

M2-Medically Important Bacteria

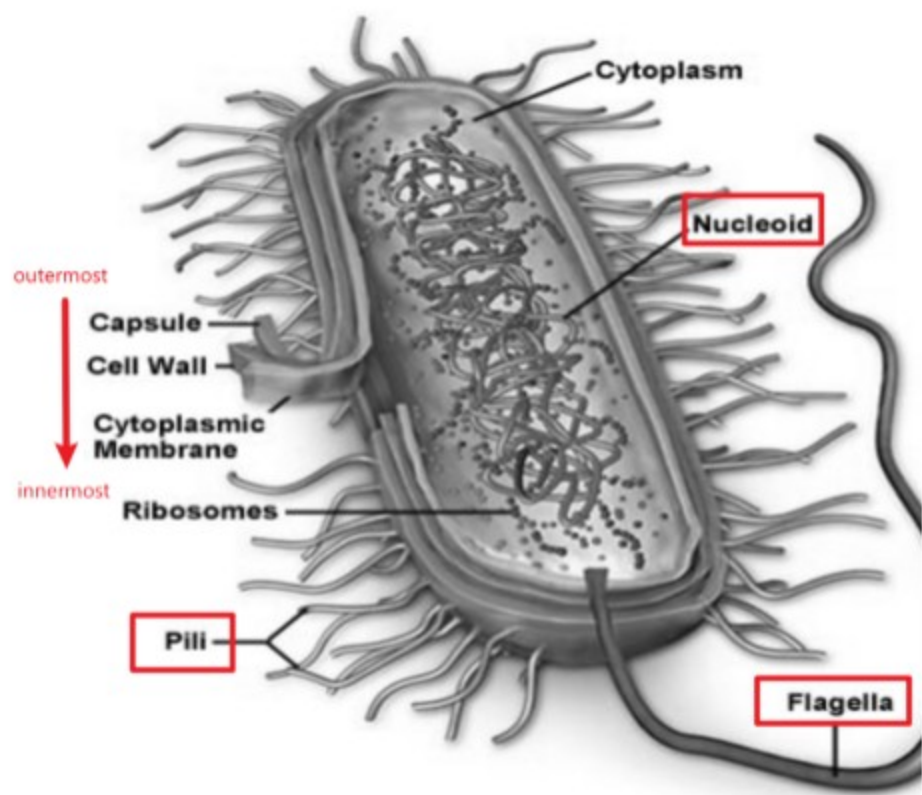
3 more properties

Learning Objective

1. Basic approaches for identification
2. Common bacterial infections and transmission routes
3. Simple classification of medically important bacteria
4. Some key examples of medically important bacteria

Identification & Classification

Some common structures of Prokaryotes



- The Capsule
 - Protects the cell by acting as a barrier that prevents water loss due to desiccation.
 - The capsule can also hide the cell's surface antigens, preventing the host's immune system from recognizing and attacking the cell.
 - The slippery surface of the capsule can inhibit phagocytosis.
- The nucleoid is the region of a prokaryotic cell where the genetic material is located.
 - It is not surrounded by a membrane.
 - It contains a single, circular chromosome that contains all of the necessary genetic information for the cell
 - It may also contains extrachromosomal elements (Plasmid)
 - [M1-Introduction to Microbiology - Plasmids](#)
- Pili are hair-like structures that extend out from the surface of some prokaryotic cells.
 - They are involved in processes such as adherence to surfaces and conjugation, which is the transfer of genetic material between cells.
- Flagella are whip-like structures that extend out from the surface of some prokaryotic cells.
 - They are involved in processes such as movement and chemotaxis
 - ▶ Addition: Chemotaxis

Bacterial Identification

1. Colony morphology
 - Colony morphology is the visual appearance of the colonies formed by a bacterial species on an agar plate.
 - The size, shape, color, and texture of the colonies can provide important information about the bacterial species.
 - Some examples of colony morphology features that can be used for identification include:
 - Colony shape: circular, irregular, filamentous, etc.
 - Colony margin: entire, undulate, lobate, filamentous, etc.
 - Colony elevation: flat, raised, convex, pulvinate, umbonate, etc.
 - Colony texture: smooth, rough, mucoid, dry, etc.
 - Colony color: white, yellow, red, blue, etc.
 - ▶ Chinese Translation
2. Requirements for Oxygen
 - Aerobic
 - Anaerobic (厭氧)
3. Cell shape, size & Structure

Some common shape of bacteria will be mentioned below: ¶ Intro to some medically important bacteria.

