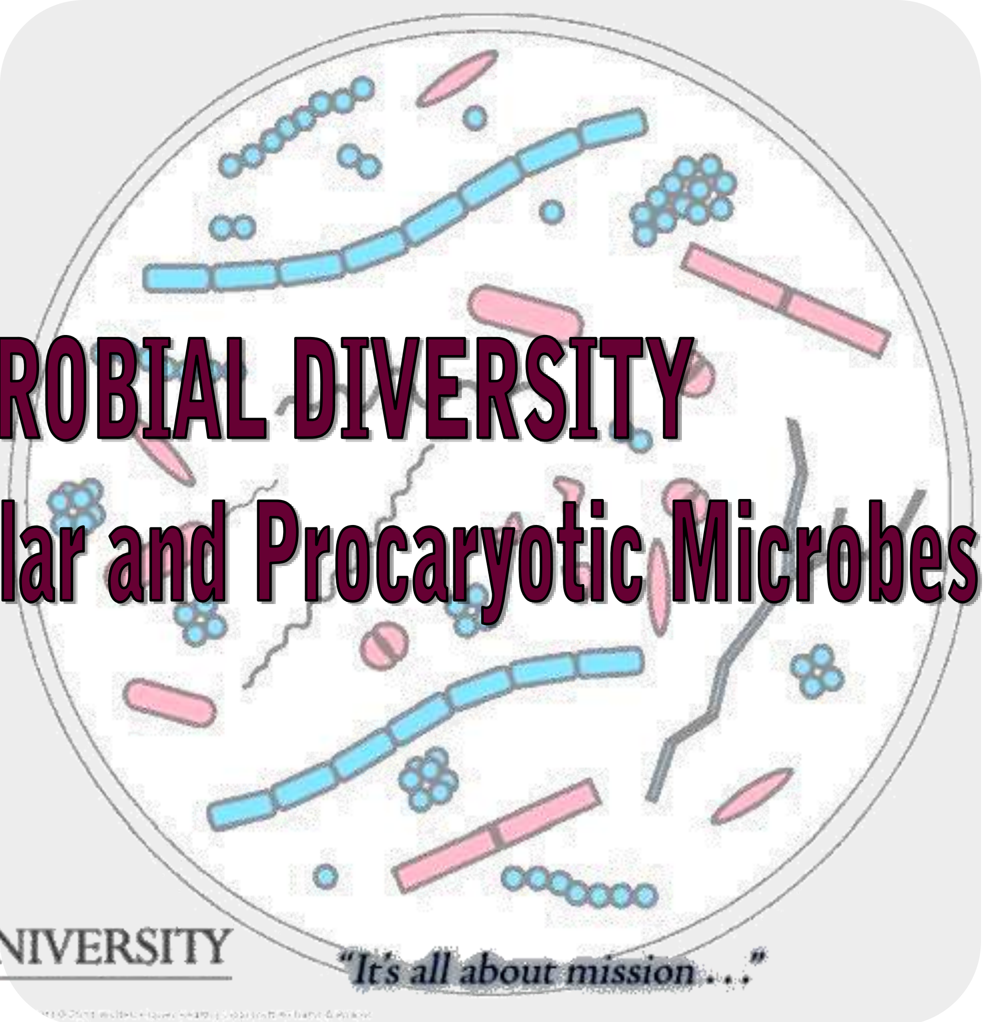
MICROBIAL DIVERSITY
Part1: Acellular and Procaryotic Microbes



MISSION, Vision, Values, & GOALS

LOMA LINDA UNIVERSITY
School of Public Health

"It's all about mission . . ."

Instructor: Bertha Escobar-Poni, MD

Chapter 4 Outline

- Introduction
- Acellular Infectious Agents
  - Viruses
  - Viroids and Prions
- The Domain *Bacteria*
  - Characteristics
  - Unique Bacteria
  - Photosynthetic Bacteria
- The Domain *Archaea*

Categories of Microorganisms

- Microbes
  1. Cellular
     1. Procaryotic [bacteria and archaea]
     2. Eucaryotic [algae, protozoa, and fungi]
  2. Acellular or infectious particles
     1. viruses, viroids, and prions

Acellular Microbes
Viruses

- Complete virus particles are called ***virions*.**
  - Most viruses are from 10 to 300 nm in diameter.
- Viruses infect humans, animals, plants, fungi, protozoa, algae and bacterial cells.
- Some viruses, called *oncogenic viruses* or *oncoviruses*, cause specific types of cancer.

Acellular Microbes
Viruses

- A typical **virion** consists of
  1. a genome of either DNA or RNA,
  2. surrounded by a *capsid* (protein coat) which is composed of protein units called *capsomeres*.
- Some viruses (*enveloped viruses*) have an *outer envelope composed of lipids and polysaccharides.*

Acellular Microbes

Properties of Viruses

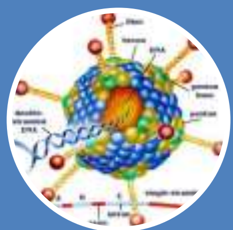
- 5 properties that distinguish them from living cells:
  1. They possess either DNA or RNA – living cells possess both.
  2. They are unable to replicate on their own.
  3. Unlike cells, they do not divide by binary fission, mitosis, or meiosis.
  4. They *lack the genes and enzymes necessary for energy production*.
  5. They depend on the ribosomes, enzymes, and metabolites of the host cell for protein and nucleic acid production.

Acellular Microbes

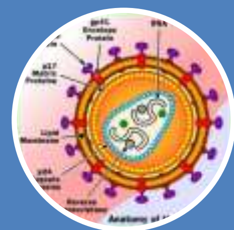
Viruses are classified by:

1. Type of ***genetic material*** (either DNA or RNA)
2. Shape and size of ***capsid***
3. Number of ***capsomeres***
4. Presence or absence of an ***envelope***
5. Type of ***host*** it infects
6. ***Disease*** it produces
7. ***Target cell(s)***
8. Immunologic/***antigenic*** properties

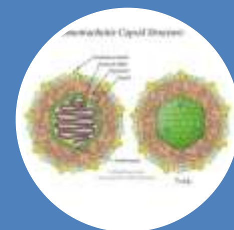
Categories of Viruses
Based on Type of Nucleic Acid



Double-stranded DNA viruses
(Adenovirus)



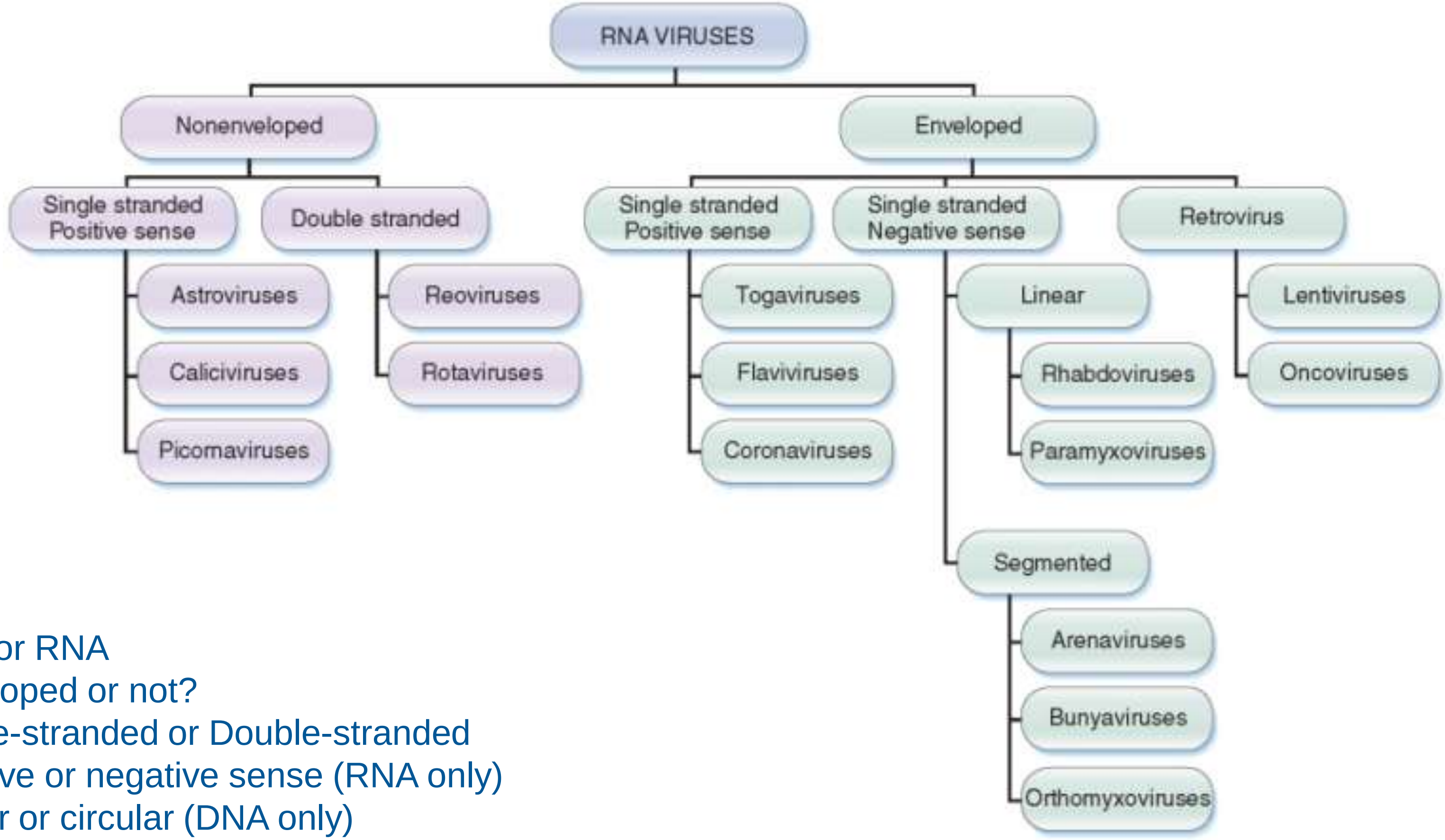
Single-stranded RNA viruses



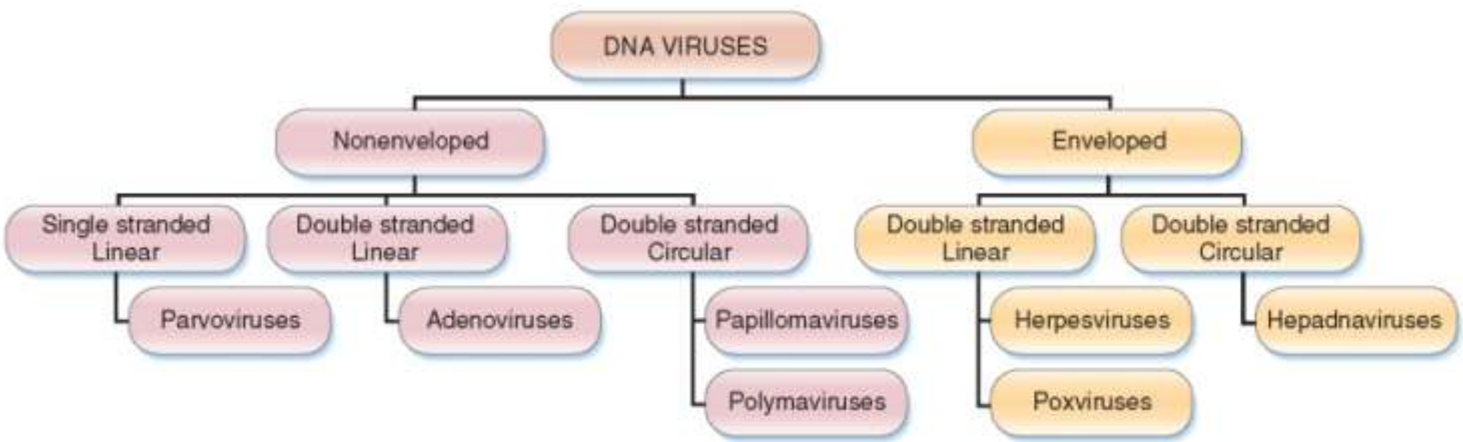
Single-stranded DNA viruses

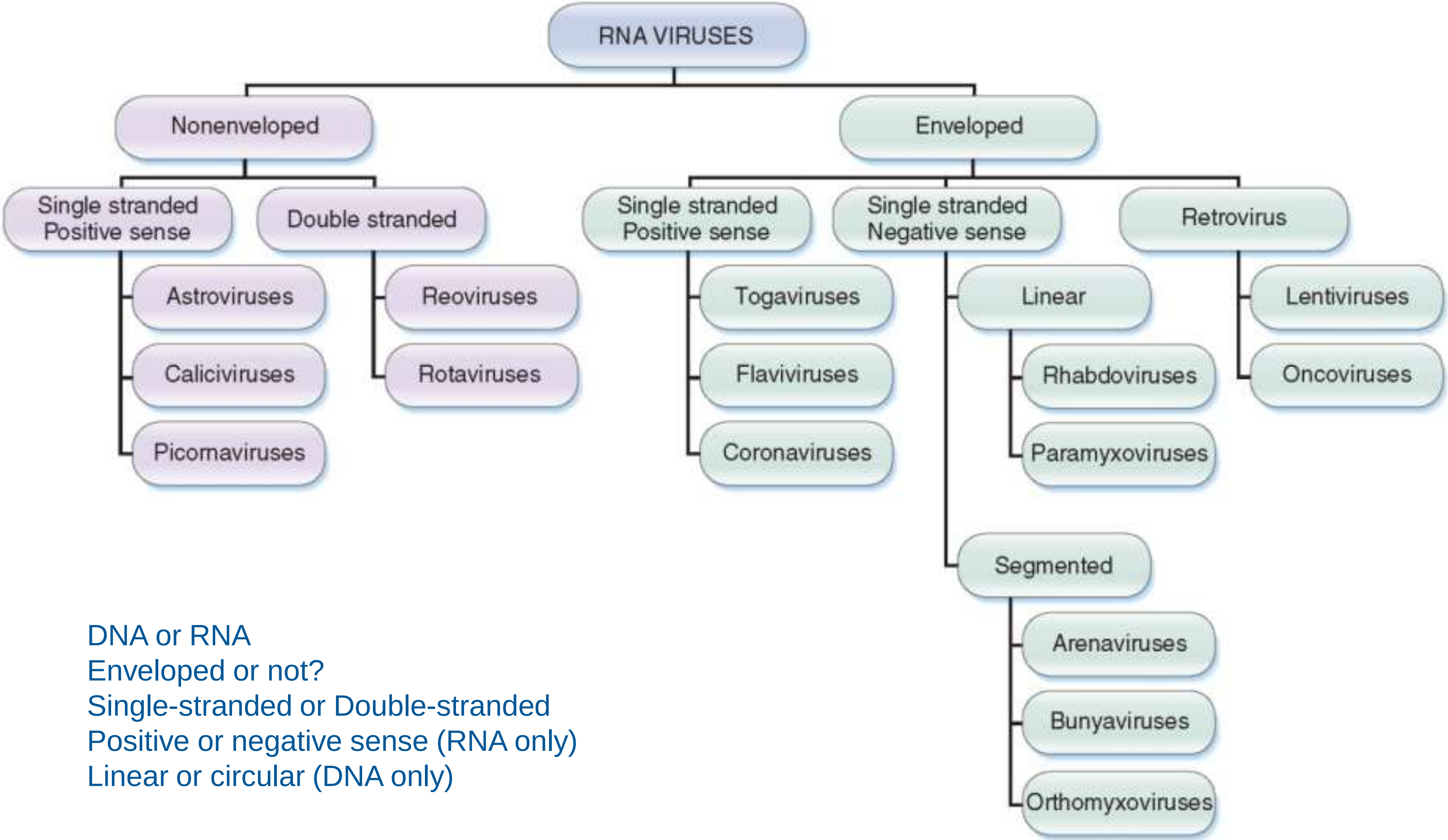
Double-stranded RNA viruses

- Most viral genomes are of the first two types.
- Most viral genomes are circular molecules, but some are linear.

