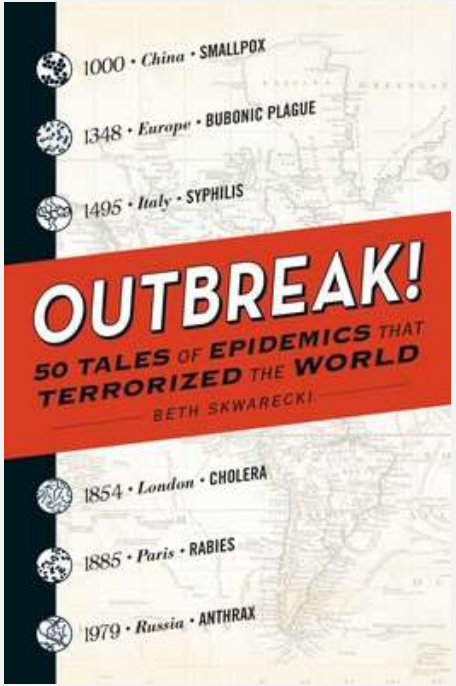
Candida auris

Clostridioides difficile

https://www.cdc.gov/hai/organisms/organisms.html

Role of the Lab During Outbreak Investigation

- Assist in the identification of an outbreak by confirming organism identities, recognizing organism clusters, detecting unusual organisms and reviewing antimicrobial susceptibility patterns.
- Retrieve and review archival data to determine background 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.
- IP should work closely with the laboratory team, especially when planning for a potential outbreak.
- May be part of an interdisciplinary outbreak response team



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

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

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, denoting that 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.

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

Recent Examples

Ongoing avian influenza outbreaks in animals pose risk to humans

Situation analysis and advice to countries from FAO, WHO, WOAH

12 July 2023 | Statement | Geneva/Rome/Rome | Reading time: 6 min (1743 words)

The current outbreaks of avian influenza (also called "bird flu") have caused devastation in animal populations, including poultry, wild birds, and some mammals, and harmed farmers' livelihoods and the food trade. Although largely affecting animals, these outbreaks pose ongoing risks to humans.

The Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO), and the World Organisation for Animal Health (WOAH) are urging countries to work together across sectors to save as many animals as possible and to protect people.

Avian influenza viruses normally spread among birds, but the increasing number of H5N1 avian influenza detections among mammals—which are biologically closer to humans than birds are—raises concern that the virus might adapt to infect humans more easily. In addition, some mammals may act as mixing vessels for influenza viruses, leading to the emergence of new viruses that could be more harmful to animals and humans.

Severe *Vibrio vulnificus* Infections in the United States Associated with Warming Coastal Waters

Print

HAN HEALTH ALERT NETWORK

This is an official CDC HEALTH ADVISORY

Distributed via the CDC Health Alert Network
September 01, 2023,12:30 PM ET
CDCHAN-00497

Summary

The Centers for Disease Control and Prevention (CDC) is issuing this Health Alert Network (HAN) Health Advisory to:

- Notify healthcare providers, laboratories, and public health departments about recent reports of fatal *Vibrio vulnificus* (*V. vulnificus*) infections, including wound and foodborne infections.
- Urge healthcare professionals to consider *V. vulnificus* as a possible cause of infected wounds that were exposed to coastal waters, particularly near the Gulf of Mexico or East Coast, and during periods with warmer coastal sea surface temperatures.
- Share important guidance for managing *V. vulnificus* wound infections.

Highly Pathogenic Avian Influenza A(H5N1) Virus: Identification of Human Infection and Recommendations for Investigations and Response

Print

HAN HEALTH ALERT NETWORK

This is an official CDC HEALTH ADVISORY

Distributed via the CDC Health Alert Network
April 05, 2024, 01:30 PM ET
CDCHAN-00506

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

Print

HAN HEALTH ALERT NETWORK

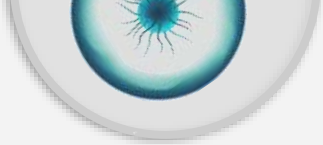
This is an official CDC HEALTH UPDATE

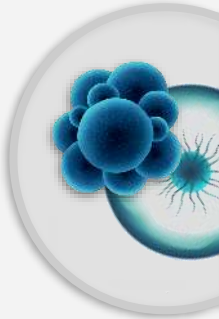
Distributed via the CDC Health Alert Network
August 28, 2023, 2:15 PM ET
CDCHAN-00496

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.

Summary





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

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/spasm.
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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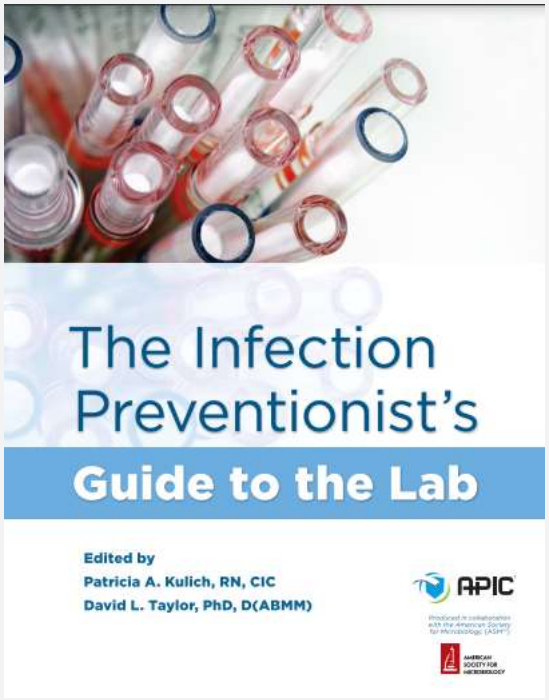
RESOURCES



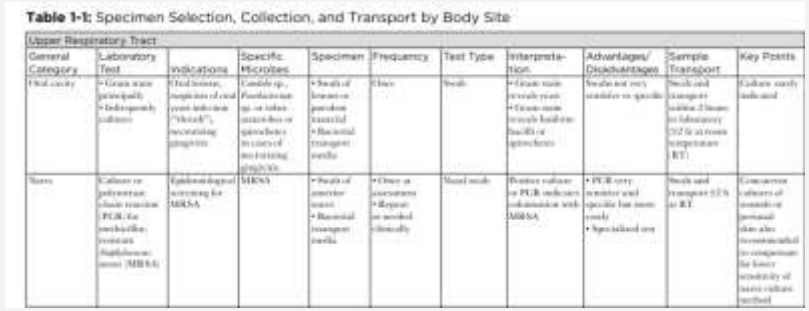


Table 1-1: Specimen Selection, Collection, and Transport by Body Site

General Category	Laboratory Test	Indications	Specific Microbes	Specimen	Frequency	Test Type	Interpretation	Advantages/ Disadvantages	Sample Transport	Key Points
Upper Respiratory Tract										
Oral cavity	• Gram stain (principally) • Infrequently cultured	Oral lesions, suspicion of viral exanthem infection ("thrush"), necrotizing gingivitis	Candida sp., Fusobacterium sp. or other anaerobes or spirochetes in cases of necrotizing gingivitis	• Swab of lesion 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 (NOT at room temperature or 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 as 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 (RT to RT)	Concurrent cultures of wounds or perineal skin also recommended to compensate for lower sensitivity of nares culture method

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My experience:
Provides very technical info that isn't necessarily

***Published in 2012**

RESOURCES

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

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Thanks!

Questions?

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