There are also some special structure:

 - Endospore
 - Origin: Greek, endo- meaning "within" and spora meaning "seed"
 - 中文翻译: 芽孢
 - Flagella
 - Origin: Latin, meaning "whip"
 - 中文翻译: 鞭毛
4. Cell Arrangement

There are some common cell arrangement, including

 - in pair,
 - form chains, and
 - hypha [菌絲]

Kenny Wong Aug 25 (edited)

這與Cell Shape, Size & Structure 并不相同，這強調的是細菌如何聚落在一起，聚落在一起的特色是什麼。

Take streptococci pneumoniae as an example. 'strepto-' means a chain of ... more

5. Staining Reaction

▼ Gram stain

- Gram staining differentiates bacterial species based on the composition of their cell walls.
- Gram-positive bacteria have a thick layer of peptidoglycan : [Polysaccharides + Protein] (about 30-100 nm) in their cell walls, which stains purple when exposed to crystal violet dye.
 - Do notice that:
Gram-positive bacteria contains large amounts of teichoic acid (Polymer of ribitol).
- Gram-negative bacteria have a thin layer of peptidoglycan (about 20-30 nm) and an outer membrane that is not stained by crystal violet but the counterstain safranin.

▼ Acid Fast Stain

- Acid fast stain can differentiate bacterial species based on cell wall composition.
- This staining is useful for identifying Mycobacterium species with a unique cell wall structure that includes mycolic acids.
- The process involves staining bacterial cells with carbol fuchsin, which binds to mycolic acids in the cell wall.
- An acid-alcohol solution removes the stain from cells that do not have an acid-fast cell wall.
- Cells are counterstained with methylene blue or another contrasting stain.
- Acid-fast cells appear red or pink under a microscope, while non-acid-fast cells appear blue or green.

6. Chemical Content

7. Growth characteristic

- a. Nutritional requirements
- b. Physical conditions requirements for growth

8. Biochemical test - [API 20E Test]

- Measure various aspects of bacterial metabolism
 - C and N sources the bacteria can use
 - End products of their metabolic processes
 - Enzymes produce for these processes

9. Immunological test

- Antigens of the cell
- Distinctive for certain kind of microbiology

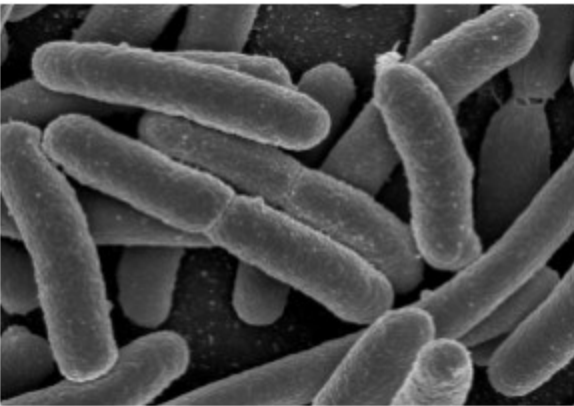
10. Genetic Test

- DNA Sequence (Homology)
- DNA base content
- Ribosomal Sequencing

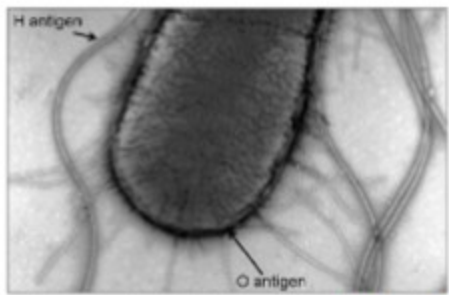
▼ Intro to some medically important bacteria

Shape	Examples
Rod-shaped (bacilli)	<i>Escherichia coli</i>
Bacilli with tapered ends (fusiform bacilli)	<i>Fusobacterium nucleatum</i>
Spherical (cocci)	<i>Stapylococcus aureus</i>
Kidney-shape cocci (vibrios)	<i>Vibrio cholerae</i>
Spiral (spirilla)	<i>Spirillum volutans</i>
Flexible spirilla (spirochaetes)	<i>Treponema pallidum</i>
Fugus-like threads (hyphae)	<i>Strptomyc ces albus</i>
Irregular (pleomorphic)	<i>Mycoplasma pneumoniae</i>
Group	
Pairs	<i>Neisseria gonorrhoeae</i>
Palisades	<i>Corynebacterium diphteriae</i>
Clusters	<i>Stapylococcus aureus</i>
Chains	<i>Streptococci pneumoniae</i>

| Escherichia Coli [Rod-shaped / Bacilli]