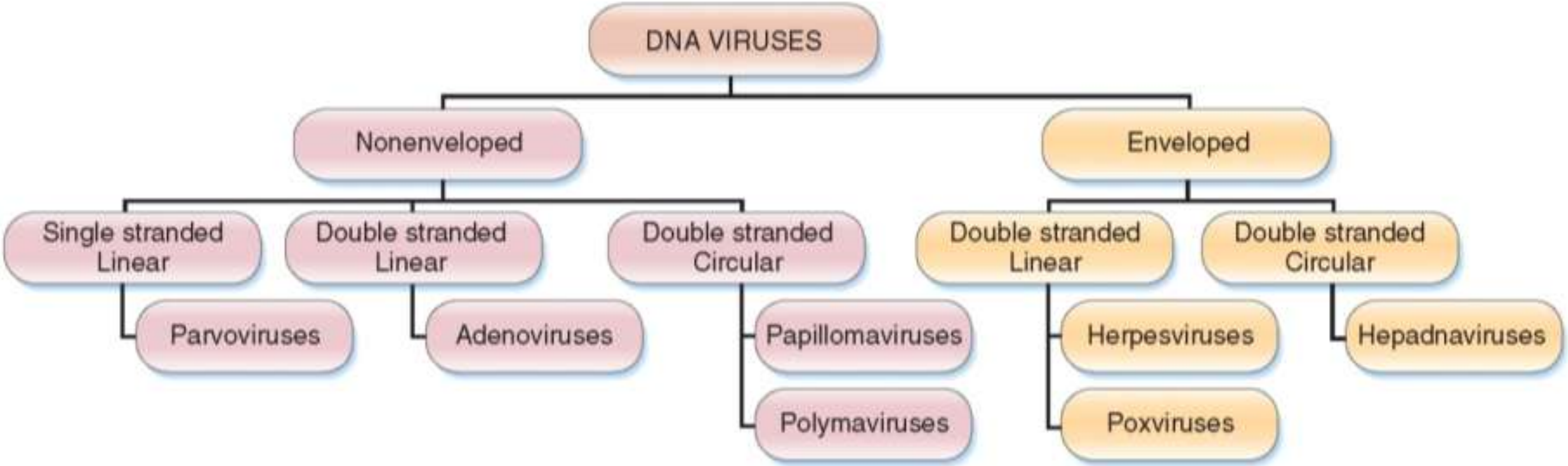


DNA or RNA
Enveloped or not?
Single-stranded or Double-stranded
Positive or negative sense (RNA only)
Linear or circular (DNA only)





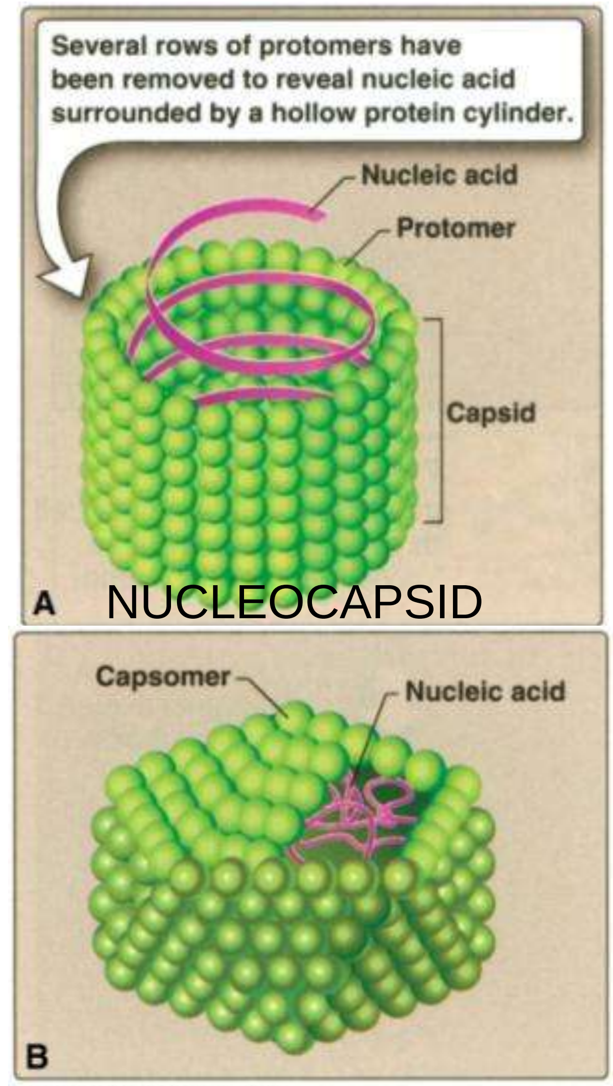
DNA or RNA
Enveloped or not?
Single-stranded or Double-stranded
Positive or negative sense (RNA only)
Linear or circular (DNA only)



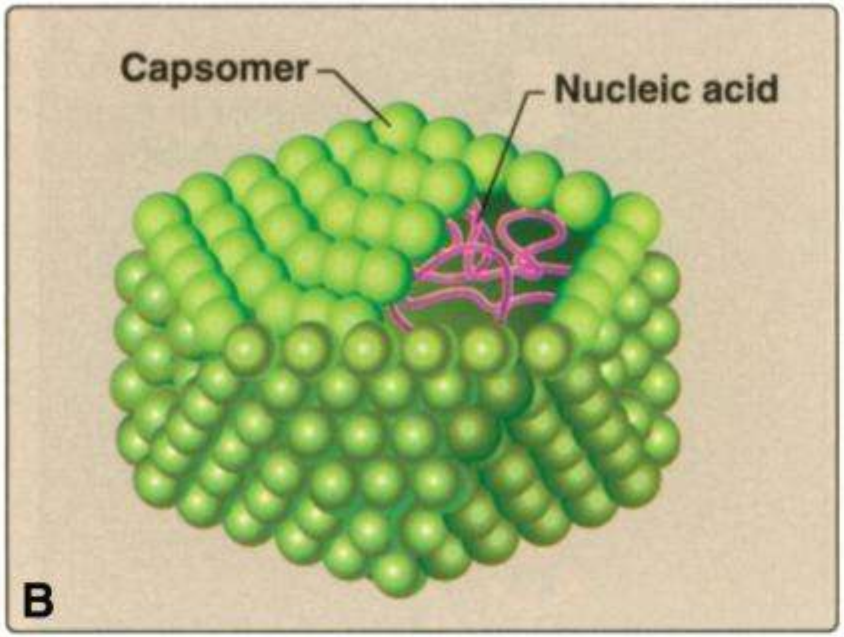
DNA or RNA
Enveloped or not?
Single-stranded or Double-stranded
Positive or negative sense (RNA only)
Linear or circular (DNA only)

CAPSIDS OF VIRUSES

- Various shapes and sizes
  - Polyhedral (many sides)
  - Helical (coiled tubes)
  - Bullet shaped,
  - Spherical
  - Complex combination
- Nucleocapsid: capsid + Nucleic acid
- The size of the virus is determined by the size of each facet and the number of capsomeres in each facet



CAPSIDS OF VIRUSES

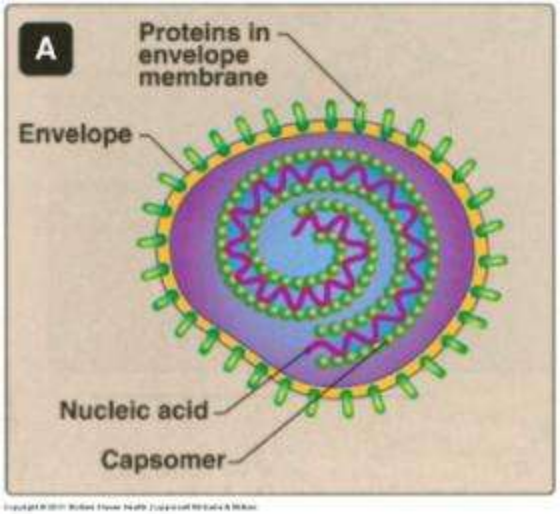


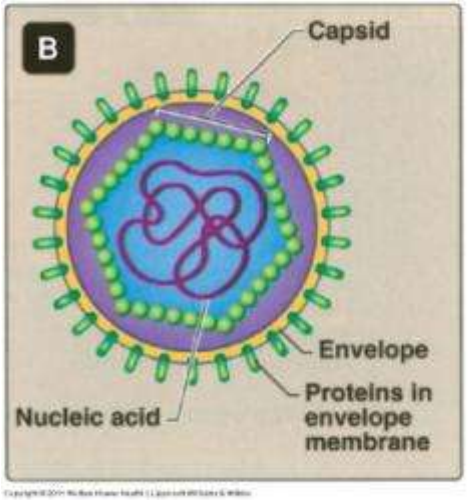
- Polyhedral (many sides)
- Have 20 sides/facets, different sizes
  - Icosahedrons (geometrically)
- Each facet consists of several capsomeres
- The size of the virus is determined by the size of each facet and the number of capsomeres in each facet

TABLE 4-1 Relative Sizes and Shapes of Some Viruses

VIRUSES	NUCLEIC ACID TYPE	SHAPE	SIZE RANGE (nm)
Animal Viruses			
Vaccinia	DNA	Complex	200 × 300
Mumps	RNA	Helical	150–250
Herpes simplex	DNA	Polyhedral	100–150
Influenza	RNA	Helical	80–120
Retroviruses	RNA	Helical	100–120
Adenoviruses	DNA	Polyhedral	60–90
Retroviruses	RNA	Polyhedral	60–80
Papovaviruses	DNA	Polyhedral	40–60
Polioviruses	RNA	Polyhedral	28
Plant Viruses			
Turnip yellow mosaic	RNA	Polyhedral	28
Wound tumor	RNA	Polyhedral	55–60
Alfalfa mosaic	RNA	Polyhedral	18 × 36–40
Tobacco mosaic	RNA	Helical	18 × 300
Bacteriophages			
T2	DNA	Complex	65 × 210
L	DNA	Complex	54 × 194
F_x-174	DNA	Complex	25

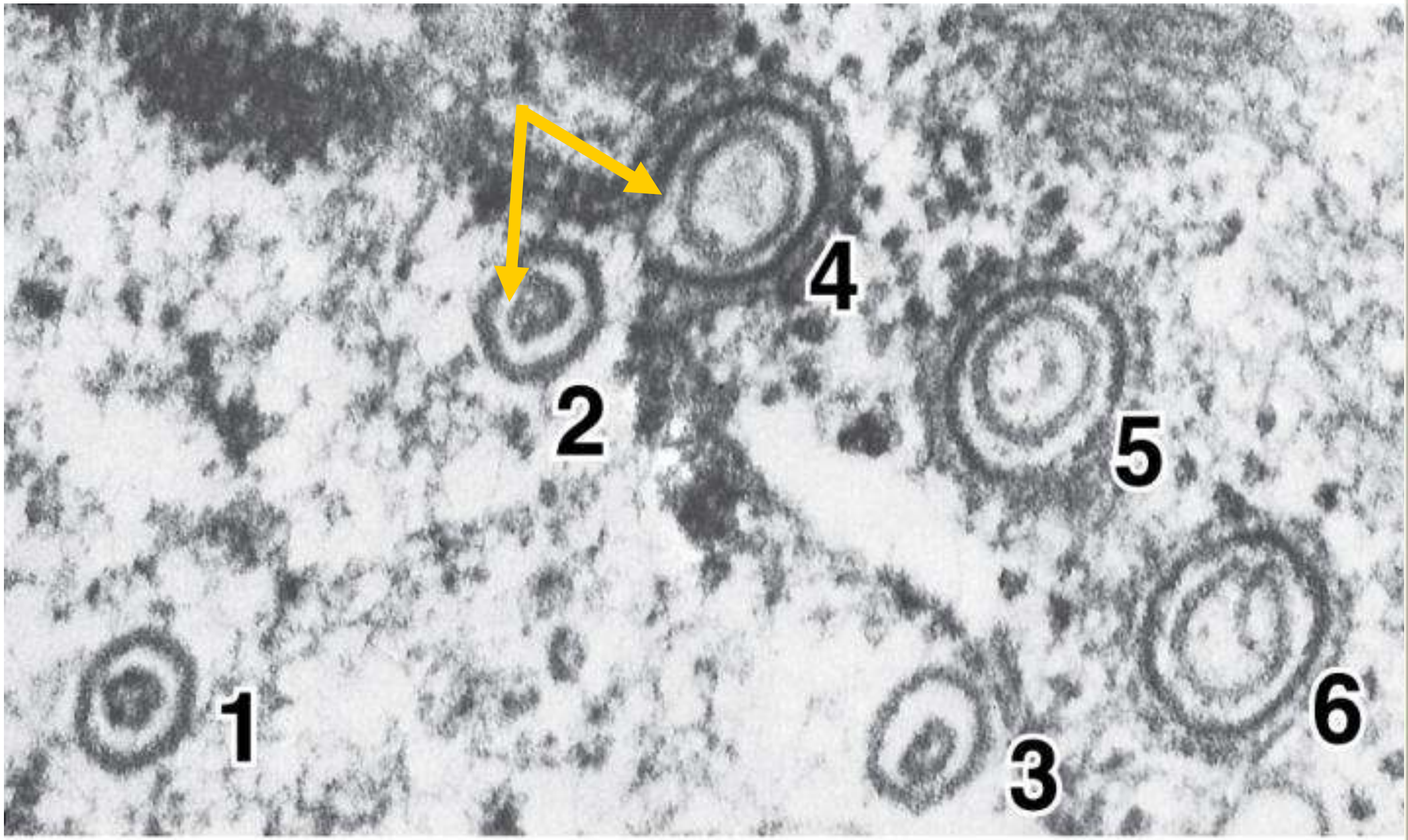
Enveloped Viruses





- Envelope is acquired by certain animal viruses as they escape from the nucleus or cytoplasm of the host cell by budding (from nuclear or cell membrane)
- Viruses add *protein fibers*, *spikes* and *knobs* that enable the virus to recognize the next host cell to be invaded.
- The envelope around the capsid can appear as the virus is spherical or irregular in shape.

Herpesviruses acquiring their envelopes as they leave a host cell's nucleus by budding.



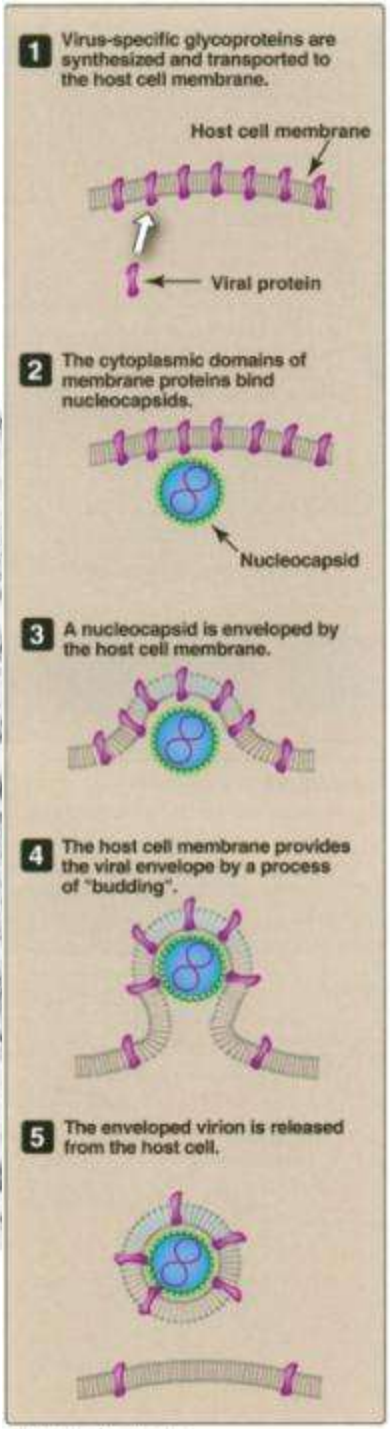
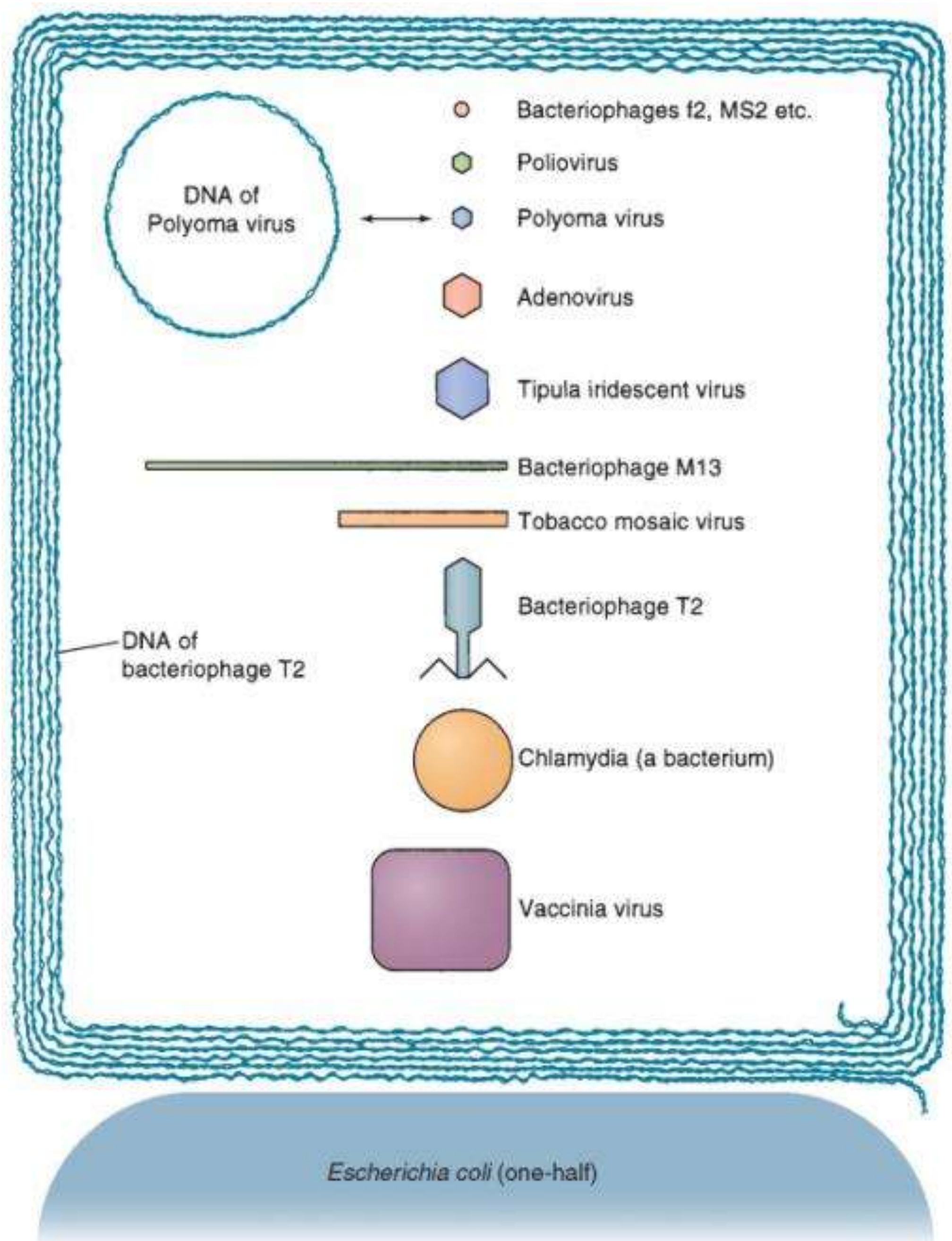