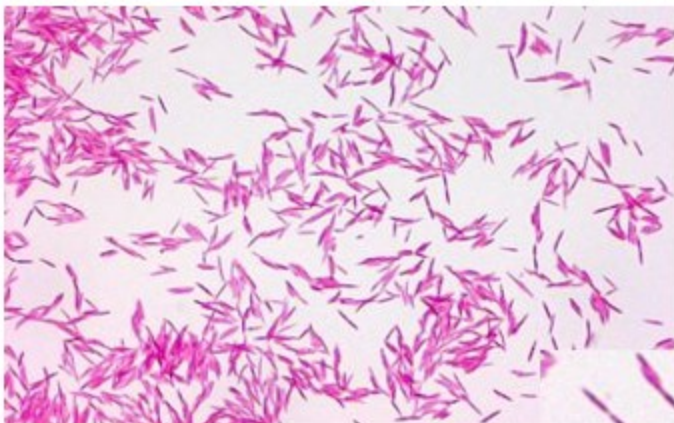


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H antigen
E. coli O157 H7
o antigen

| Fusobacterium nucleatum [Bacilli with tapered ends / fusiform bacilli]



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Es_che_ri_chia coli [Rod-shaped, Bacilli]

- where coli comes from Latin word "Colon"

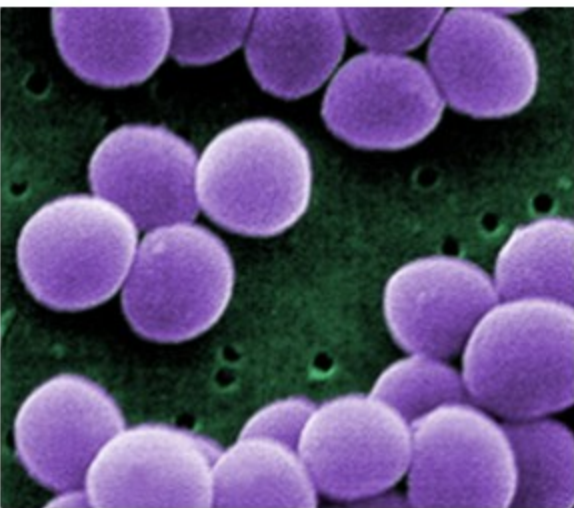
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Fuso_bacterium nucleatum [Oral bacterium]

- where Fuso means "spindle" in English.
(Origin: Latin "fusus", Chinese "纺锤形")

- where nucleatum means "appearin; ... more

Staphylococcus aureus [Spherical / cocci]



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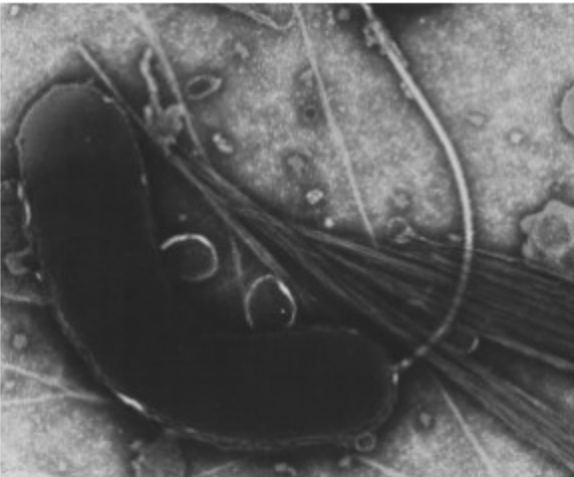
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Staphylo_coccus aureus

"Staphylo-" means **grape-like clusters**
"-coccus" means **berry**

"aureus" means **golden**

Vibrio cholerae [Kidney shape cocci / vibrio]
- 霍乱弧菌

► Disease - Asiatic Cholera



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Vibrio cho_le_rae

Vibrio means "vibrate"
cholerae means "bile/gastrointestinal fluid"

Which means leading to "severe diarrhea"

Spirillum volutans [Spiral / Spirilla]
- 革兰氏阴性细菌

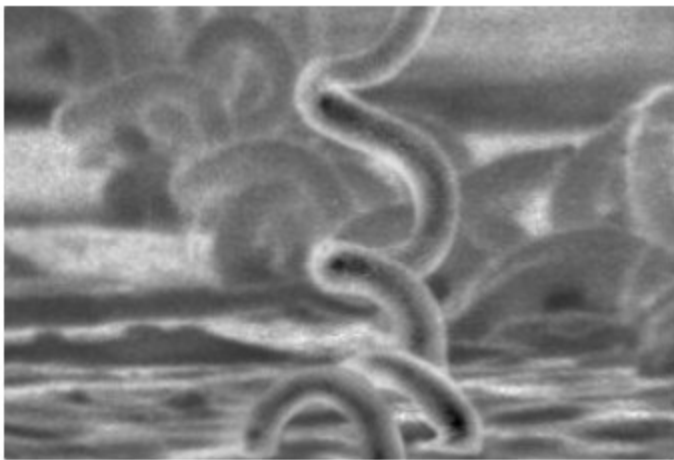


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Spirillum volutans
- *Spirillum* means "coil". It refers to the **spiral shape** of this bacterium.
- *Volutans* means "**to roll**".

Treponema pallidum [Flexible spirilla / Spirochaetes]
- 梅毒螺旋菌



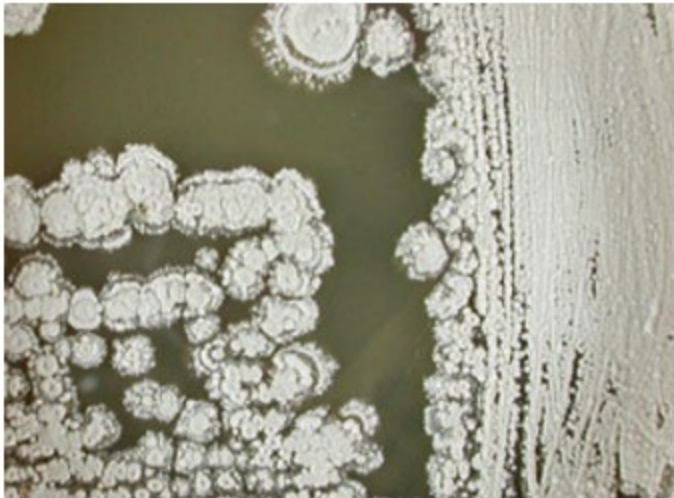
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Spirochaetes shape
"Spiro-" means **spiral**
"-chaetes" means **hair**

Treponema pallidum (梅毒螺旋菌)
- "*Trepa*-" means **turn...** ... more

Streptomyces albus [Fungus-like threads / hyphae]
- 白色链霉菌



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- "*Streptos*-" means **twisted**
- "-*mykes*" means **fungus**
- "*albus*" means **white**

Mycoplasma pneumoniae [Irregular / pleomorphic]
- 肺炎肺炎菌

▼ Additional Information related to Pleomorphic bacteria

The term 'pleomorphic' does come from Latin roots. It breaks down as:

Pleo- = from the Greek root 'pleion' meaning '**more**'

-Morph = from Greek morphē meaning '**form**'

-Ic = a Latin suffix denoting "**having the nature of**"

So **pleomorphic means "having many forms"**. It refers to bacteria that can assume multiple shapes or growth patterns.

Some key points about pleomorphic bacteria:

- They are able to **transition between different forms including cocci, bacilli, and spirals.**
- This ability to **alter shape is related to stages of their growth cycle.**
- Their pleomorphism is facilitated by the **lack of a rigid cell wall.**
- Some examples are Mycoplasma and Spirillum.

So in summary, the term pleomorphic derives from Greek and Latin roots 'pleion' and 'morphē' meaning many forms. It is an apt descriptor for bacteria that can assume a variety of shapes due to their flexible cell structure. The etymology reflects the defining trait.



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"Mycos-" originate from "*mykes*" which means **fungus**
"-*plasma*" means **formed or molded** refers to "lack of cell wall"

"Pneumon-" means **lung...** ... more

Streptococci pneumoniae
- 肺炎链球菌

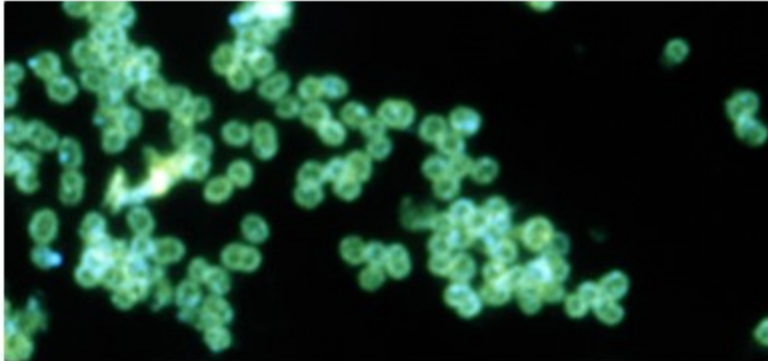


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"*Strepto*-" means **twisted**
"-*cocci*" means **berries**
Thus, "Streptococci" is **chained, spherical bacteria**