TABLE 4-2 Selected Important Groups of Viruses and Viral Diseases

VIRUS TYPE	VIRAL CHARACTERISTICS	VIRUS	DISEASE
Poxviruses	Large, brick shape with envelope, dsDNA	Variola Vaccinia	Smallpox Cowpox
Polyoma-papilloma	dsDNA, polyhedral	Papillomavirus Polyomavirus	Warts Some tumors, some cancer
Herpesvirus	Polyhedral with envelope, dsDNA	Herpes simplex I Herpes simplex II Herpes zoster Varicella	Cold sores or fever blisters Genital herpes Shingles Chickenpox
Adenovirus	dsDNA, icosahedral, with envelope		Respiratory infections, pneumonia, conjunctivitis, some tumors
Picornaviruses (the name means small RNA viruses)	ssRNA, tiny icosahedral, with envelope	Rhinovirus Poliovirus Hepatitis types A and B Coxsackievirus	Colds Poliomyelitis Hepatitis Respiratory infections, meningitis
Reoviruses	dsRNA, icosahedral with envelope	Enterovirus	Intestinal infections
Myxoviruses	RNA, helical with envelope	Orthomyxoviruses types A and B Myxovirus parotidis Paramyxovirus Rhabdovirus	Influenza Mumps Measles (rubeola) Rabies
Arbovirus	Arthropodborne RNA, cubic	Mosquitoborne type B Mosquitoborne types A and B Tickborne, coronavirus	Yellow fever Encephalitis (many types) Colorado tick fever
Retrovirus	dsRNA, helical with envelope	RNA tumor virus HTLV virus HIV	Tumors Leukemia AIDS

ds, double-stranded; ss, single-stranded.

Comparative sizes of virions, their nucleic acids, and bacteria.

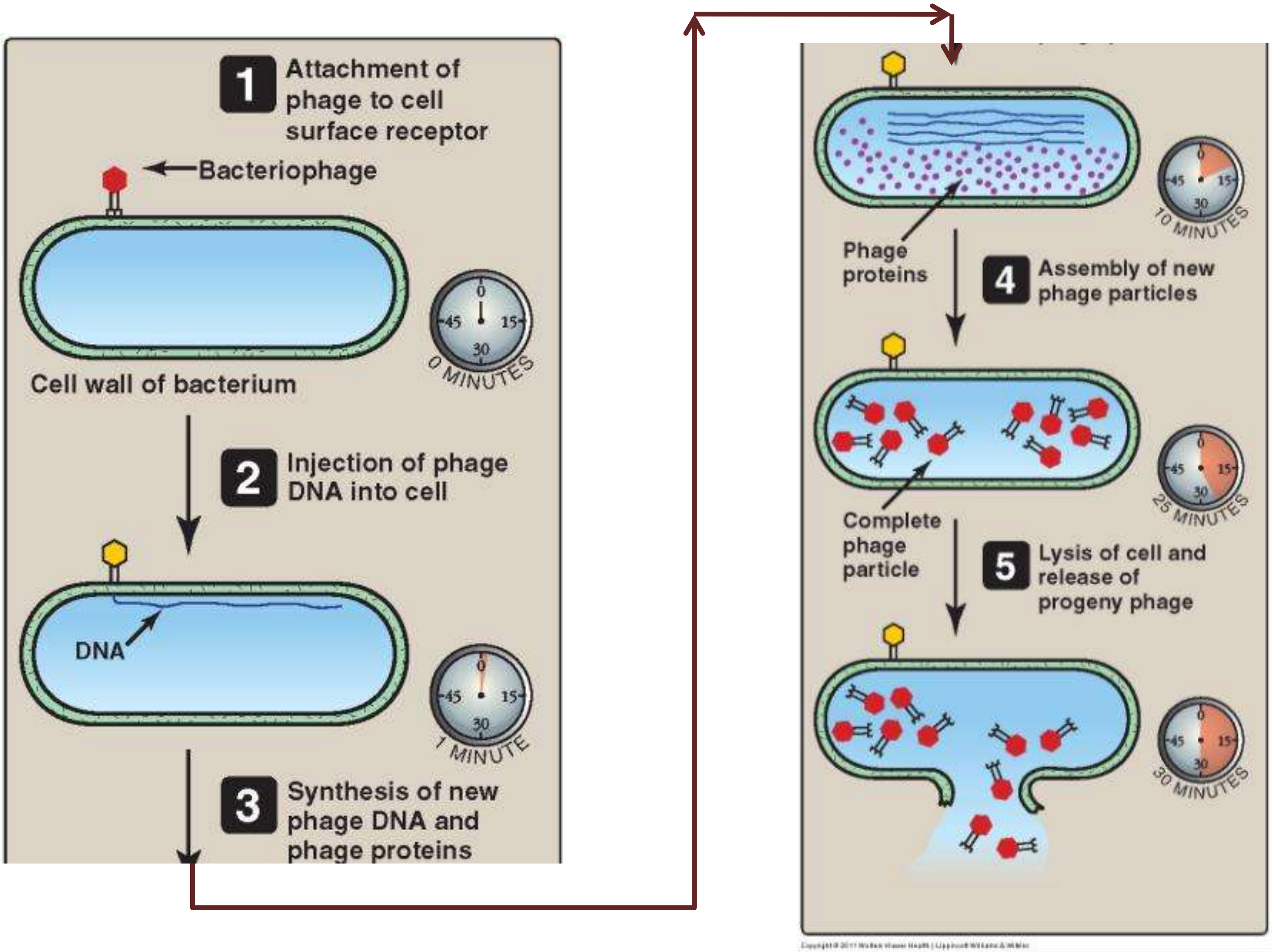


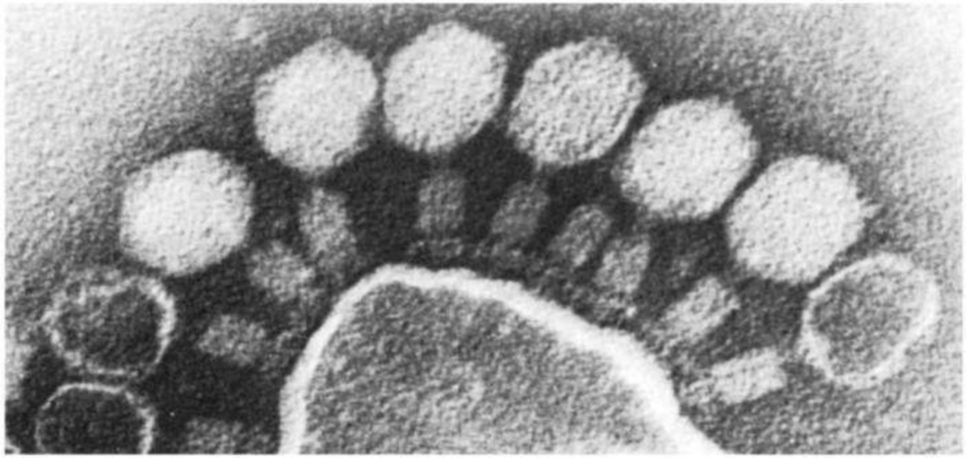
Acellular Microbes
Bacteriophages

- Viruses that ***infect bacteria*** are known as *bacteriophages* or simply *phages*.
- Categories based on their shape: Icosahedrom, Filamentous, Complex
- Categories based on the type of nucleic acid:
  - Single- or Double-stranded: DNA phages and RNA phages
- Two categories based on the events after invasion:

1. virulent bacteriophages
   - Virulent bacteriophages always cause what is known as the *lytic cycle,* which ends with the destruction of the bacterial cell
   - The 5 steps in the lytic cycle are: (1) attachment, (2)penetration, (3)biosynthesis, (4)assembly, and (5)release
2. temperate bacteriophages

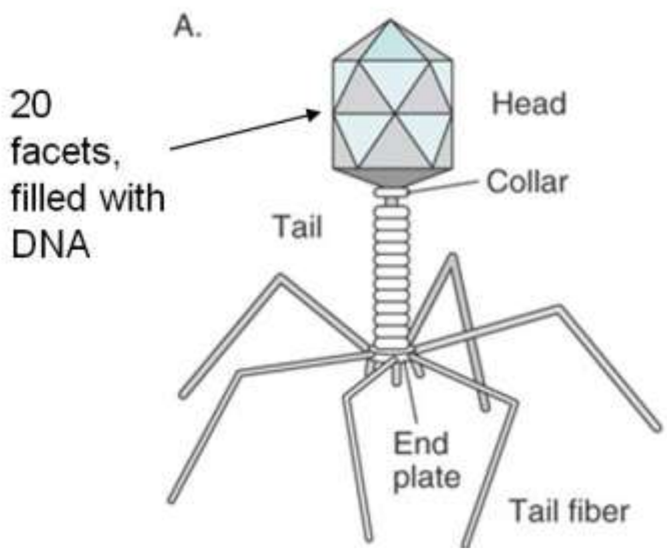
Steps in the Multiplication of Bacteriophages (Lytic Cycle)



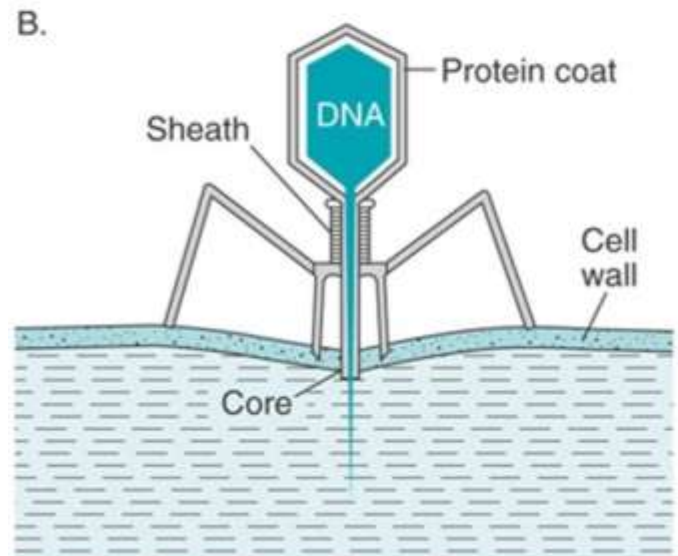


A partially lysed cell of *Vibrio cholerae* with attached virions of phage CP-T1.

The bacteriophage T4 is an assembly of protein components.



Viral DNA enters the cell through the core.



Acellular Microbes

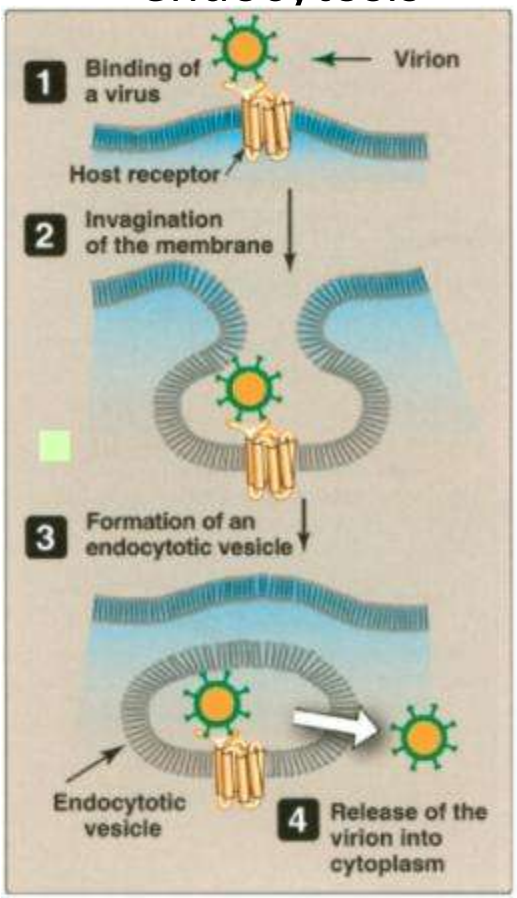
Animal Viruses

- These are the viruses that infect humans and animals
- Animal viruses escape from their host cells either by lysis of the cell or budding.
- Viruses that escape by budding become enveloped viruses

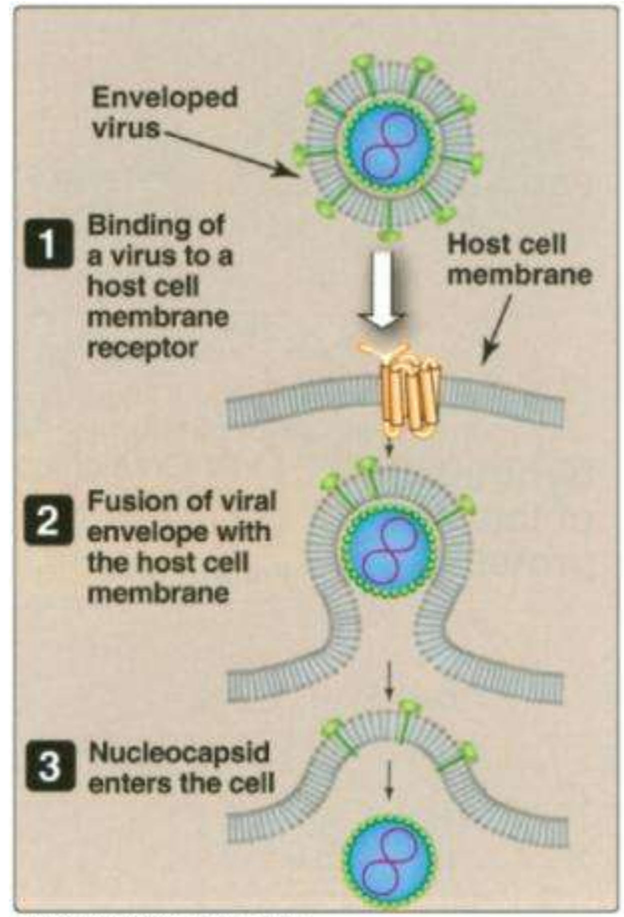
TABLE 4-4	Steps in the Multiplication of Animal Viruses	
STEP	NAME OF STEP	WHAT OCCURS DURING THIS STEP
1	Attachment (adsorption)	The virus attaches to a protein or polysaccharide molecule (receptor) on the surface of a host cell
2	Penetration	The entire virus enters the host cell, in some cases because it was phagocytized by the cell
3	Uncoating	The viral nucleic acid escapes from the capsid
4	Biosynthesis	Viral genes are expressed, resulting in the production of pieces or parts of viruses (i.e., viral DNA and viral proteins)
5	Assembly	The viral pieces or parts are assembled to create complete virions
6	Release	The complete virions escape from the host cell by lysis or budding