Neisseria gonorrhoeae
- 淋病双球菌 (性傳染病)



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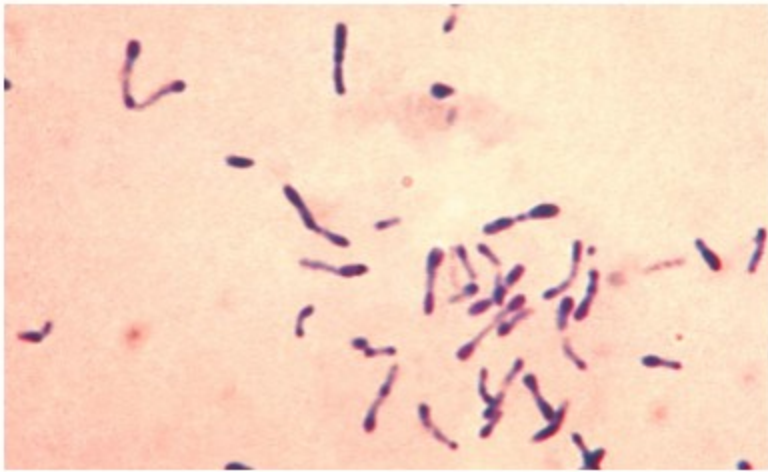
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- Neisseria is named after Albert Neisser

- Gonorrhoeae comes from :
"Gonos" meaning seed, and
"rhoia" meaning flow.
Together they refer to the discharge / ... more

Corynebacterium diphtheriae
- 白喉杆菌

► Additional knowledge to leathery pseudomembrane



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Corynebacterium Diphtheriae

'Coryne-' means club, describing the club-like shape of the bacteria

'Diphtheriae' is from Greek 'diphtheri' / ... more

Some Medically Important Bacteria

Medically important bacteria

Bacterial pathogen	Disease(s)	Transmission
Gram-negative bacteria		
Coliforms (e.g. E. coli, Enterobacter)	Gastroenteritis, urinary tract infections, neonatal meningitis	F W E
Salmonella enterica	Gastroenteritis	F W
Salmonella typhi	Typhoid fever	F W
Shigella dysenteriae	Bacillary dysentery	F W
Yersina pestis	Bubonic plague	IV
Pseudomonas aeruginosa	Opportunistic infections, swimmer's ear, hot tub itch, cellulitis, pneumonia, more	S W C HA E
Vibrio cholerae	Asiatic cholera	W
Bordetella pertussis	Whooping cough	RC
Haemophilus influenzae	Meningitis, pneumonia, sinusitis	RC
Helicobacter pylori	Gastric and duodenal ulcers	F?
Campylobacter jejuni	Gastroenteritis	F W
Neisseria gonorrhoeae	Gonorrhea	S C
Neisseria meningitidis	Meningococemia and meningitis	R C E
Brucella abortus	Undulant fever	IA M
Bacteroides fragilis	Anaerobic infections	E
Gram-positive bacteria		
Staphylococcus aureus	Food poisoning, wound infections, toxic shock syndrome, more	F C E HA IA
Streptococcus pyogenes (Group A strep)	Strep throat, scarlet fever, mastitis, necrotizing fasciitis, more	C
Streptococcus pneumoniae	Pneumonia, otitis media, meningitis	RC E
Bacillus anthracis	Anthrax	S IA
Bacillus cereus	Food poisoning	F
Clostridium tetani	Tetanus	S
Clostridium perfringens	Food poisoning, gas gangrene, uterine infections	F S E
Clostridium botulinum	Botulism, infant botulism	F
Clostridium difficile	Antibiotic-associated diarrhea, pseudomembranous colitis	C HA E
Corynebacterium diphtheriae	Diphtheria	RC
Listeria monocytogenes	Listeriosis	F
Not typed by Gram stain		
Mycobacterium tuberculosis	TB (tuberculosis)	RC M
Mycobacterium leprae	Leprosy	C
Chlamydia trachomatis	Chlamydia, lymphogranuloma venereum, trachoma	SC C
Chlamydia pneumoniae	Pneumonia	RC
Mycoplasma pneumoniae	Atypical pneumonia	RC
Rickettsias	Rickettsiosis: typhus, RMSF	IV
Treponema pallidum	Syphilis	SC
Borrelia burgdorferi	Lyme disease	IV

KEY TO TRANSMISSION.