PENETRATION

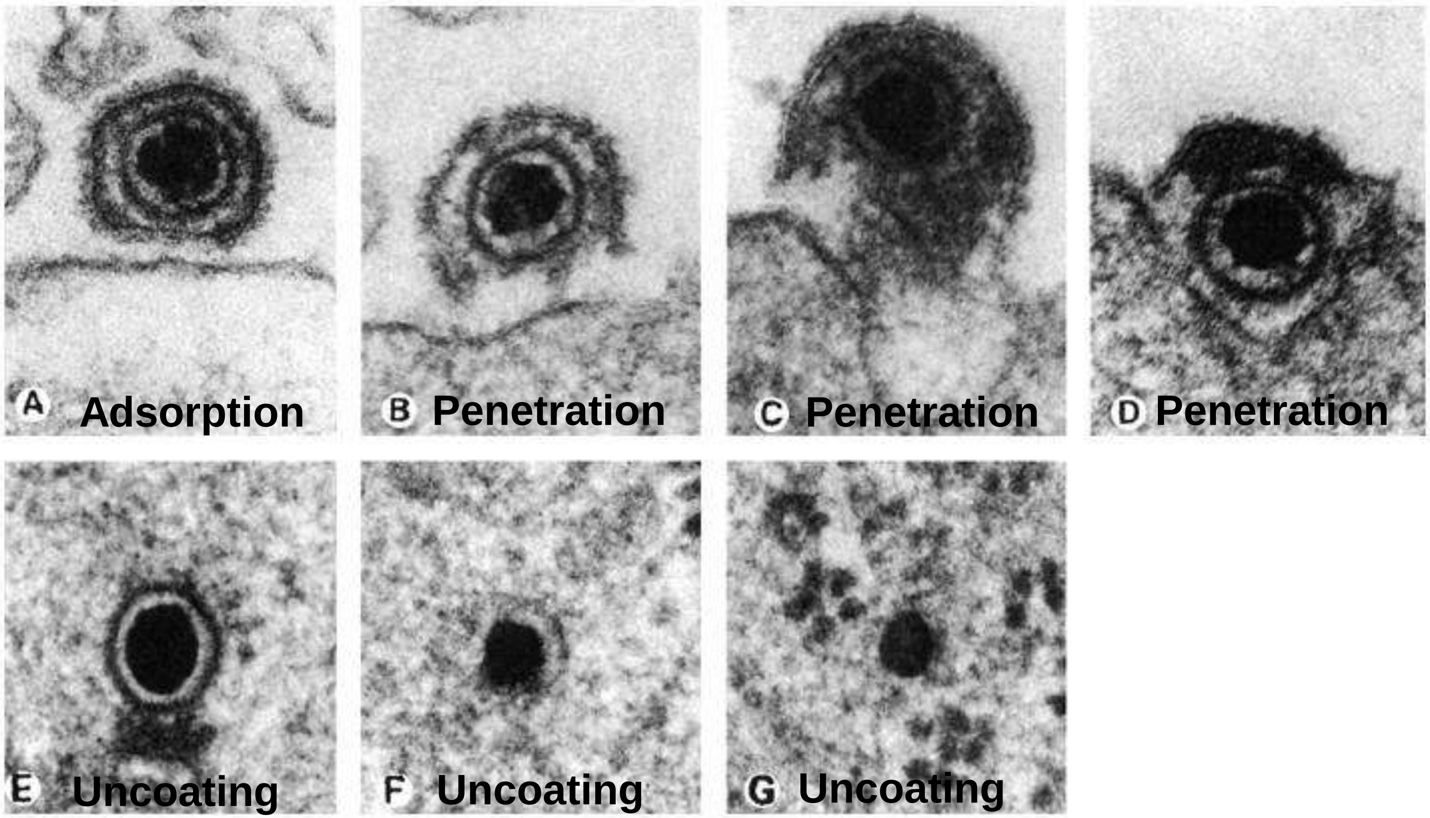
Nonenveloped virus via endocytosis



Enveloped virus



Multiplication of Herpes Simplex on HeLa Cells



Inclusions Bodies

- Remnants or collections of viruses in (nucleus or cytoplasm of) infected cells
  - Used as diagnostic tool
    - Cytoplasmic
      - In rabies => negri bodies
      - Inclusions of AIDS and Guarniery bodies (smallpox)
    - Nuclear
      - Herpes and poliomyelitis
      - Human warts

Acellular Microbes

Latent Virus Infections

- Viral infections in which the virus is able to hide from a host's immune system by entering cells and remaining dormant.
  - Herpes viral infections are examples.
    - Once acquired, herpes virus infections (e.g., those that cause cold sores, genital herpes, chickenpox/shingles) never completely go away; for example, chickenpox may be followed, years later, by shingles - both are from the same virus.

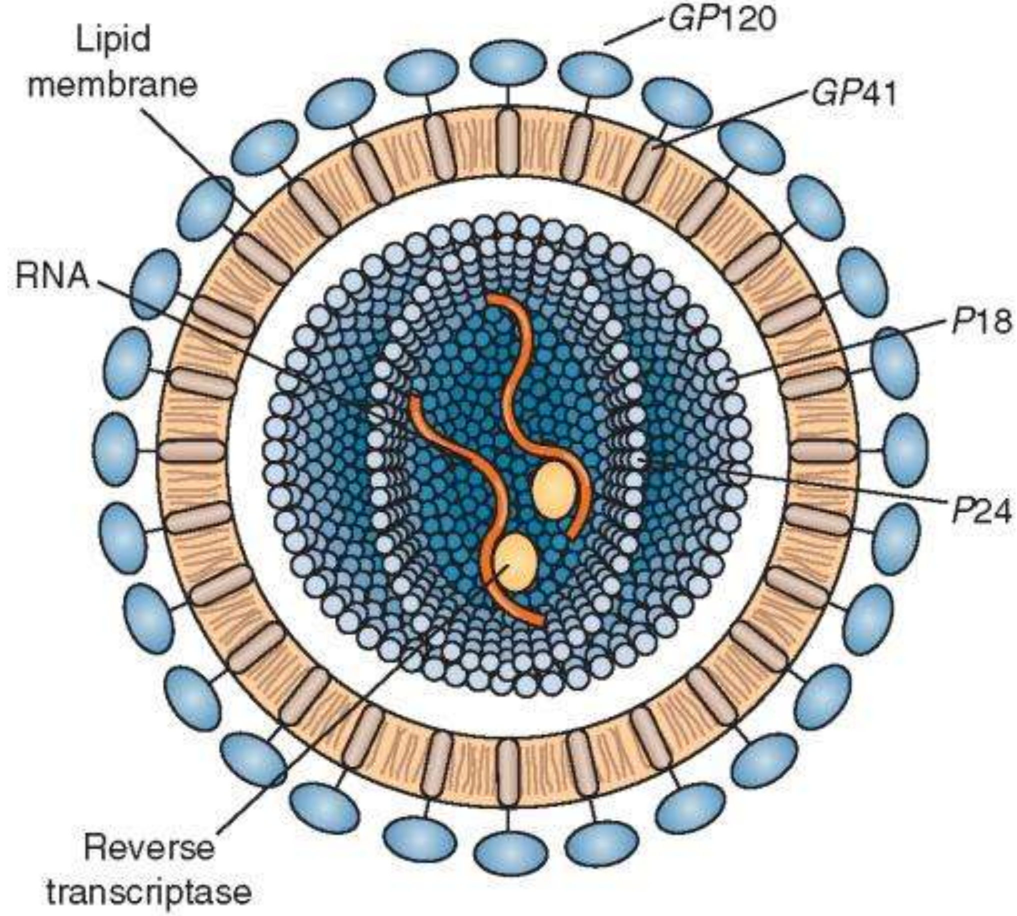
Acellular Microbes

Antiviral Agents

- Antibiotics are not effective against viral infections.
- Antiviral agents are drugs that are used to treat viral infections.
- These agents interfere with virus-specific enzymes and virus production by disrupting critical phases in viral multiplication or inhibiting synthesis of viral DNA, RNA, or proteins.

- Oncogenic Viruses or Oncoviruses
  - Viruses that cause cancer.
  - Examples include Epstein-Barr virus, human papillomaviruses, and HTLV-1.
- Human Immunodeficiency Virus (HIV)
  - The cause of acquired immunodeficiency syndrome (AIDS).
  - It is an enveloped, single-stranded RNA virus.
  - The primary targets for HIV are CD4+ cells.

Human Immunodeficiency Virus (HIV)



Acellular Microbes, cont.

- Viroids and Prions (smaller and less complex infectious particles than viruses)
  - Viroids
    - Viroids are short, naked fragments of single-stranded RNA, which can interfere with the metabolism of plant cells.
    - Viroids are transmitted between plants in the same manner as viruses.
    - Examples of plant diseases caused by viroids: potato spindle tuber and citrus exocortis.

Acellular Microbes, cont.

- Prions
  - Prions are small infectious proteins that cause fatal neurologic diseases in animals; examples: Scrapie, Bovine Spongiform Encephalopathy (“Mad Cow Disease”) and Creutzfeldt-Jacob disease.
  - Of all pathogens, prions are the most resistant to disinfectants.
  - The mechanism by which prions cause disease remains a mystery.

The Domain *Bacteria*

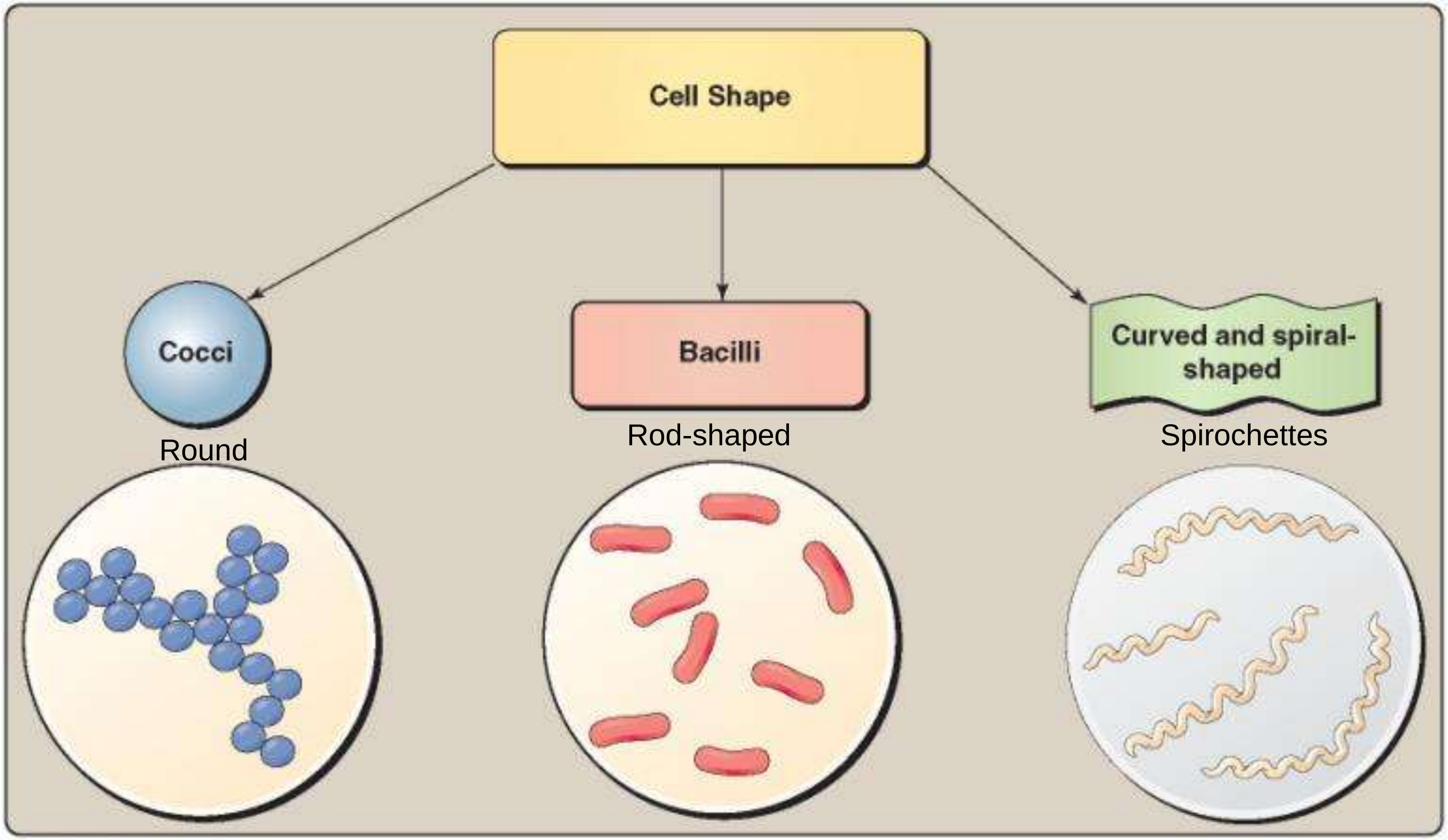
Characteristics and Identification parameters

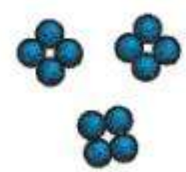
Divided into 3 major phenotypic categories:

- Those that are Gram-negative and have a cell wall
- Those that are Gram-positive and have a cell wall
- Those that lack a cell wall (*Mycoplasma* spp.)

- cell morphology
- staining reactions
- motility
- colony morphology
- atmospheric requirements
- nutritional requirements
- biochemical & metabolic activities
- enzymes that the organism produces
- pathogenicity
- genetic composition

Categories of Bacteria Based on the Shape of Their Cells



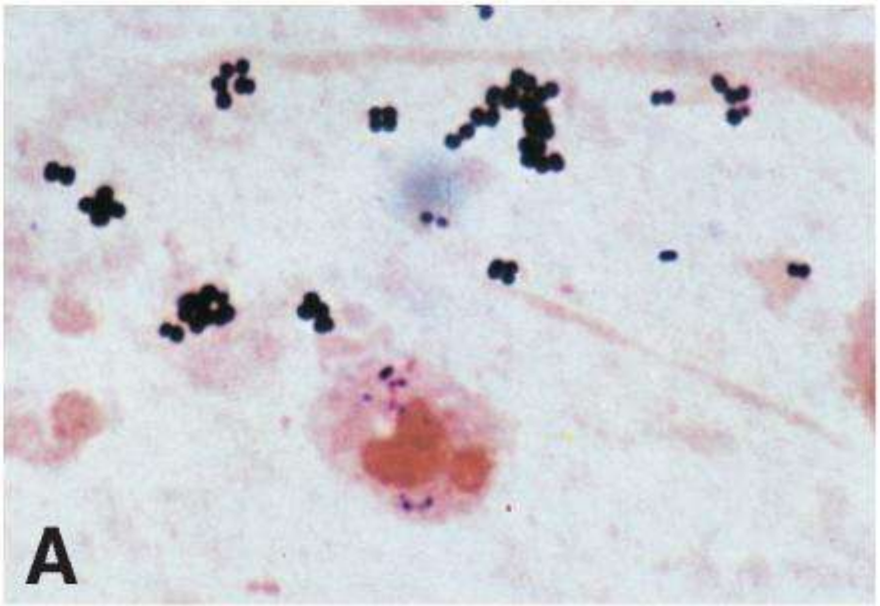
Arrangement	Description	Appearance	Example	Disease
Diplococci	Cocci in pairs		*Neisseria gonorrhoeae*	Gonorrhea
Streptococci	Cocci in chains		*Streptococcus pyogenes*	Strep throat
Staphylococci	Cocci in clusters		*Staphylococcus aureus*	Boils
Tetrad	A packet of 4 cocci		*Micrococcus luteus*	Rarely pathogenic
Octad	A packet of 8 cocci		*Sarcina ventriculi*	Rarely pathogenic

Medically Important *cocci*

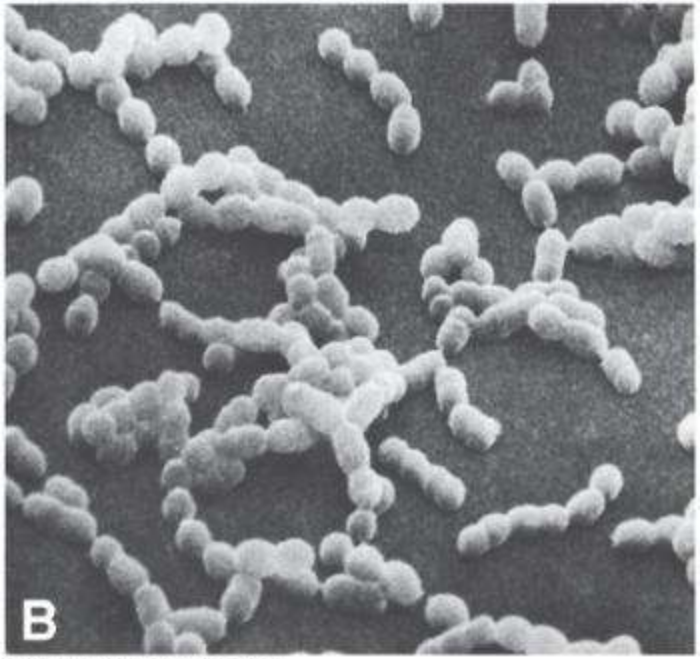
- *Enterococcus* spp.
- *Neisseria* spp
- *Staphycoccus* spp
- *Streptococcus* spp

Morphologic Arrangements of Cocci

- The average coccus is about 1 µm in diameter.
- Some cocci have "coccus" in their name.



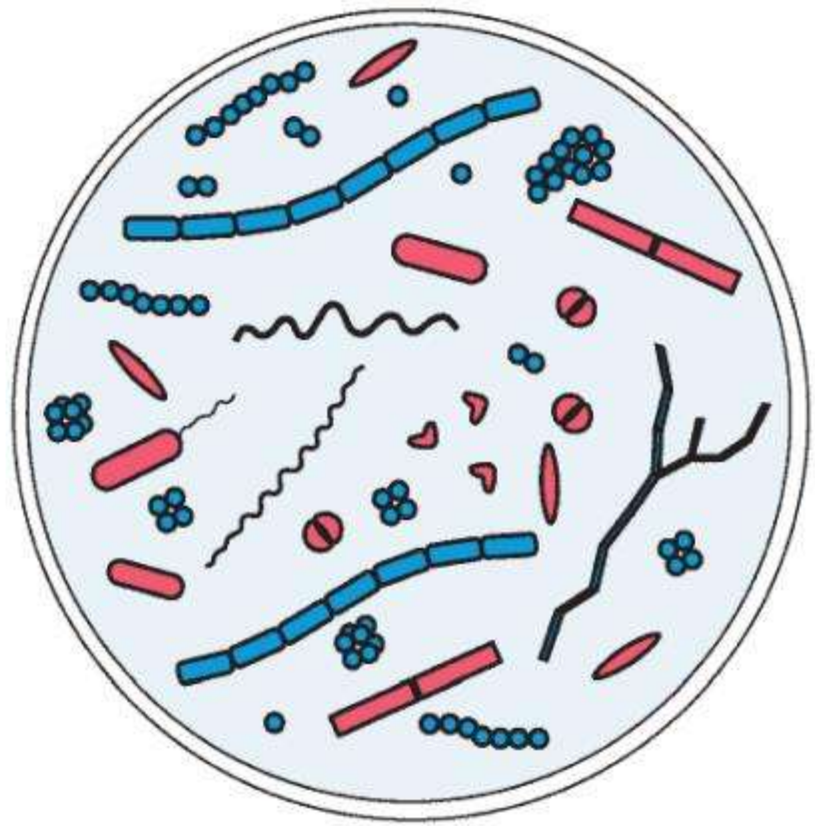
Gram-positive *Staphylococcus aureus* in clusters.



SEM of *Streptococcus mutans* illustrating cocci in chains.

Diagram Showing Various Forms of Bacteria That Might be Observed in Gram-Stained Smears

- Single cocci
- Diplococci
- Tetrads
- Octads
- Streptococci
- Staphylococci
- Single baccili
- Diplobacilli
- Streptobacilli
- Branching bacilli
- Loosely coiled spirochetes
- Tightly coiled spirochetes



The Domain *Bacteria*

Bacilli

- Often referred to as rods; may be short or long, thick or thin, and pointed or with curved or blunt ends.
- They may occur singly, in pairs (*diplobacilli*), in chains (*streptobacilli*), in long filaments, or branched.
- An average sized bacillus is 1 x 3 µm.
- Extremely short bacilli are called *coccobacilli*.
- Examples of medically important bacilli:
  - *Escherichia, Klebsiella,* and *Proteus* spp.
  - *Pseudomonas, Haemophilus,* and *Bacillus* spp.

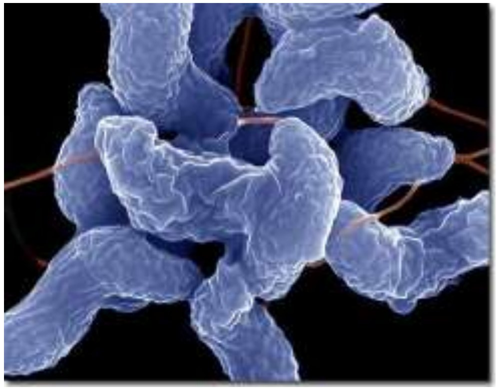
The Domain *Bacteria*

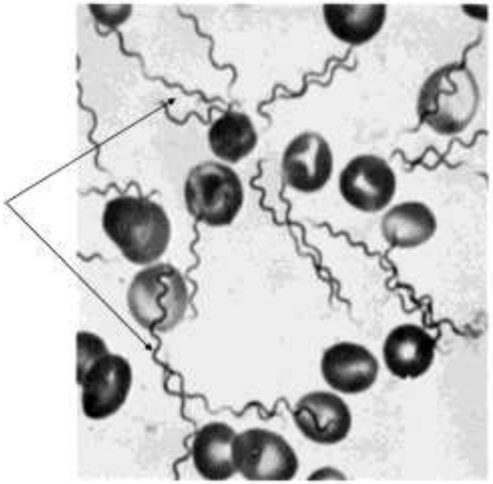
Bacilli

Curved and Spiral-Shaped Bacteria

- Curved (comma-shaped) bacteria (samples):
  - *Vibrio* spp.
  - *Campylobacter* spp.
  - *Helicobacter* spp.
- Spiral-shaped bacteria (samples):
  - *Treponema* spp.
  - *Borrelia* spp.

Campilobacter





Spiral-Shaped Bacteria
Borrelia hermsii in a stained blood smear; a cause of relapsing fever.

Medically Important *bacilli*

- *Enterobacteriaceae*
  - *Enterobacter* spp.
  - *Eschericia* spp.
  - *Klebsiella* spp.
  - *Proteus* spp.
  - *Salmonella* spp.
  - *Shigella* spp.
- *Pseudomonas aeruginosa*
- *Bacillus* spp.
- *Clostridium* spp.

CWD Bacteria

Cell Wall Deficient Bacteria

- Due to adverse growth conditions some bacteria may lose their characteristic shape, but they can regain if they are placed in the favorable conditions - e.g. *Mycoplasma*
- Because they do not have cell walls, mycoplasmas are resistant to antibiotics that inhibit cell wall synthesis.

Domain *Bacteria*

Staining Procedures

- Three Major Categories of Staining Procedures
  1. Simple stains (shape and morphology arrangement)
  2. Structural staining procedures
     - Capsule stains
     - Spore stains
     - Flagella stains
  3. Differential staining procedures
     - Gram and acid-fast staining procedures

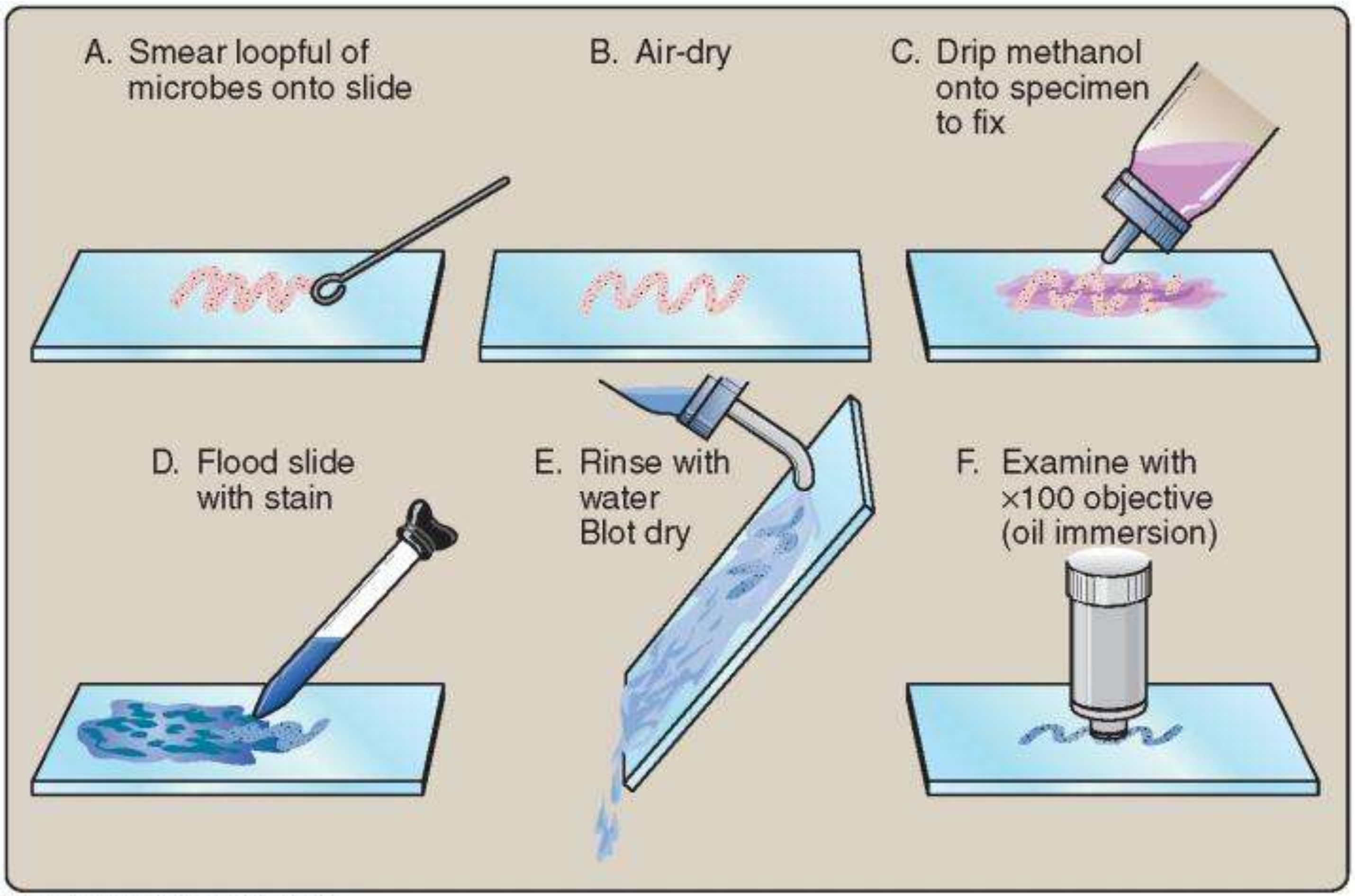
Domain Bacteria

Staining Procedures, cont.

- Bacterial smears must be fixed prior to staining
- The fixation process serves *to kill organisms*, *preserve their morphology*, and *anchors the smear to the slide*
- The two most common types of fixation:
  - Heat-fixation; not a standardized technique; excess heat will distort bacterial morphology
  - Methanol-fixation; a standardized technique; the preferred method

Simple Bacterial Staining Technique

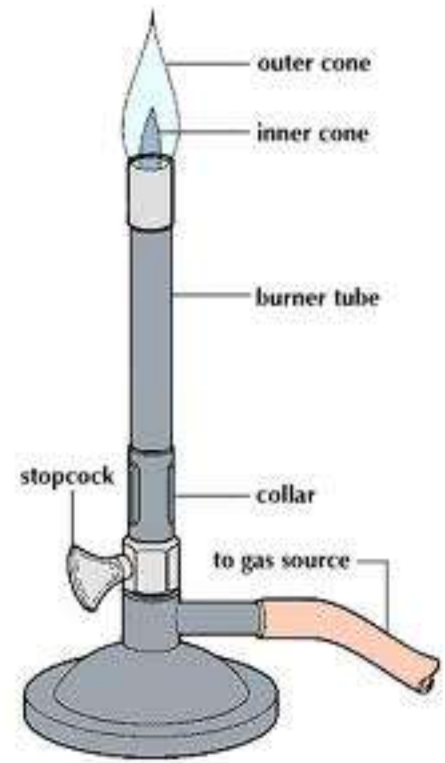
Methanol fixation (more satisfactory)



Heat Fixation

Bunsen Bruner

- Passing the air-dried smear through a Bunsen burner flame
- Excess heat can distort the morphology of the cells



Domain Bacteria

The Gram Staining Procedure

- Divides bacteria into 2 major groups:
  - Gram-positive (bacteria are blue-to-purple)
  - Gram-negative (bacteria are pink-to-red)
- The final Gram reaction (positive or negative) depends upon the organism's cell wall structure.
  - The cell walls of Gram-positive bacteria have a thick layer of peptidoglycan, making it difficult to remove the crystal violet-iodine complex.
  - Gram-negative organisms have a thin layer of peptidoglycan, making it easier to remove the crystal violet; the cells are subsequently stained with safranin.

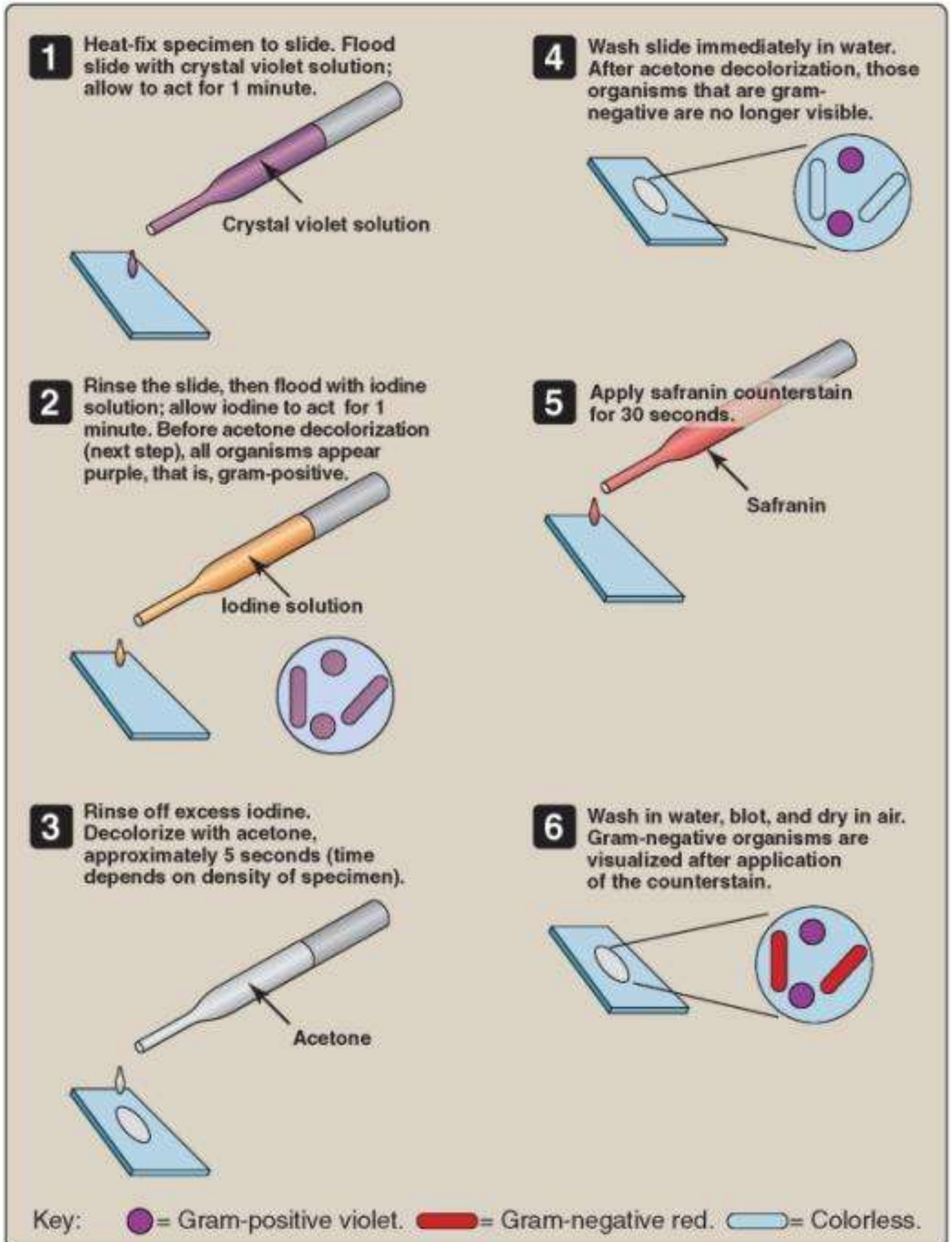
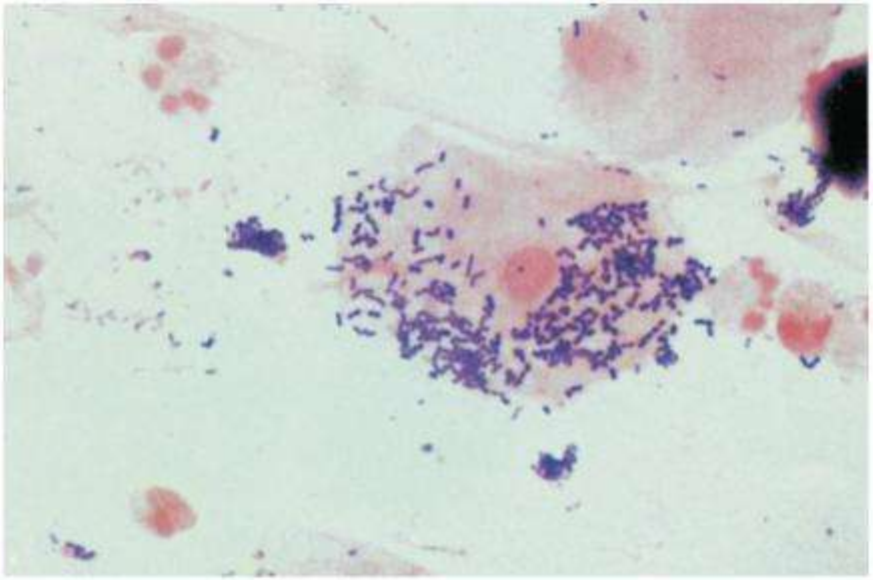
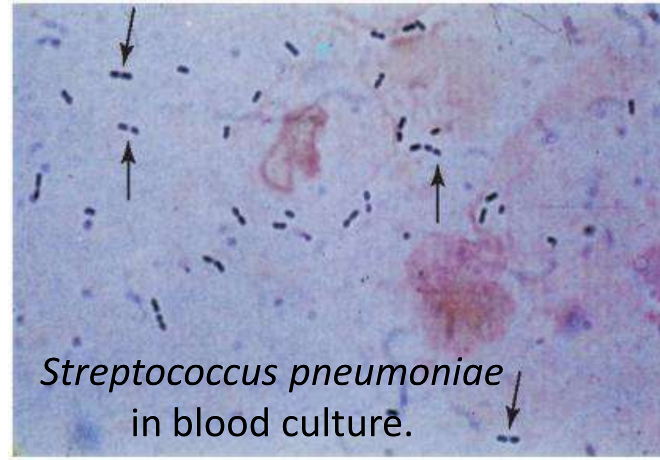

1
Heat-fix specimen to slide. Flood slide with crystal violet solution; allow to act for 1 minute.
Crystal violet solution
2
Rinse the slide, then flood with iodine solution; allow iodine to act for 1 minute. Before acetone decolorization (next step), all organisms appear purple, that is, gram-positive.
Iodine solution
3
Rinse off excess iodine. Decolorize with acetone, approximately 5 seconds (time depends on density of specimen).
Acetone
4
Wash slide immediately in water. After acetone decolorization, those organisms that are gram-negative are no longer visible.
5
Apply safranin counterstain for 30 seconds.
Safranin
6
Wash in water, blot, and dry in air. Gram-negative organisms are visualized after application of the counterstain.
Key:
= Gram-positive violet.
= Gram-negative red.
= Colorless.