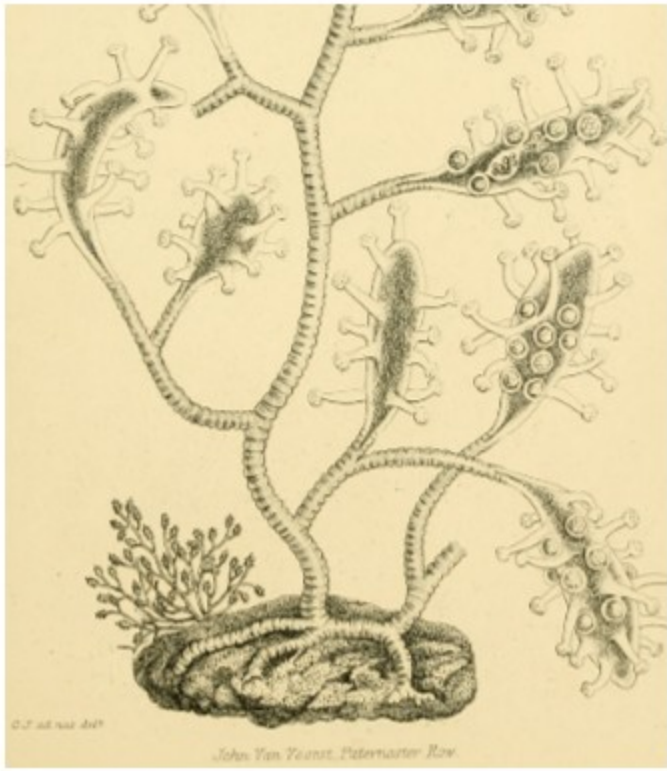
C = Contact
E = Endogenous
F = Food borne
HA = Hospital Acquired
IA = Infected Animal
IV = Insect Vector
M = Milk
RC = Respiratory Contact
SC = Sexual Contact
S = Soil
W = Water

► Gram-Negative

▼ Gram-Positive

- Staphylococcus aureus
- Streptococcus pyogenes (Group A strep)
 - "Pyogenes" is derived from the Greek word "pyon" meaning "pus" and "genes" meaning "producing". Therefore, Streptococcus pyogenes is a bacteria that produces pus (膿) .
- Streptococcus pneumoniae
- Bacillus anthracis
 - The word "anthracis" in Bacillus anthracis refers to the **disease anthrax (炭疽病)**, which is caused by this bacterium.
- Bacillus cereus
 - The origin of the name "cereus" is actually from Latin. It means "wax-like", likely in reference to the bacterium's ability to produce **spores (孢子)** that have a **shiny, wax-like appearance**.
- Clostridium tetani
 - "Clostridium" means spindle.
 - "Tetani" means "stiff". This is a reference to the characteristic muscle stiffness that occurs in individuals infected with Clostridium tetani, the bacterium responsible for causing **tetanus (破傷風)**.
- Clostridium perfringens
 - "perfringens" means "to penetrate." This name was chosen due to the bacterium's ability to **produce various enzymes and toxins** that can **break down and destroy tissues in the body**.
- Clostridium botulinum (肉毒桿菌)
 - Botulinum** is named after the Latin word "**botulus**", which means sausage. This is because the bacterium was first identified as the cause of contaminated sausages.
- Clostridium difficile
 - Clostridium difficile is named after its ability to be **difficult to culture in the laboratory**. The word "difficile" is derived from the Latin word "difficilis," which means "difficult".

- ▼ Corynebacterium diphtheriae



- Diphtheriae (白喉)
- "Coryne-" comes from the Greek "koryne", meaning club-shaped, and the Latin "bacterium", meaning small staff.

- ▼ Listeria monocytogenes

- Causing Listeriosis

▼ Not typed by Gram stain

- ▼ Mycobacterium tuberculosis

- Mycobacterium tuberculosis is non-free living bacteria.