TABLE 4-5	Differences between Gram-Positive and Gram-Negative Bacteria	
	GRAM-POSITIVE BACTERIA	**GRAM-NEGATIVE BACTERIA**
Color at the end of the Gram staining procedure	Blue-to-purple	Pink-to-red
Peptidoglycan in cell walls	Thick layer	Thin layer
Teichoic acids and lipoteichoic acids in cell walls	Present	Absent
Lipopolysaccharide in cell walls	Absent	Present



Various Gram-Positive Bacteria

Chains of *streptococci* in smear from broth culture.

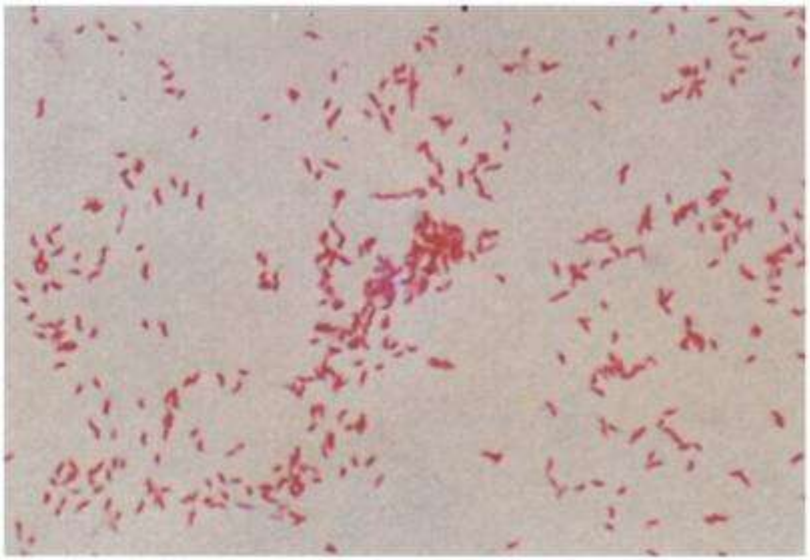


Streptococcus pneumoniae in blood culture.

A bacillus, *Clostridium perfringens*, in a smear from a broth culture.

Clostridium tetani in a smear from a broth culture (note terminal spores on some cells).

Gram-Negative Bacteria



Gram-negative bacilli in a smear from a bacterial colony.

Loosely coiled Gram-negative spirochetes, *Borrelia burgdorferi*, the cause of Lyme disease.

TABLE 4-6 Characteristics of Some Important Pathogenic Bacteria

STAINING REACTION	MORPHOLOGY	BACTERIUM	DISEASE(S)
Gram-positive	Cocci in clusters	*Staphylococcus aureus*	Wound infections, boils, pneumonia, septicemia, food poisoning
	Cocci in chains	*Streptococcus pyogenes*	Strep throat, scarlet fever, necrotizing fasciitis, septicemia
	Diplococci	*Streptococcus pneumoniae*	Pneumonia, meningitis, ear and sinus infections
	Bacillus	*Corynebacterium diphtheriae*	Diphtheria
	Spore-forming bacillus	*Bacillus anthracis*	Anthrax
		Clostridium botulinum	Botulism
		Clostridium perfringens	Wound infections, gas gangrene, food poisoning
		Clostridium tetani	tetanus
Gram-negative	Diplococci	*Neisseria gonorrhoeae*	gonorrhea
		Neisseria meningitidis	Meningitis, respiratory infections
	Bacillus	*Bordetella pertussis*	Whooping cough (pertussis)
		Brucella abortus	Brucellosis
		Chlamydia trachomatis	Genital infections, trachoma
		Escherichia coli	Urinary tract infections, septicemia
		Francisella tularensis	Tularemia
		Haemophilus ducreyi	Chancroid
		Haemophilus influenzae	Meningitis; respiratory, ear and sinus infections
		Klebsiella pneumoniae	Urinary tract and respiratory infections
		Proteus vulgaris	Urinary tract infections
		Pseudomonas aeruginosa	Respiratory, urinary, and wound infections
		Rickettsia rickettsii	Rocky Mountain spotted fever
		Salmonella typhi	Typhoid fever
		Salmonella spp.	Gastroenteritis
		Shigella spp.	Gastroenteritis
		Yersinia pestis	Plague
	Curved bacillus	*Vibrio cholerae*	Cholera
	Spirochete	*Treponema pallidum*	Syphillis
Acid-fast, Gram-variable	Branching bacilli	*Mycobacterium leprae*	Leprosy (Hansen disease)
		Mycobacterium tuberculosis	Tuberculosis

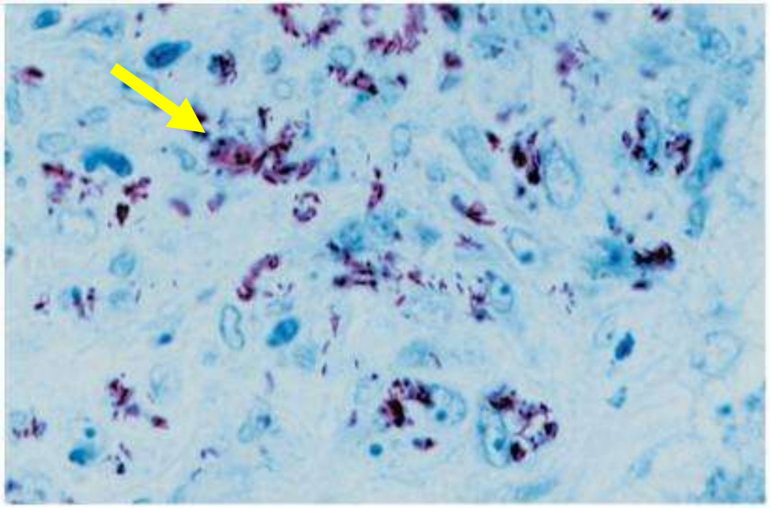
Domain *Bacteria*

Staining Procedures, cont.

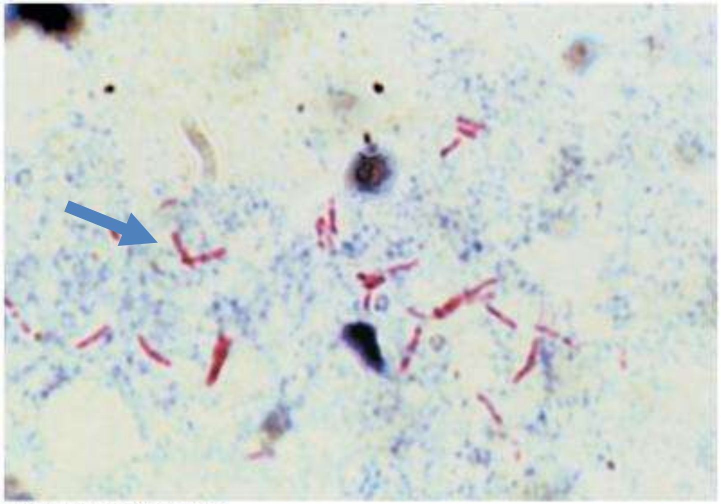
- Some bacteria are neither consistently purple nor pink after Gram staining; they are known as *Gram-variable bacteria;* example, *Mycobacterium* spp.
- *Mycobacterium* spp. are often identified using the *acid-fast stain.*

The acid-fast stain

- Carbol fuchsin is the red dye that is driven through the bacterial cell wall
- Heat is used to soften the waxes in the cell wall
- Because mycobacteria are not decolorized by the acid-alcohol mixture, they are said to be *acid-fast*

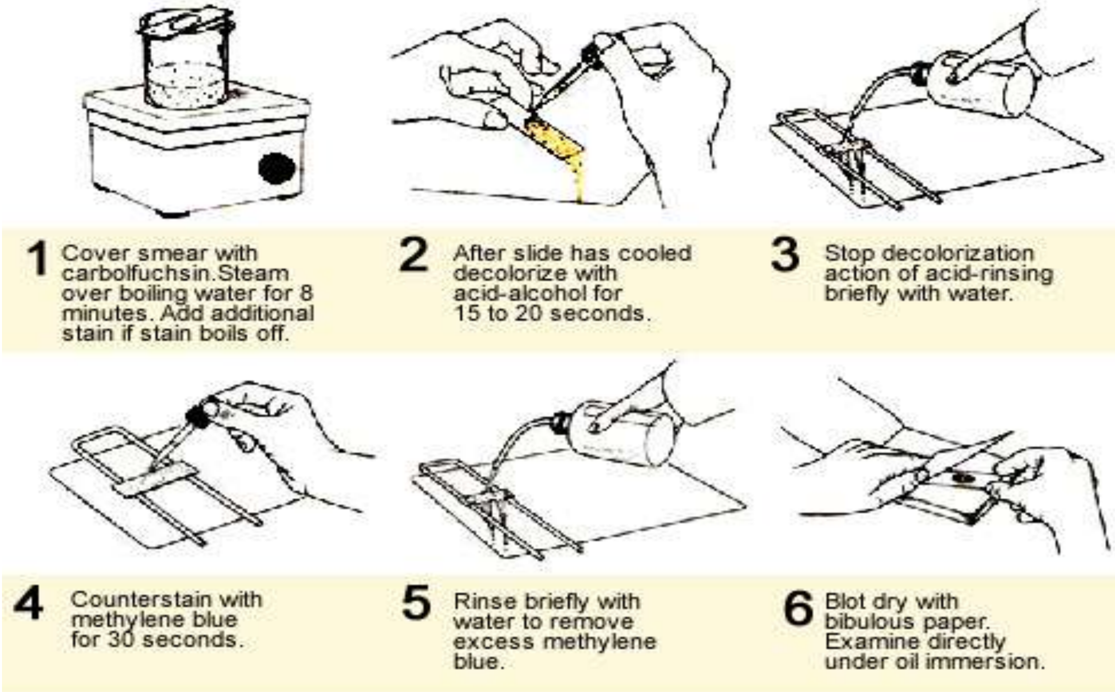


Many acid-fast mycobacteria in a liver biopsy.



Acid-fast bacilli in a digested sputum specimen.

Acid–Fast Stain



Ziehl-Neelsen acid-fast staining procedure

- To identify *Mycobacteria* spp.
- Red Dye: carbol fuchsin driven into the bacteria wall by heat (heat to melt the wax in the wall).
- An acid-alcohol for decolorizing – but acid-fast mycobacteria do not

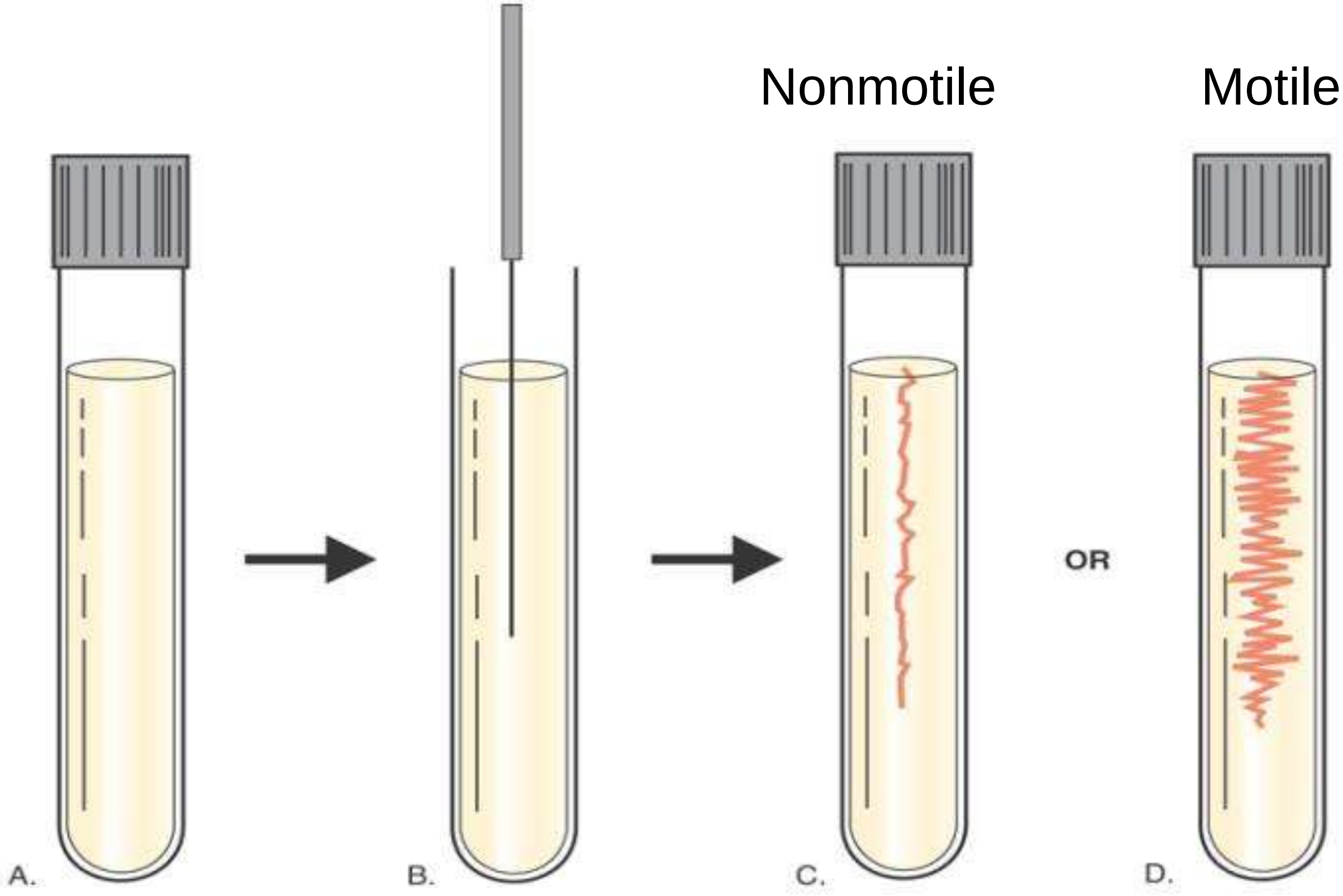
TABLE 4-7 Types of Bacterial Staining Procedures

CATEGORY	EXAMPLE(S)	PURPOSE
Simple staining procedure	Staining with methylene blue	Merely to stain the cells so that their size, shape, and morphologic arrangement can be determined
Structural staining procedures	Capsule stains	To determine whether the organism is encapsulated
	Flagella stains	To determine whether the organism possesses flagella and, if so, their number and location on the cell
	Endospore stains	To determine whether the organism is a spore-former and, if so, to determine whether the spores are terminal or subterminal spores
Differential staining procedures	Gram stain	To differentiate between Gram-positive and Gram-negative bacteria
	Acid-fast stain	To differentiate between acid-fast and non–acid-fast bacteria

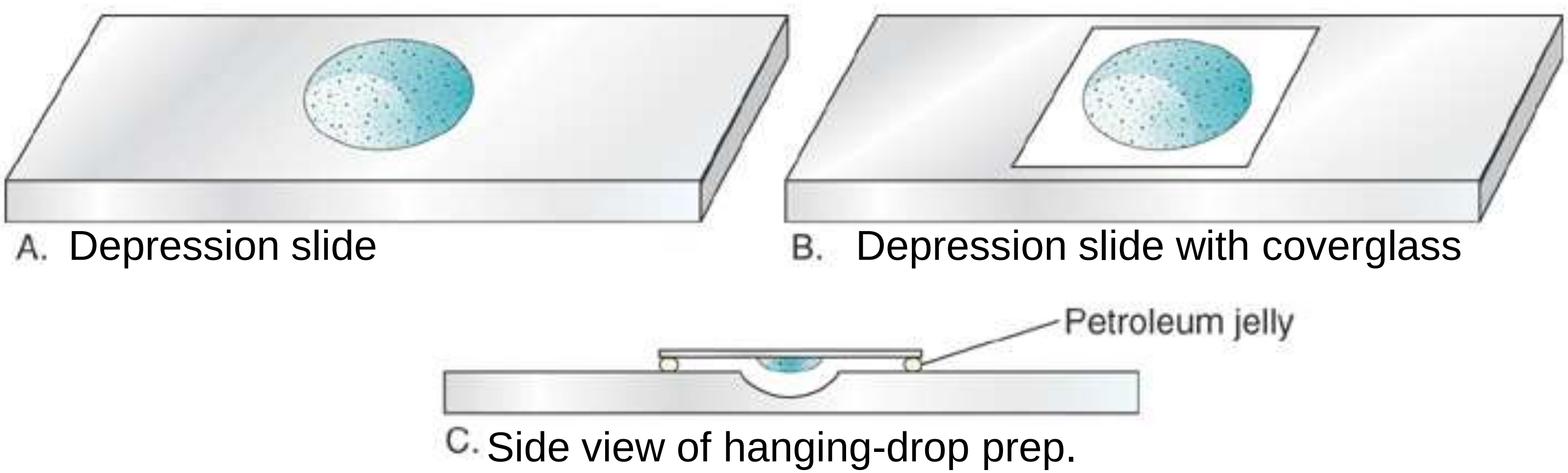
MOTILITY

- If a bacterium is able to “swim” => motile.
- Bacterial motility is most often associated with *flagella*; less often with *axial filaments*.
- Most spiral-shaped bacteria and about 50% of bacilli are motile
- Cocci are generally nonmotile.
- Motility can be demonstrated by stabbing the bacteria into a tube of semisolid medium or by using the hanging-drop technique.