- ▼ Mycobacterium leprae

- Causing Leprosy (麻瘋)

- ▼ Chlamydia trachomatis (沙眼衣原体)

- 沙眼衣原体是一种绝对寄生病原体，披衣菌是一种在构造上介于细菌和病毒之间的微生物。
- Causing Chlamydia, lymphogranuloma venereum, trachoma

- 引起沙眼衣原体感染，淋巴肉芽肿性淋巴管炎，沙眼

- ▼ More about Chlamydia Bacteria

- Obligate intracellular pathogens
- No cell wall

- Chlamydia pneumoniae

- ▼ Mycoplasma pneumoniae

- Causing Atypical pneumonia

- ▼ Rickettsias - Bacilli or Coccus Shape

- Rickettsias are parasitic bacteria that live in arthropods (ticks and mites)→ replicate inside of host cells.
- Obligate intracellular parasites
- Cause Rocky Mountain spotted fever, typhus

- ▼ Treponema pallidum

- Treponema pallidum is a type of bacteria that causes syphilis, a sexually transmitted infection.
- Treponema pallidum is named for its spiral shape (treponema means "spiral body" in Greek) and its ability to cause a pale (pallid) rash on the skin, which is a characteristic symptom of syphilis.

- ▼ Borrelia burgdorferi

- Causing Lyme disease, through Insect Vector

▼ Staphylococcus spp.

β -hemolytic	α -hemolytic	γ -hemolytic
clear, complete hemolysis	green, partial hemolysis	no hemolysis

Characteristics:

- clustered
- gram-positive (with thick cell wall)
- beta-hemolytic (beta-血溶性) bacteria.
- >80% of CoNS and SA has Methicillin

There are two groups of Staphylococci, which is classified by Coagulase Test:

- CoNS (Coagulase-negative Staph):
 - More than 30 Species, 15 of them are pathogens
- CoPS (Coagulase-positive Staph):
 - One Species: Staphylococcus aureus (SA), with Methicillin resistance is MRSA
 - Enterotoxins (肠毒素)
 - Epidermolytic toxins (Toxins that affect epidermis)
 - Toxic shock syndrome toxin

💡 The coagulase test is one way to differentiate the highly pathogenic S. aureus from the other less pathogenic staphylococcal species on the human body.

▼ Streptococcus spp.

Characteristic:

- Gram Positives
- Facultative anarobes (兼性厌氧菌)
 - Facultative anaerobes can survive and grow in both aerobic and anaerobic environments.
 - They can switch between using oxygen for energy (aerobic respiration) and using other molecules or fermentation to produce energy in the absence of oxygen.
- Can be divided into serological groups of A-V
- Commonly found as commensal species in the upper respiratory tract (常见于上呼吸道的共生物种)
- Asymptomatic carrier status (无症状携带者状态)
- Able to produce a range of toxins (especially: Streptococcus pyogenes - 化脓性链球菌)

Type of hemolysis on blood agar:

- α -hemolytic (green, partial hemolysis):
 - Pneumoniae
 - Optochin sensitives
 - Have Capsule
 - Viridans (Variant of Streptococcus Spp.)

- Optochin resistance
 - No Capsule
- **β-hemolytic (Complete hemolysis)**
 - pyogenes
 - Bacitracin sensitives
 - Produce a range of toxins
 - Agalactiae
 - Streptococcus agalactiae得名于其与乳腺炎的关联，**乳腺炎是乳牛的乳腺感染，会导致产奶量降低**。“Agalactiae”在希腊语中意为“无奶”。然而，它也常见于人体内，可能引起一系列感染。
 - Bacitracin resistances
- **γ-hemolytic (No hemolysis)**
 - Enterococcus

▼ Coliform Bacteria

Characteristic:

- Rod-shaped
- Gram-negative

Genra:

- Name after the scientists:
 - Citrobacter
 - Escherichia
 - Hafnia
 - Klebsiella
 - Serratia
- Enterobacter

Infections:

- GI Infection
- Urinary tract infection
- Nosocomial infection (医院感染)

▼ Salmonella & Shigella

Characteristic:

- Bacilli
- Gram Negative
- Facultative anaerobes
- Causing GE, Enteric Fever (Typhoid Fever), and dysentery (only for shigella, 痢疾)

Salmonella:

- Only 2 Species but with >2000 variants differentiated by surface antigens (serovars)
 - Salmonella enterica
 - Salmonella bongori

Shigella:

- Very low infective dose
- Produce **Potent Shiga toxins** and other enterotoxins

▼ Campylobacter & Helicobacter

Characteristic:

- Gram Negative
- Twist (Campylobacter @ Poultry), Curved/Spiral (Helicobacter @ Human reservoirs)

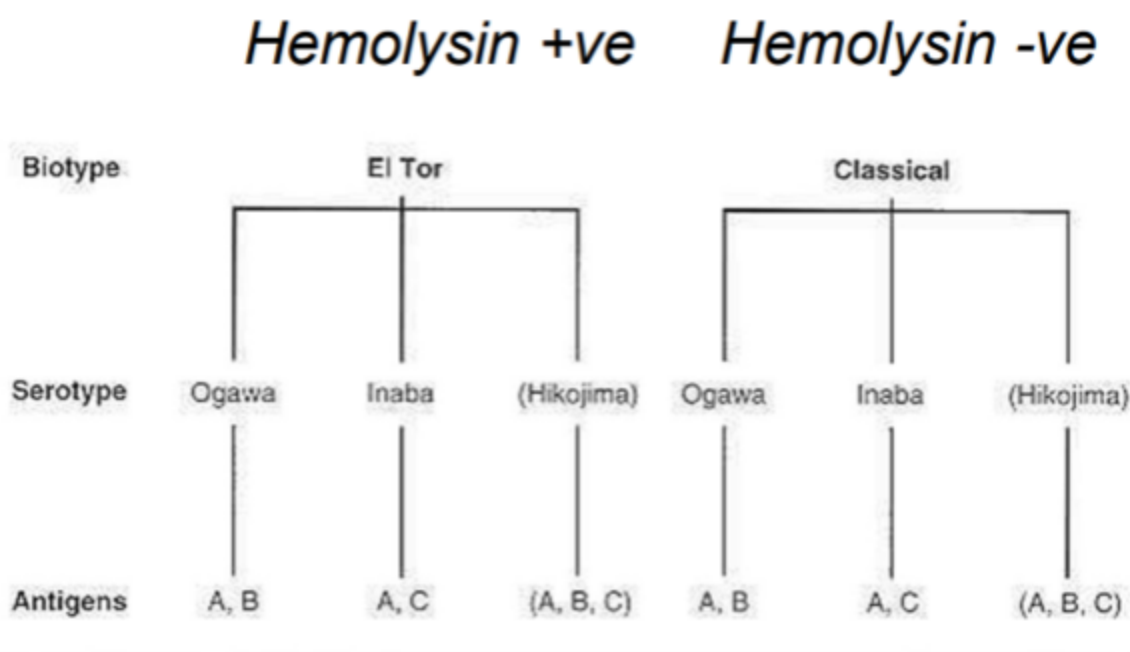
Campylobacter:

- Aerobic
- Examples: Campylobacter jejuni, Campylobacter coli → Acute GE & Guillain-Barre syndrome

Helicobacter pyloric:

- Chronic superficial gastritis
- Peptic Ulcer diseases

▼ Vibrio spp.



Characteristic:

- Gram Negative
- Transmission: Oral Facal, Wound Infection
- Enterotoxins produced to give large watery diarrhea
- 2 Main serogroups:
- O-1
 - By phenotypic traits (Hemolysis)
 - +VE: El Tor
 - -VE: Classic
 - By Antigenic markers:
 - Ogawa
 - Inaba
- O-139

▼ Neisseriaceae

Characteristic:

- Gram Negative
- Genera:
 - Neisseria
 - Moraxella
 - Kingella
 - Eikenella
- Commonly Found:
 - Neisseria gonorrhoeae
 - Asymptomatic
 - Neisseria meningitidis
 - Spread by droplet

▼ Bacillus & Clostridium

Characteristic:

- Gram Positives
- Facultative anaerobes
- Spore-forming and spores can survive extreme environments
- Causing: Anthrax, Tetanus, Botulism by Exotoxins

Examples:

- **Bacillus anthracis**: associated with herbivores (藥草)
- **Thermophilic Bacillus stearothermophilus**: test heat sterilization process
- Clostridia: @ small intestine

▼ Filamentous bacteria

Characteristics:

- Gram positives
- Show true branching
 - Made of Wax & Glycolipid
- Examples:
 - Nocardia
 - Mycobacterium [Different to Mycoplasma]

▼ Spirochaetes

Characteristic:

- **Thin-walled Bacteria**: Gram negative
- slender flexuous spiral filaments
- without possession of flagella (沒有鞭毛)

▼ Mycoplasma

Characteristic:

- **Wall-Less Bacteria**: Gram negative
 - Pleomorphic (多様性)
-