Semisolid Agar Method for Determining Motility



Hanging-Drop Prep for Study of Living Bacteria

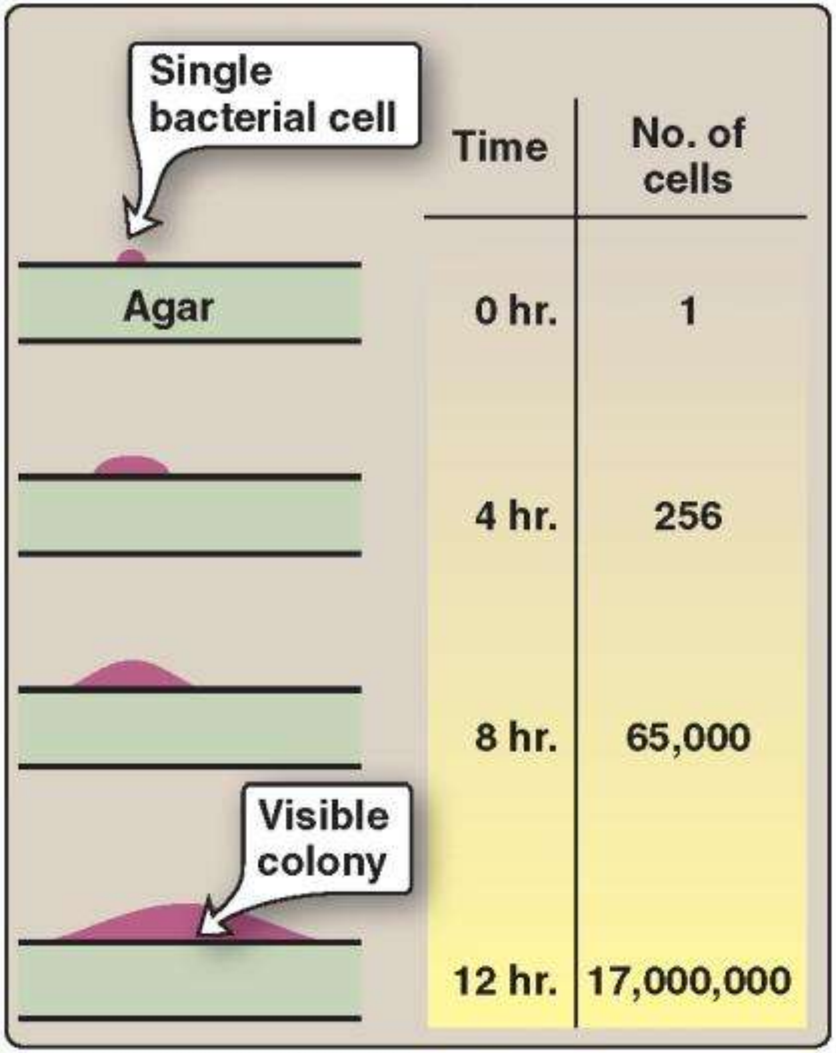


Domain *Bacteria*

Colony Morphology

- Contains millions of organisms.
- Varies from one species to another.
- Includes:
  - *size, color, overall shape, elevation, and the appearance of the edge or margin of the colony.*
  - the results of enzymatic activity on various types of media.
- True for both, cell morphology and staining characteristics
  – Colony morphology is an important “clue” to the identification of bacteria.

Size of colonies is determined by the organism’s generation time and is another important characteristic of a particular bacterial species.

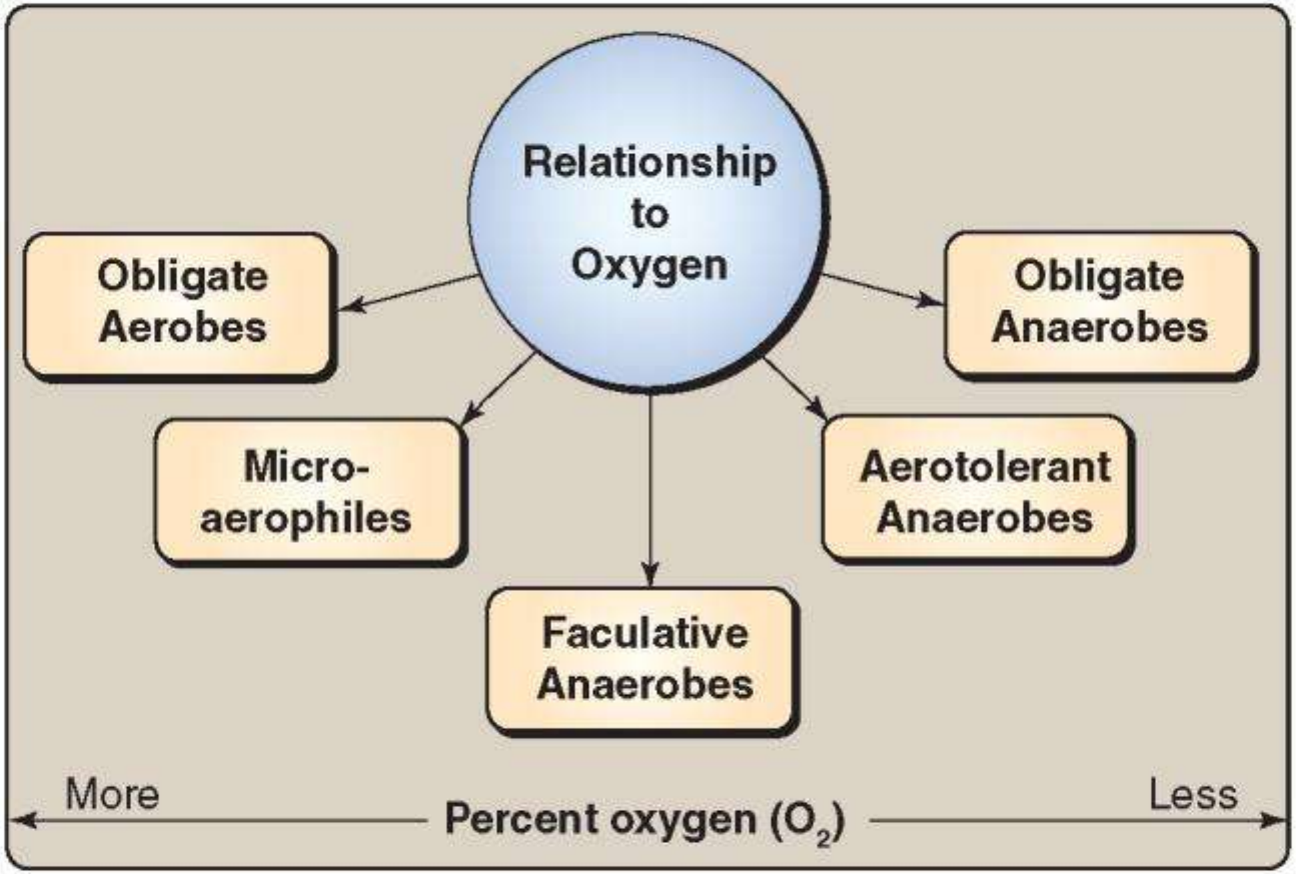


Formation of a bacterial colony on solid growth medium; here, the generation time is assumed to be 30 minutes.

Domain *Bacteria*

Atmospheric Requirements

- Bacteria can be classified on the basis of their atmospheric requirements, including their relationship to O_2 and CO_2
- With respect to O_2, bacterial isolates can be classified as:
  - Obligate aerobes (mycobacteria and some fungi)
  - Microaerophilic aerobes (*N. gonorrheae* & *Campylobacter* spp.)
  - Facultative anaerobes (*enterobacteriaceae, streptococci* and most *staphylococci*)
  - Aerotolerant anaerobes
  - Obligate anaerobes
- *Capnophiles*
  - *Capnophilic organisms* grow best (in the laboratory) in the presence of increased concentrations of CO_2 (usually 5 to 10%)
  - Some anaerobes are capnophiles
    - *Neisseria* spp, *Campylobacter* spp, *Haemophilus* spp.


Relationship to Oxygen
Obligate Aerobes
Obligate Anaerobes
Micro-aerophiles
Aerotolerant Anaerobes
Faculative Anaerobes
More
Less
Percent oxygen (O_2)

Domain *Bacteria*

Nutritional Requirements

- All bacteria need:
  - *carbon, hydrogen, oxygen, sulfur, phosphorus*, and *nitrogen* for growth.
- Some bacteria require special elements
  - e.g., calcium, iron, or zinc
- ***Fastidious*** ("fussy") are organisms with especially demanding nutritional requirements
- The *nutritional needs* of a particular organism are usually *characteristic for that species* and are sometimes *important clues to its identity*.

Domain *Bacteria*

Biochemical and Metabolic Activities

- As bacteria grow, they produce many waste products and secretions (e.g. ***enzymes)***.
  - Pathogenic strains of many bacteria, like staphylococci and streptococci, can be tentatively identified by the enzymes they secrete.
- In particular environments, some bacteria produce gases such as ***carbon dioxide*** or ***hydrogen sulfide***.
- To identify bacteria in the lab, they are inoculated into various substrates (i.e., carbohydrates and amino acids) to determine whether they possess the enzymes necessary to break down those substrates.

Domain *Bacteria*

Pathogenicity

- Many pathogens are able to cause disease because they possess ***capsules***, ***pili,*** or ***endotoxins***, or because they secrete ***exotoxins*** and ***exoenzymes*** that damage cells and tissues.
- Frequently, pathogenicity is tested by injecting the organism into mice or cell cultures.
- Examples of some common pathogenic bacteria:
  - *Neisseria meningitidis, Salmonella typhi, Shigella* spp.*, Vibrio cholerae, Yersina pestis, Treponema pallidum*

Domain *Bacteria*

Genetic Composition

- Laboratory identification of bacteria is moving toward analyzing the organism's DNA or RNA – techniques collectively referred to as *molecular diagnostic procedures*.
  - The composition of the genetic material (DNA) of an organism is unique to each species.
  - DNA probes make it possible to identify an isolate without relying on phenotypic characteristics.
- Through the use of 16S rRNA sequencing, the degree of relatedness between 2 different bacteria can be determined.

Unique Bacteria

- ***Rickettsias, chlamydias,*** and ***mycoplasmas*** are bacteria, but they do not possess all the attributes of typical bacterial cells.
- Rickettsias and chlamydias have a Gram-negative type of cell wall and are *obligate intracellular pathogens* (i.e., they must live within a host cell; they cannot grow on artificial culture media).
  - Rickettsias have "leaky membranes"
  - Chlamydias are "energy parasites"

Rickettsia prowazekii, the cause of epidemic louseborne typhus.

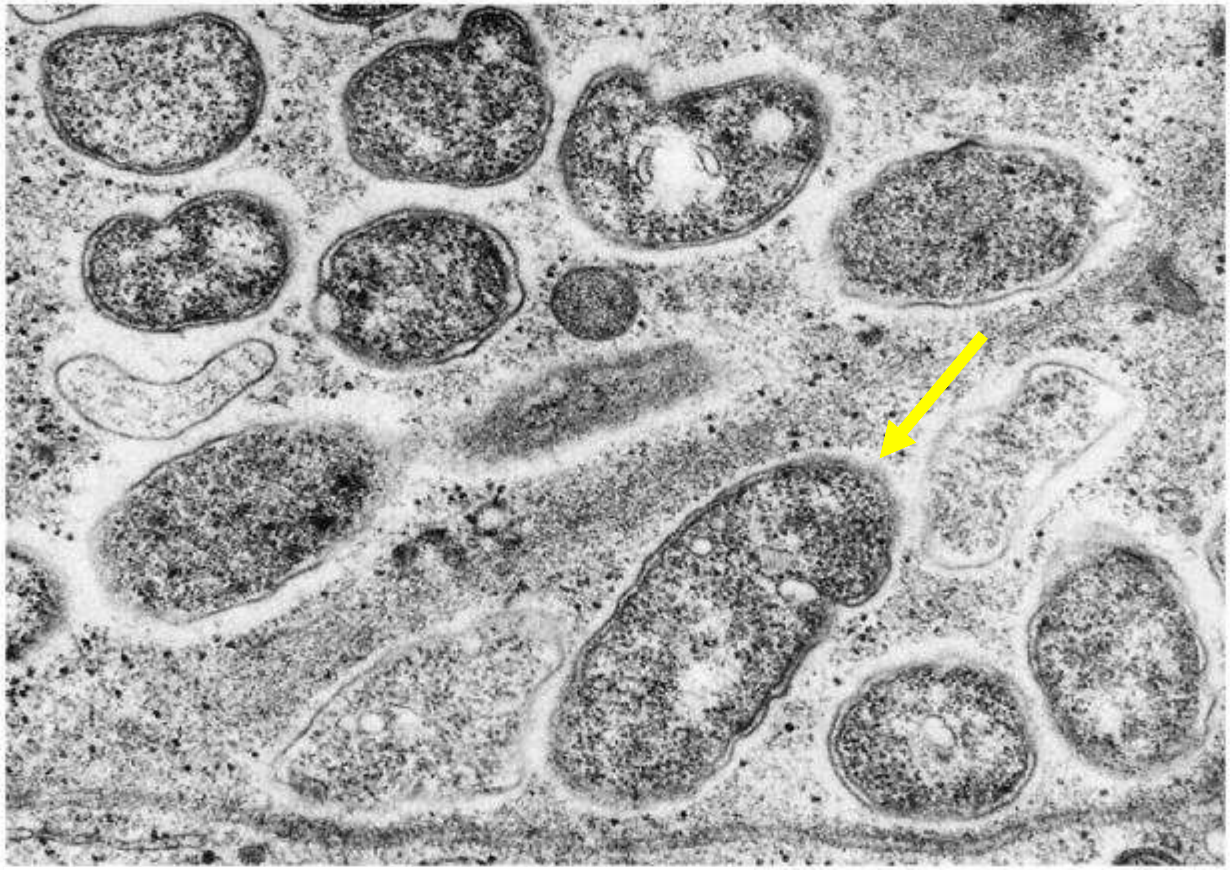


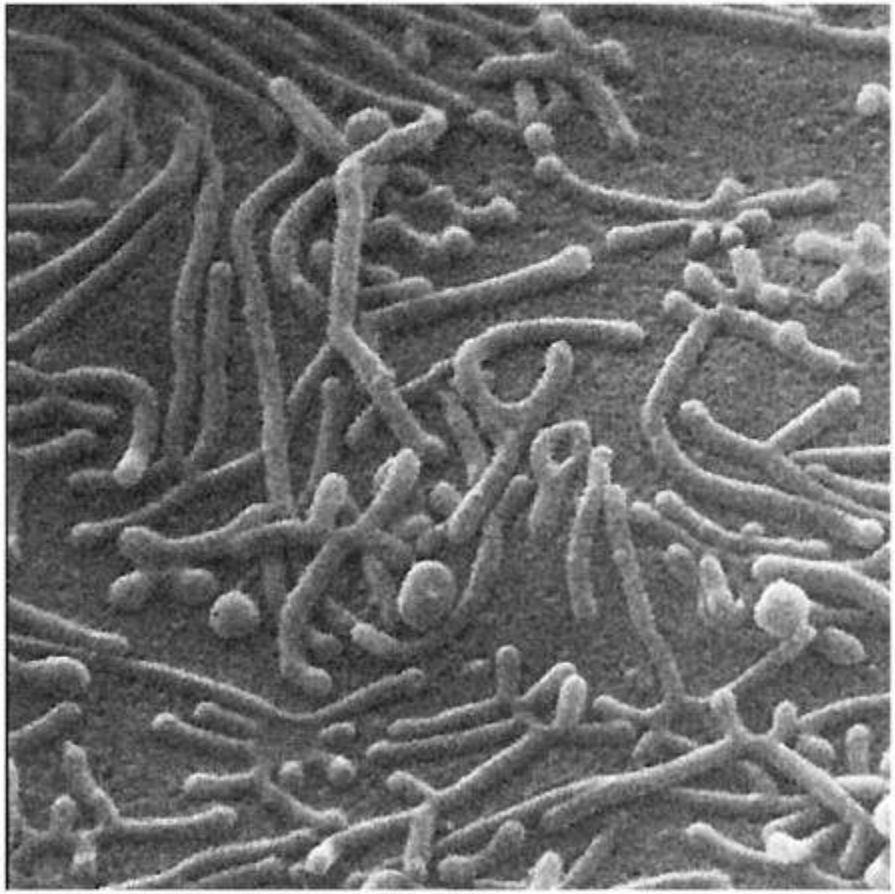
TABLE 4-8 Human Diseases Caused by Unique Bacteria

GENUS	SPECIES	HUMAN DISEASE(S)
Rickettsia	*R. akari* *R. prowazekii* *R. rickettsii* *R. typhi*	Rickettsialpox (a miteborne disease) Epidemic typhus (a louseborne disease) Rocky Mountain spotted fever (a tickborne disease) Endemic or murine typhus (a fleaborne disease)
Ehrlichia spp.	*E. chaffeensis*	Human monocytic ehrlichiosis
Anaplasma spp.	*Anaplasma phagocytophilum*	Human granulocytic ehrlichiosis
Chlamydia (and *Chlamydia*-like bacteria)	*Chlamydophila pneumoniae*	Pneumonia
	Chlamydophila psittaci	Psittacosis (a respiratory disease; a zoonosis; sometimes called "parrot fever")
	Chlamydia trachomatis	Different serotypes cause different diseases, including trachoma (an eye disease) inclusion conjunctivitis (an eye disease), nongonococcal urethritis (NGU; a sexually transmitted disease), lymphogranuloma venereum (LGV; a sexually transmitted disease)
Mycoplasma	*M. pneumoniae* *M. genitalium*	Atypical pneumonia Nongonococcal urethritis (NGU)
Orientia	*O. tsutsugamushi*	Scrub typhus (a miteborne disease)
Ureaplasma	*U. urealyticum*	Nongonococcal urethritis (NGU)

Unique Bacteria, cont.

- Mycoplasmas
  - Smallest of the cellular microbes
  - Lack a cell wall and therefore assume many shapes (they are pleomorphic)
  - In humans, pathogenic mycoplasmas cause primary atypical pneumonia and genitourinary infections
  - Because they have no cell wall, they are resistant to drugs like penicillin that attack cell walls
  - They produce tiny “fried egg” colonies on artificial media

SEM of *Mycoplasma pneumoniae*



Photosynthetic Bacteria

- Photosynthetic bacteria include purple bacteria, green bacteria, and cyanobacteria; they all use light as an energy source, but not in the same way.
  - Purple and green bacteria do not produce oxygen, whereas cyanobacteria do.
  - Photosynthesis that produces oxygen is called *oxygenic photosynthesis.*
  - Photosynthesis that does not produce oxygen is called *anoxygenic photosynthesis.*

TABLE 4-9 Examples of Extremophiles

TYPE OF EXTREME ENVIRONMENT	NAME GIVEN TO THESE TYPES OF EXTREMOPHILES
Extremely acidic	Acidophiles
Extremely alkaline	Alkaliphiles
Extremely hot	Thermophiles
Extremely cold	Psychrophiles
Extremely salty	Halophiles
Extremely high pressure	Piezophiles (formerly barophiles)

The Domain *Archaea*

- *Archaea* (meaning ancient) were discovered in 1977; they are procaryotic organisms.
- Genetically, archaea are more closely related to eucaryotes than they are to bacteria.
- Archaea vary widely in shape; some live in extreme environments, such as extremely acidic, extremely hot, or extremely salty environments.
- Archaea possess cell walls, but their cell walls do not contain peptidoglycan (in contrast, all bacterial cell walls contain peptidoglycan).

The Domain *Archaea*

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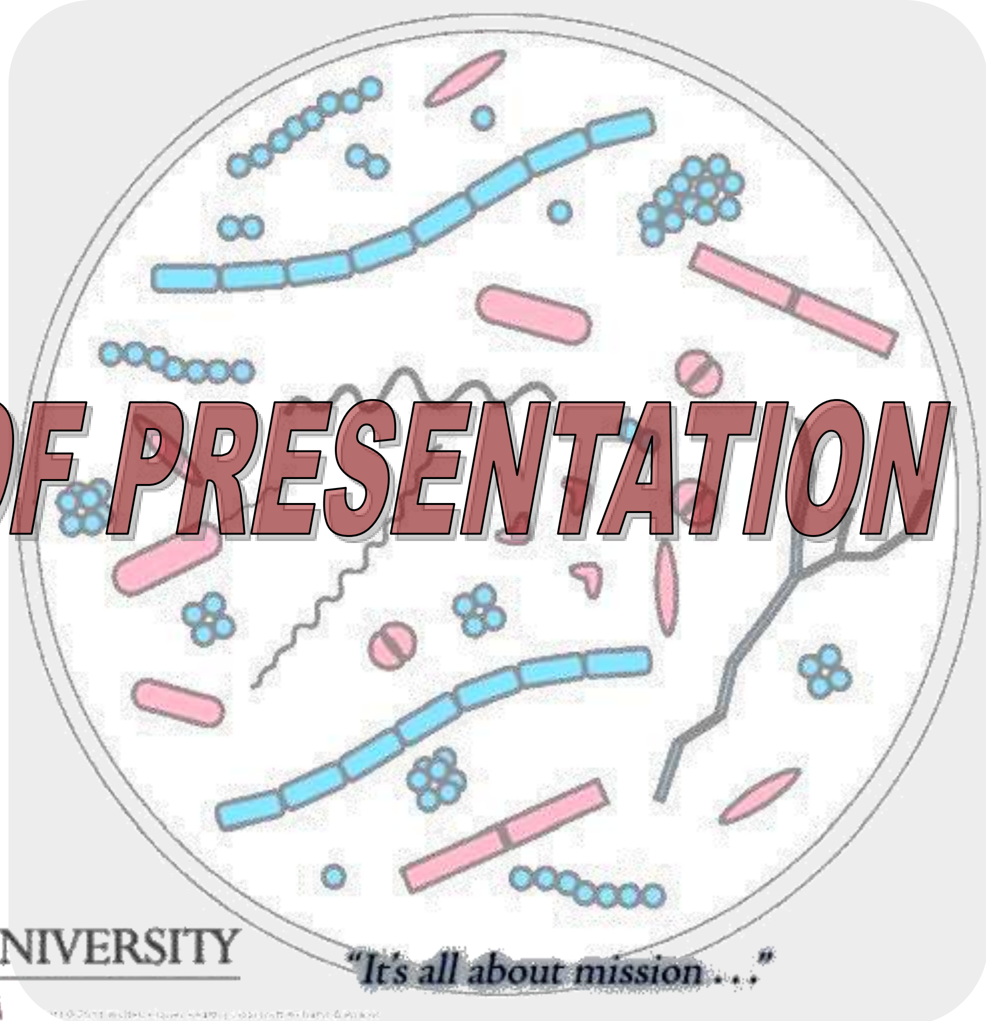
END OF PRESENTATION



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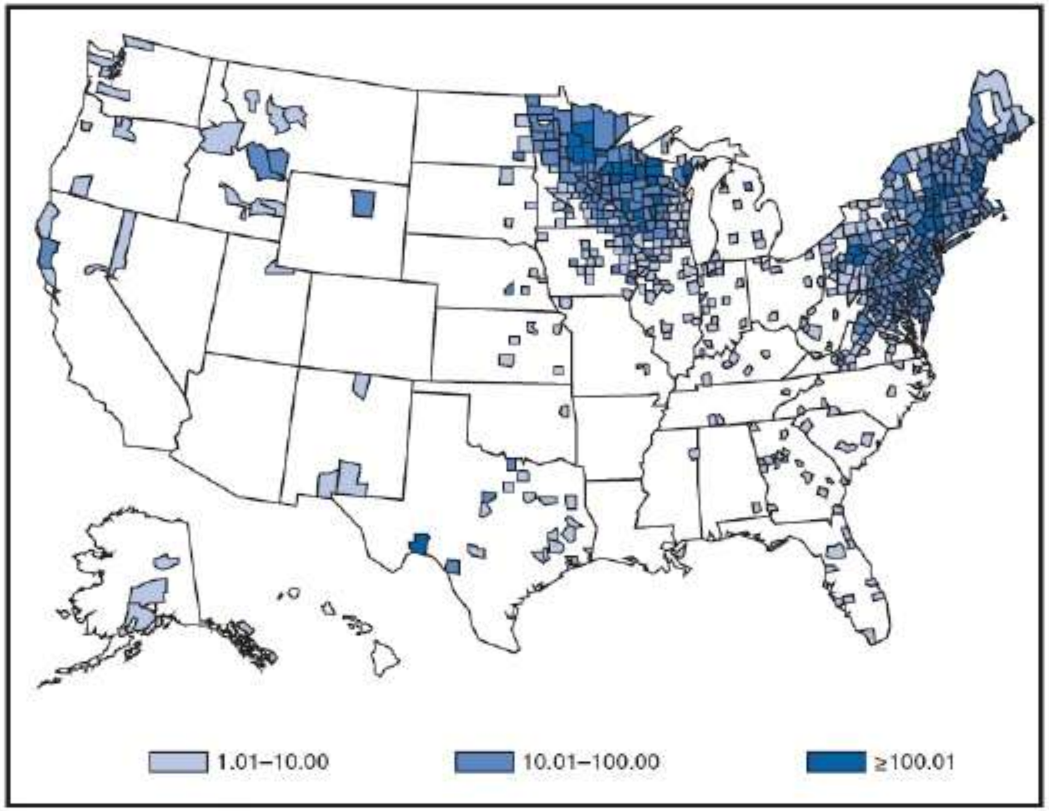
EXTRA INFORMATION ABOUT TICKS AND SOME DISEASES

Lyme Disease in Emergency Medicine
Author: William E Caputo, MD; Chief Editor: Rick Kulkarni, MD
Updated: May 24, 2011

LYME DISEASE. Incidence* of reported cases, by county — United States, 2008

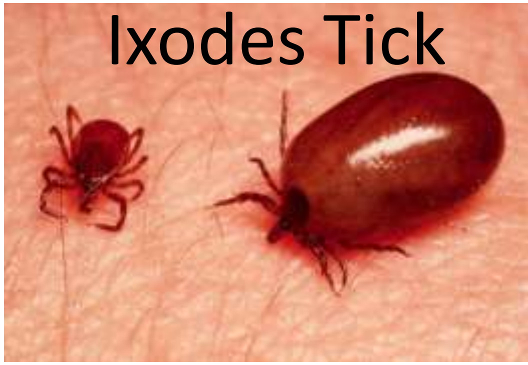


* Per 100,000 population.

http://emedicine.medscape.com/article/786767-overview

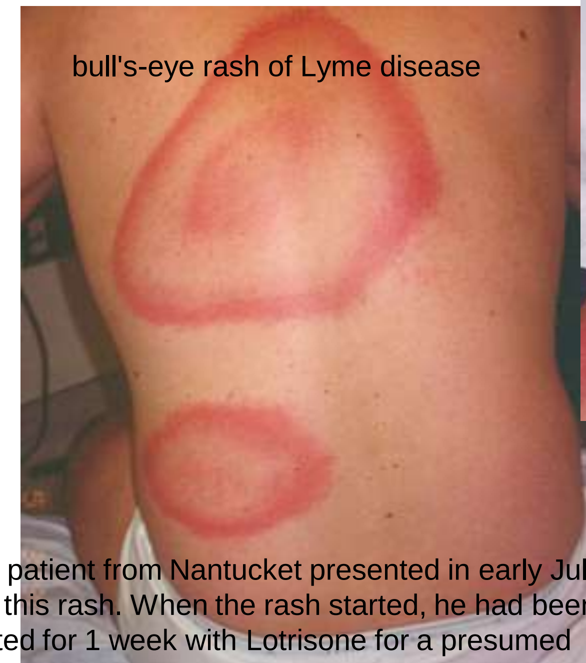
Approximately 90% of Lyme disease cases are reported from the northeastern and upper midwestern United States. A rash that can be confused with early Lyme disease sometimes occurs following bites of the lone star tick (Amblyomma americanum). These ticks, which do not transmit the Lyme disease bacterium, are common human-biting ticks in the southern and southeastern United States

Normal and Engorged Ixodes Tick

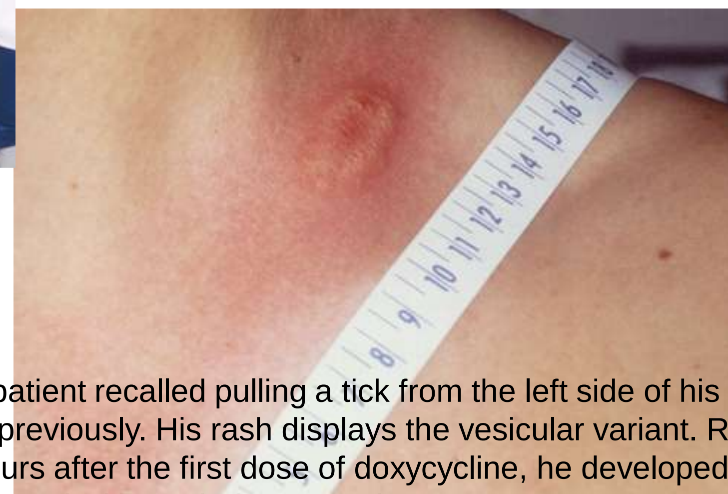


This patient's erythema migrans rash demonstrates several key features of the rash, including size, location, and presence of a central punctum, which can be seen right at the lateral margin of the inferior gluteal fold. Note that the color is uniform; this pattern probably is more common than the classic pattern of central clearing.

bull's-eye rash of Lyme disease

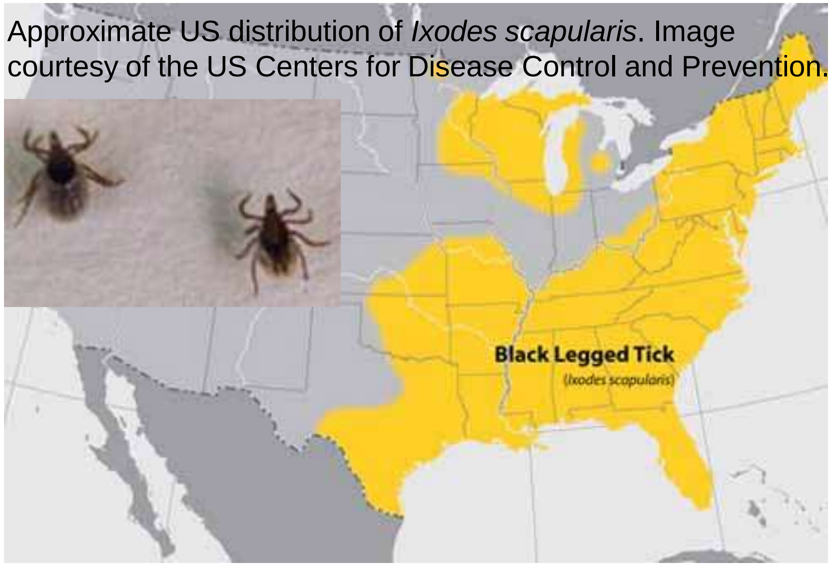


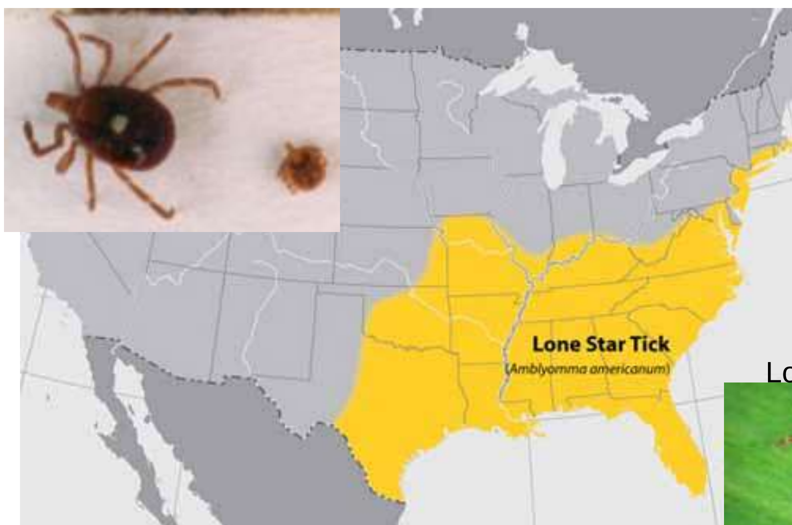
This patient from Nantucket presented in early July with this rash. When the rash started, he had been treated for 1 week with Lotrisone for a presumed tineal infection, but the initial lesion grew, and new ones developed. He worked outside as a carpenter but had no definite tick bite.



This patient recalled pulling a tick from the left side of his neck 7 days previously. His rash displays the vesicular variant. Roughly 18 hours after the first dose of doxycycline, he developed a typical Jarisch-Herxheimer reaction.

Approximate US distribution of *Ixodes scapularis*. Image courtesy of the US Centers for Disease Control and Prevention.





Lone Star Tick